DEPARTMENT OF NATURAL RESOURCES

Colorado Water Conservation Board

RULES CONCERNING THE COLORADO INSTREAM FLOW AND NATURAL LAKE LEVEL PROGRAM

2 CCR 408-2

[Editor's Notes follow the text of the rules at the end of this CCR Document.]

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1. TITLE.

Rules Concerning the Colorado Instream Flow and Natural Lake Level Program, hereafter referred to as the Instream Flow ("ISF") Program as established in §37-92-102 (3) C.R.S., shall be hereinafter referred to as the "ISF Rules."

2. PURPOSE OF RULES.

The purpose of the ISF Rules is to set forth the procedures to be followed by the Board and Staff when implementing and administering the ISF Program. By this reference, the Board incorporates the Basis and Purpose statement prepared and adopted at the time of rulemaking. A copy of this document is on file at the Board office.

3. STATUTORY AUTHORITY.

The statutory authority for the ISF Rules is found at §37-60-108, C.R.S. and §37-92-102 (3), C.R.S. Nothing in these rules shall be construed as authorizing the Board to deprive the people of the state of Colorado of the beneficial use of those waters available by law and interstate compact.

4. DEFINITIONS.

4a. Agenda Mailing List.

The agenda mailing list consists of all Persons who have sent a notice to the Board Office that they wish to be included on such list. These Persons will be mailed a Board meeting agenda prior to each scheduled Board meeting.

4b. Board.

Means the Colorado Water Conservation Board as defined in §§37-60-101, 103 and 104, C.R.S.

4c. Board Office.

The Colorado Water Conservation Board's office is located at 1313 Sherman Street, 7th Floor, Denver, CO 80203. The phone number is (303) 866-3441. The facsimile number is (303) 866-4474. The Board's website is https://cwcb.colorado.gov.

4d. Contested Hearing Mailing List.

The Contested Hearing Mailing List shall consist of all Persons who have received Party status or Contested Hearing Participant status pursuant to Rules 5l. or 5m. This mailing list is specific to a contested appropriation.

4e. Contested Hearing Participant.

Any Person who desires to participate in the contested ISF process, but not as a Party, may obtain Contested Hearing Participant status pursuant to Rule 5m. A Person with such status will receive all Party documents. Contested Hearing Participants may comment on their own behalf, but may not submit for the record technical evidence, technical witnesses or legal memoranda.

4f. CWCB Hearing Officer.

The Hearing Officer is appointed by the Board and is responsible for managing and coordinating proceedings related to contested ISF appropriations, acquisitions or modifications, such as setting prehearing conferences and adjusting deadlines and schedules to further the Parties' settlement efforts or for other good cause shown. The Hearing Officer does not have the authority to rule on substantive issues.

4g. Final Action.

For purposes of Rule 5, final action means a Board decision to (1) file a water right application, (2) not file a water right application or (3) table action on an ISF appropriation; however, tabling an action shall not be construed as abandonment of its intent to appropriate.

4h. Final Staff ISF Recommendation.

Staff's ISF recommendation to the Board is based on Staff's data and report, and public comments and data contained in the official record.

4i. ISF.

Means any water, or water rights appropriated by the Board for preservation of the natural environment to a reasonable degree, or any water, water rights or interests in water acquired by the Board for preservation or improvement of the natural environment to a reasonable degree. “ISF” includes both instream flows between specific points on a stream and natural surface water levels or volumes for natural lakes.

4j. ISF Subscription Mailing List(s).

The ISF Subscription Mailing List(s) are specific to each water division. The ISF Subscription Mailing List(s) shall consist of all Persons who have subscribed to the list(s) by sending notice(s) to the Board Office that they wish to be included on such list for a particular water division. The Staff shall, at such times as it deems appropriate, mail to all Persons on the water court resume mailing list in each water division an invitation to be included on the ISF Subscription Mailing List for that water division. Persons on the list are responsible for keeping Staff apprised of address changes. Persons on the ISF Subscription Mailing List(s) shall receive agendas and other notices describing activities related to ISF recommendations, appropriations and acquisitions in the particular water division. Persons may be required to pay a fee in order to be on the ISF Subscription Mailing List(s).

4k. Mail.

For the purposes of the ISF Rules, mail refers to regular or special delivery by the U.S. Postal Service or other such services, electronic delivery (e-mail), or delivery by FAX transmission.

4l. Party.

Any Person may obtain Party status pursuant to Rule 5l. Only a Person who has obtained Party status may submit, for the record, technical evidence, technical witnesses or legal memoranda. Each Party is responsible for mailing copies of all documents to all other Parties and Contested Hearing Participants.

4m. Person.

Means any human being, partnership, association, corporation, special district, water conservancy district, water conservation district, municipal entity, county government, state government or agency thereof, and federal government or agency thereof.

4n. Proper Notice.

Means the customary public notice procedure that is provided each year by the Board in the preamble to the Board's January Board meeting agenda. This customary public notice procedure may include posting of the agenda at the Board office, filing legal notices when required, mailing to Persons on the Board mailing lists and posting notices on the Board's website.

4o. Stacking.

As used in Rule 6, the terms “stack” or “stacking” refer to an instance in which the Board holds more than one water right for the same lake or reach of stream and exercises the rights independently according to their decrees.

4p. Staff.

Means the Director of the Colorado Water Conservation Board (“CWCB Director”) and other personnel employed by the Board.

5. ORIGINAL APPROPRIATION PROCEDURE.

5a. Recommendation of Streams and Lakes for Protection.

All Persons interested in recommending certain stream reaches or natural lakes for inclusion in the ISF Program may make recommendations to the Board or Staff at any time. Staff will provide a preliminary response to any Person making such a recommendation within 30 working days after receipt of the recommendation at the Board Office. Staff will collaborate with State and Federal agencies and other interested Persons to plan and coordinate collection of field data necessary for development of ISF recommendations. The Staff shall advise the Board, at least annually, of all new recommendations received and of streams and lakes being studied for inclusion in the ISF Program.

5b. Method of Making Recommendations.

All recommendations transmitted to the Board or Staff for water to be retained in streams or lakes to preserve the natural environment to a reasonable degree must be made with specificity and in writing.

5c. Board Approval Process.

Periodically, after studying streams and lakes for inclusion in the ISF Program, Staff will recommend that the Board appropriate ISF rights. The Board and Staff will use the following annual schedule for initiating, processing and appropriating ISF water rights:

January

- The January Board meeting agenda will list proposed ISF appropriations to be appropriated that year.
- Staff will provide data, engineering and other information supporting each proposed ISF appropriation to the Board prior to or at the January Board meeting.
- Staff will present its information and recommendation for each proposed ISF appropriation at the January Board meeting.
- The Board will take public comment on the proposed ISF appropriations at the January Board meeting.
- The Board may declare its intent to appropriate for each proposed ISF appropriation at the January Board meeting, provided that the particular ISF appropriation has been listed as being under consideration in a notice, mailed at least 60 days prior to the January Board meeting, to the ISF Subscription Mailing List for the relevant water division(s).
- Notice of the Board having declared its intent to appropriate will be distributed through the ISF Subscription Mailing List for the relevant water division(s).

March

- The Board will take public comment on all ISF appropriations at the March Board meeting.
- Notice to Contest an ISF appropriation, pursuant to Rule 5k, must be submitted to the Board Office by March 31st, or the first business day thereafter.

April

- Staff will notify all Persons on the ISF Subscription Mailing List(s) of contested ISF appropriations by April 10th, or the first business day thereafter.
- Notice of Party status or Contested Hearing Participant status, pursuant to Rules 5l. or 5m., must be submitted to the Board Office by April 30th, or the first business day thereafter.

May

- Staff will report to the Board which ISF appropriations are being contested.
- The Board may set hearing dates for contested ISF appropriations.
- At the May Board meeting, the Board may take final action on all uncontested ISF appropriations.

July

- A prehearing conference will be held prior to the July Board meeting for all contested ISF appropriations (Date specific to be determined by the Hearing Officer).

- Five working days before the prehearing conference, all Parties shall file at the Board office, for the record, any and all legal memoranda, engineering data, biological data and reports or other information upon which the Party will rely.

August

- All Parties must submit written rebuttal statements, including testimony and exhibits, by August 15th, or the first business day thereafter. Except for such rebuttal and testimony provided at the hearing pursuant to Rule 5p.(2), the Board will not accept any statements, related documentation or exhibits submitted by any Party after the prehearing conference, except for good cause shown or as agreed upon by the Parties.

September

- Staff will make its final recommendations to the Board, based upon its original report, all public comments, documents submitted by the Parties and all data contained in the official record, at the September Board meeting.

- Notice of the Final Staff ISF Recommendations will be sent to all Persons on the Contested Hearing Mailing List prior to the September Board meeting.

- Parties may choose to continue or withdraw their Notice to Contest an ISF appropriation at or before the September Board Meeting.

- The Board will hold hearings on all contested ISF appropriations.

November

- The Board shall update the public on the results of any hearings through its agenda and may take final action on contested ISF appropriations.

When necessary, the Board may modify or delay this schedule or any part thereof as it deems appropriate.

5d. Board's Intent to Appropriate.

Notice of the Board's potential action to declare its intent to appropriate shall be given in the January Board meeting agenda and the Board will take public comment regarding its intent to appropriate at the January meeting.

(1) After reviewing Staff's recommendations for proposed ISF appropriations, the Board may declare its intent to appropriate specific ISF water rights. At that time, the Board shall direct the Staff to publicly notice the Board's declaration of its intent to appropriate.

(2) After the Board declares its intent to appropriate, notice shall be published in a mailing to the ISF Subscription Mailing Lists for the relevant water divisions and shall include:

(a) A description of the appropriation (e.g. stream reach, lake location, amounts, etc.);

(b) Availability (time and place) for review of Summary Reports and Investigations Files for each appropriation; and,

(c) Summary identification of any data, exhibits, testimony or other information in addition to the Summary Reports and Investigations Files supporting the appropriation.

(3) Published notice shall also contain the following information:

(a) The Board may change flow amounts of contested ISF appropriations based on information received during the public notice and comment period.

(b) Staff will maintain, pursuant to Rule 5e.(3), an ISF Subscription Mailing List for each water division composed of the names of all Persons who have sent notice to the Board Office that they wish to be included on such list for a particular water division. Any Person desiring to be on the ISF Subscription Mailing List(s) must send notice to the Board Office.

(c) Any meetings held between Staff and members of the public will be open to the public. Staff may provide Proper Notice prior to any such meetings and may provide notice to Persons on the ISF Subscription Mailing List(s).

(d) Any Notice to Contest must be received at the Board office no later than March 31st, or the first business day thereafter. All Notices of Party status and Contested Hearing Participant status must be received at the Board office no later than April 30th, or the first business day thereafter.

(e) Staff will announce its Final Staff ISF Recommendation concerning contested appropriations at the September Board meeting and will send notice of the Final Staff ISF Recommendations to all Persons on the Contested Hearing Mailing List.

(f) The Board may take final action on any uncontested ISF appropriations at the May Board meeting.

(4) After the Board declares its intent to appropriate, notice of the Board's action shall be mailed within five working days to the County Commissioners of the county(ies) in which the proposed reach or lake is located.

(5) Final action by the Board on ISF appropriations will occur no earlier than the May Board meeting.

5e. Public Comment.

(1) The Board will hear comment on the recommended action to declare its intent to appropriate at the January Board Meeting.

(2) ISF appropriations will be noticed in the Board agenda for each regularly scheduled subsequent meeting until the Board takes final action. Prior to March 31st, at each regularly scheduled Board meeting, time will be allocated for public comment. Subsequent to March 31st, the Board will accept public comment on any contested ISF appropriations or lake levels only at the hearings held on those appropriations pursuant to Rule 5j.

(3) Staff will maintain an ISF Subscription Mailing List for each water division. Any Person desiring to receive information concerning proposed ISF appropriations for that water division must contact the Board Office to request inclusion on that ISF Subscription Mailing List.

5f. Date of Appropriation.

The Board may select an appropriation date that may be no earlier than the date the Board declares its intent to appropriate. The Board may declare its intent to appropriate when it concludes that it has received sufficient information that reasonably supports the findings required in Rule 5i.

5g. Notice.

Agenda and ISF Subscription Mailing List(s) notice shall be given pursuant to Rule 5d. and the public shall be afforded an opportunity to comment pursuant to Rule 5e. Notice of the date of final action on uncontested ISF appropriations shall be mailed to Persons on the ISF Subscription Mailing Lists for the relevant water divisions, maintained pursuant to Rule 5e.(3).

5h. Final Board Action on an ISF Appropriation.

The Board may take final action on any uncontested ISF appropriation(s) at the May Board meeting or any Board meeting thereafter. If a Notice to Contest has been filed, the Board shall proceed under Rules 5j. - 5q.

5i. Required Findings.

Before initiating a water right filing to confirm its appropriation, the Board must make the following determinations:

(1) Natural Environment.

That there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted.

(2) Water Availability.

That the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made.

(3) Material Injury.

That such environment can exist without material injury to water rights.

These determinations shall be subject to judicial review in the water court application and decree proceedings initiated by the Board, based on the Board's administrative record and utilizing the criteria of §§24-4-106(6) and (7), C.R.S.

5j. Procedural Rules for Contested ISF Appropriations.

(1) Whenever an ISF appropriation is contested, the Board shall hold a hearing at which any Party may present evidence, witnesses and arguments for or against the appropriation and any Contested Hearing Participant or member of the public may comment. The hearing shall be a notice and comment hearing as authorized in §37-92-102(4)(a), C.R.S., and shall not be a formal agency adjudication under §24-4-105, C.R.S.

(2) These rules are intended to assure that information is received by the Board in a timely manner. Where these rules do not address a procedure or issue, the Board shall determine the procedures to be followed on a case-by-case basis. The Board may waive the requirements of these rules whenever the Board determines that strict adherence to the rules is not in the best interests of fairness, unless such waiver would violate applicable statutes. For any such waiver, the Board shall provide appropriate justification, in writing, to Persons who have Party or Contested Hearing Participant status.

(3) In a hearing on a contested ISF appropriation, a Party may raise only those issues relevant to the statutory determinations required by §37-92-102(3)(c), C.R.S. and the required findings in Rule 5i.

5k. Notice to Contest.

(1) To contest an ISF appropriation, a Person must comply with the provisions of this section. The Board must receive a Notice to Contest the ISF appropriation by March 31st, or the first business day thereafter.

(2) A Notice to Contest an ISF appropriation shall be made in writing and contain the following information:

(a) Identification of the Person(s) requesting the hearing;

(b) Identification of the ISF appropriation(s) at issue; and,

(c) The contested facts and a general description of the data upon which the Person will rely to the extent known at that time.

(3) After a Party has filed a Notice to Contest an ISF appropriation, any other Person may participate as a Party or a Contested Hearing Participant pursuant to Rules 5l. or 5m.

(4) Staff will notify all Persons on the relevant ISF Subscription Mailing List(s) of contested ISF appropriations by April 10th, or the first business day thereafter.

5l. Party Status.

(1) Party status will be granted to any Person who timely files a Notice of Party Status with the Staff. Any Person filing a Notice to Contest shall be granted Party status and need not also file a Notice of Party Status. A Notice of Party status must be received by April 30th, or the first business day thereafter. A Notice of Party status shall set forth a brief and plain statement of the reasons for obtaining Party status, the contested facts, the matters that the Person claims should be decided and a general description of the data to be presented to the Board. The Board will have discretion to grant or deny Party status to any Person who files a Notice of Party Status after April 30th or the first business day thereafter, for good cause shown.

(2) Only a Party may submit for the record technical evidence, technical witnesses or file legal memoranda. Each Party is responsible for mailing copies of all documents submitted for Board consideration to all other Parties and Contested Hearing Participants.

(3) The Staff shall automatically be a Party in all proceedings concerning contested ISF appropriations.

(4) Where a contested ISF appropriation is based fully or in part on another agency's recommendation pursuant to Rule 5a., that agency shall automatically be a Party in any proceeding.

(5) All Parties, whether they achieved such status by filing a Notice to Contest or a Notice of Party Status, shall be afforded the same rights in the contested ISF appropriation proceedings. Specifically, but without limiting the generality of the foregoing sentence, any Person who filed a Notice of Party Status is entitled to raise issues not raised by any Person who filed a Notice to Contest.

5m. Contested Hearing Participant Status.

(1) Any Person who desires to participate in the process, but not as a Party, may obtain Contested Hearing Participant status by filing a notice thereof at the Board Office prior to April 30th. A Person with such status will receive all Party documents specific to the contested appropriation. Contested Hearing Participants may comment on their own behalf, but may not submit for the record technical evidence, technical witnesses or legal memoranda. The Board will have discretion to grant or deny Contested Hearing Participant status to any Person who filed a Notice of Contested Hearing Participant Status after April 30th or the first business day thereafter, for good cause shown.

(2) The request for Contested Hearing Participant status must be received by April 30th, or the first business day thereafter.

(3) Staff shall notify all Parties and Contested Hearing Participants of the list of Contested Hearing Participants prior to May 31st. Thereafter, Parties shall also mail their prehearing statements and any other documents to Contested Hearing Participants.

5n. Prehearing Conference.

(1) The Board will designate a Hearing Officer, who shall schedule and preside over prehearing conferences and assist the Parties with procedural matters, such as setting prehearing conferences and adjusting deadlines and schedules to further the Parties' settlement efforts or for other good cause shown. All prehearing conferences will be scheduled and held prior to the July Board meeting.

(2) On or before five working days before the prehearing conference, each Party shall file 25 copies of its prehearing statement with the Board, and provide an electronic version when possible. The prehearing statement shall identify all exhibits, engineering data, biological data and reports or other information that the Party will rely upon at the hearing and shall contain:

(a) A specific statement of the factual and legal claims asserted (issues to be resolved) and the legal basis upon which the Party will rely;

(b) Copies of all exhibits to be introduced at the hearing;

(c) A list of witnesses to be called and a brief description of their testimony;

(d) Any alternative proposal to the proposed ISF appropriation;

(e) All written testimony to be offered into evidence at the hearing;

and

(f) Any legal memoranda.

Each Party shall deliver a copy of its prehearing statement to all other Parties, Contested Hearing Participants, the Hearing Officer and directly to the Assistant Attorneys General representing Staff and the Board five working days before the prehearing conference. The Board will not consider information, other than rebuttal statements and testimony provided at the hearing pursuant to Rule 5p.(2), submitted by the Parties after this deadline except for good cause shown or as agreed upon by the Parties.

(3) Any Contested Hearing Participant may also submit written comments 5 working days prior to the prehearing conference. Contested Hearing Participants who submit written comments for the Board's consideration shall provide 25 copies to the Board, and a copy to all other Contested Hearing Participants, Parties, the Hearing Officer and the Assistant Attorneys General representing Staff and Board, and provide an electronic version when possible.

(4) The prehearing conference will afford the Parties the opportunity to address such issues as time available for each Party at the hearing, avoiding presentation of duplicative information, consolidation of concerns, etc. The Parties may formulate stipulations respecting the issues to be raised, witnesses and exhibits to be presented, and/or any other matters which may be agreed to or admitted by the Parties. At the prehearing conference, the Parties shall make known any objections to the procedures or evidence that they may raise at the hearing unless such objections could not have been reasonably determined at that time.

(5) August 15th, or the first business day thereafter, is the last day for submission of written rebuttal statements, including testimony, legal memoranda, and exhibits. Twenty-five copies of such materials must be provided to the Board, and an electronic version also provided, when possible. Except for such rebuttal and testimony provided at the hearing pursuant to Rule 5p.(2), the Board will not accept any statements, related documentation or exhibits submitted by any Party after the deadline set forth in Rules 5n.(2) and 5n.(3), except for good cause shown or as agreed upon by the Parties. The scope of rebuttal is limited to issues and evidence presented in the prehearing statements. Any documentation to be submitted pursuant to this subsection (5) shall be delivered to the Board and mailed to all Parties and Contested Hearing Participants by August 15th, or the first business day thereafter, unless the Parties agree otherwise.

5o. Notice of Hearings on Contested ISF Appropriations.

(1) Staff shall mail notice of prehearing conference(s) on contested ISF appropriations to all Persons on the Contested Hearing Mailing List for the particular ISF appropriation. The notice shall specify the time and place of the prehearing conference and any procedural requirements that the Board deems appropriate.

(2) The Board may postpone a hearing to another date by issuing written notice of the postponement no later than 7 calendar days prior to the original hearing date.

5p. Conduct of Hearings.

(1) In conducting any hearing, the Board shall have authority to: administer oaths and affirmations; regulate the course of the hearing; set the time and place for continued hearing; limit the number of technical witnesses; issue appropriate orders controlling the subsequent course of the proceedings; and take any other action authorized by these Rules.

(2) At the hearing, the Board shall hear arguments, concerns or rebuttals from Parties, Contested Hearing Participants and interested members of the public. The Board may limit testimony at the hearing. Without good cause, the Board will not permit Parties or Contested Hearing Participants to introduce written material at the hearing not previously submitted pursuant to these Rules. The Board, in making its determinations, need not consider any written material not timely presented.

(3) Only the Board may question witnesses at the hearing except where the Board determines that, for good cause shown, allowing the parties to question witnesses may materially aid the Board in reaching its decision, or where such questioning by the Parties relates to the statutory findings required by §37-92-102(3)(c), C.R.S. The Board may terminate questioning where the Board determines that such questioning is irrelevant or redundant or may terminate such questioning for other good cause.

(4) The hearing shall be recorded by a reporter or by an electronic recording device. Any Party requesting a transcription of the hearing shall be responsible for the cost of the transcription.

5q. Final Board Action.

The Board may take final action at the hearing or at a later date.

5r. Statement of Opposition.

In the event that any Person files a Statement of Opposition to an ISF water right application in Water Court, the Staff may agree to terms and conditions that would prevent injury. Where the resolution of the Statement of Opposition does not involve a change regarding the Board's determinations under Rule 5i. (including but not limited to the amount, reach, and season), the Board is not required to review and ratify the resolution. Staff may authorize its counsel to sign any court documents necessary to finalize this type of pretrial resolution without Board ratification.

5s. Withdrawal of Filing.

If the Board elects to withdraw a Water Court filing, notice shall be given in the agenda of the Board meeting at which the action is expected to occur.

6. ACQUISITION OF WATER, WATER RIGHTS OR INTERESTS IN WATER FOR INSTREAM FLOW PURPOSES.

The Board may acquire water, water rights, or interests in water for ISF purposes by the following procedures:

6a. Means of Acquisition.

The Board may acquire, by grant, purchase, donation, bequest, devise, lease, exchange, or other contractual agreement, from or with any Person, including any governmental entity, such water, water rights, or interests in water that are not on the Division Engineer’s abandonment list in such amounts as the Board determines are appropriate for stream flows or for natural surface water levels or volumes for natural lakes to preserve or improve the natural environment to a reasonable degree.

6b. 120 Day Rule.

At the request of any Person, including any governmental entity, the Board shall determine in a timely manner, not to exceed one hundred twenty days, unless further time is granted by the requesting Person, what terms and conditions the Board will accept in a contract or agreement for the acquisition. The 120-day period begins on the day the Board first considers the proposed contract or agreement at a regularly scheduled or special Board meeting.

6c. Stacking Evaluation.

The Board shall evaluate whether to combine or stack the acquired water right with any other ISF appropriation or acquisition, based upon the extent to which the acquired water will provide flows or lake levels to preserve or improve the natural environment to a reasonable degree.

If the Board elects to combine or stack the acquired water right, the details of how the water rights are to be combined or stacked with other existing ISF appropriations or acquisitions must be set forth in the application for a decree to use the acquired right for instream flow purposes.

6d. Enforcement of Acquisition Agreement.

Pursuant to section 37-92-102(3), C.R.S., any contract or agreement executed between the Board and any Person which provides water, water rights, or interests in water to the Board shall be enforceable by either party thereto as a water matter in the water court having jurisdiction over the water right according to the terms of the contract or agreement.

6e. Appropriateness of an Acquisition.

The Board shall evaluate the appropriateness of any acquisition of water, water rights, or interests in water to preserve or improve the natural environment. Such evaluation shall include, but need not be limited to consideration of the following factors:

(1) The reach of stream or lake level for which the use of the acquired water is proposed, which may be based upon any one or a combination of the following: the historical location of return flow; the length of the existing instream flow reach, where applicable; whether an existing instream flow water right relies on return flows from the water right proposed for acquisition; the environment to be preserved or improved by the proposed acquisition; or such other factors the Board may identify;

(2) The natural flow regime;

(3) Any potential material injury to existing decreed water rights;

(4) The historical consumptive use and historical return flows of the water right proposed for acquisition that may be available for instream flow use;

(5) The natural environment that may be preserved or improved by the proposed acquisition, and whether the natural environment will be preserved or improved to a reasonable degree by the water available from the proposed acquisition;

(6) The location of other water rights on the subject stream(s);

(7) The effect of the proposed acquisition on any relevant interstate compact issue, including whether the acquisition would assist in meeting or result in the delivery of more water than required under compact obligations;

(8) The effect of the proposed acquisition on the maximum utilization of the waters of the state;

(9) Whether the water acquired will be available for subsequent use or reuse downstream;

(10) The cost to complete the transaction or any other associated costs; and

(11) The administrability of the acquired water right when used for instream flow purposes.

The Board shall determine how to best utilize the acquired water, water rights or interest in water to preserve or improve the natural environment.

6f. Factors Related to Loans and Leases.

In addition to considering the factors listed above, for loans and leases of water, water rights and interests in water for ISF purposes under section 37-92-102(3),

(1) The Board shall consider the extent to which the leased or loaned water will preserve or improve the natural environment to a reasonable degree, including but not limited to:

(a) Whether the amount of water available for acquisition is needed to provide flows to meet a decreed ISF amount in below average years; and

(b) Whether the amount of water available for acquisition could be used to and would improve the natural environment to a reasonable degree, either alone or in combination with existing decreed ISF water rights.

(2) In considering the extent to which the leased or loaned water will preserve or improve the natural environment to a reasonable degree, the Board will request and review a biological analysis from Colorado Parks and Wildlife (CPW), and will review any other biological or scientific evidence presented to the Board.

(3) If other sources of water are available for acquisition on the subject stream reach(es) by purchase or donation, the Board shall fully consider each proposed acquisition and give preference first to the donation and then to a reasonable acquisition by purchase.

(4) The Board shall obtain confirmation from the Division Engineer that the proposed lease or loan is administrable and is capable of meeting all applicable statutory requirements.

(5) The Board shall determine, through negotiation and discussion with the lessor, the amount of compensation to be paid to the lessor of the water based, in part, upon the anticipated use of the water during and after the term of the lease.

(6) The Board shall consider evidence of water availability based upon the historical record(s) of diversion, the beneficial use of the subject water right, the location and timing of where return flows have historically returned to the stream, and the reason(s) the water is available for lease or loan.

6g. Recording Requirements.

(1) All contracts or agreements for leases or loans of water, water rights or interests in water under section 37-92-102(3) shall require the Board to:

(a) Maintain records of how much water the Board uses under the contract or agreement each year it is in effect; and

(b) Install any measuring device(s) deemed necessary by the Division Engineer (1) to administer the lease or loan of water, (2) to measure and record how much water flows out of the reach after use by the Board under the lease or loan; and (3) to meet any other applicable statutory requirements.

(2) All contracts or agreements for leases or loans of water shall provide for the recording of the actual amount of water legally available and capable of being diverted under the leased or loaned water right during the term of the lease or loan, with such records provided to the Division of Water Resources for review and publication.

6h. Water Reuse.

All contracts or agreements for the acquisition of water, water rights or interests in water under section 37-92-102(3) shall provide that the Board or the seller, lessor, lender or donor of the water may bring about beneficial use of the historical consumptive use of the acquired water right downstream of the ISF reach as fully consumable reusable water, pursuant to the water court decree authorizing the Board to use the acquired water.

(1) The bringing about of beneficial use of the historical consumptive use of the water may be achieved by direct use, sale, lease, loan or other contractual arrangement by the Board or the seller, lessor, lender or donor.

(2) The contract or agreement also shall provide that the Division Engineer must be notified of any agreement for such beneficial use downstream of the ISF reach prior to the use.

(3) Prior to any beneficial use by the Board of the historical consumptive use of the acquired water right downstream of the ISF reach, the Board shall find that such use:

(a) Will be consistent with the Board's statutory authority and with duly adopted Board policies and objectives; and

(b) Will not injure vested water rights or decreed conditional water rights.

6i. Applications for a Decreed Right to Use Water for ISF Purposes.

The Board shall file a change of water right application or other applications as needed or required with the water court to obtain a decreed right to use water for ISF purposes under all contracts or agreements for acquisitions of water, water rights or interests in water under section 37-92-102(3), including leases and loans of water. The Board shall file a joint application with the Person from whom the Board has acquired the water or a Person who has facilitated the acquisition, if requested by such Person. The Water Court shall determine matters that are within the scope of section 37-92-305, C.R.S. In a change of water right proceeding, the Board shall request the Water Court to:

(1) Verify the quantification of the historical consumptive use of the acquired water right;

(2) Verify the identification, quantification and location of return flows to ensure that no injury will result to vested water rights and decreed conditional water rights;

(3) Include terms and conditions providing that:

(a) The Board or the seller, lessor, lender, or donor of the water may bring about the beneficial use of the historical consumptive use of the changed water right downstream of the ISF reach as fully consumable reusable water, subject to such terms and conditions as the water court deems necessary to prevent injury to vested water rights and decreed conditional water rights; and

(b) When the Board has not identified such downstream beneficial use at the time of the change of water right, the Board may amend the subject change decree, if required by the Division Engineer, to add such beneficial use(s) of the historical consumptive use downstream of the ISF reach at the time the Board is able to bring about such use or reuse, without requiring requantification of the original historical consumptive use calculation; and

(4) Decree the method by which the historical consumptive use should be quantified and credited during the term of the agreement for the lease or loan of the water right pursuant to section 37-92-102(3), C.R.S.

6j. Limitation on Acquisitions.

The Board may not accept a donation of water rights that were acquired by condemnation, or that would require the removal of existing infrastructure without approval of the current owner of such infrastructure.

6k. Temporary (Expedited and Renewable) Loans of Water to the Board.

Section 37-83-105, C.R.S., authorizes the Board to accept and exercise two types of temporary loans of water for ISF use: (1) expedited loans; and (2) renewable loans. Expedited loans have a term of up to one year and may be used to preserve the natural environment to a reasonable degree on a decreed instream flow reach. Renewable loans, which can be used to preserve or improve the natural environment on a decreed instream flow reach, may be exercised for up to five years in a ten-year period and for no more than three consecutive years, and may be renewed for up to two additional ten-year periods. The Board may exercise both expedited and renewable temporary loans of water for instream flow use for a period not to exceed 120 days in a single calendar year, in accordance with the procedures and subject to the limitations set forth in section 37-83-105, C.R.S. The owner of a decreed water right who has offered water to the Board for an expedited or renewable loan is referred to herein as an "applicant."

(1) Expedited Loans.

(a) An expedited loan approved to preserve the natural environment to a reasonable degree has a term of up to one year, with instream flow use not to exceed 120 days in a single calendar year. The loan period begins when the State Engineer approves the expedited loan. If an expedited loan is approved, the applicant may not reapply for an additional expedited loan of the subject water right.

(b) Within five working days after receiving an offer of an expedited loan of water to the Board for temporary instream flow use, the Director will provide a response to the applicant. If the proposed loan appears to be appropriate for instream flow use, staff will coordinate with the applicant to:

i. prepare and submit the necessary documentation to the State Engineer required by sections 37-83-105(2)(a)(I) and (2)(b)(I), C.R.S.;

ii. provide the written notice required by section 37-83-105(2)(b)(II), C.R.S., and access to all documentation provided to the State Engineer under Rule 6k.(1)(b)i, to: (1) all parties on the substitute water supply plan notification list established pursuant to section 37-92-308(6), C.R.S., for the water division in which the proposed loan is located; and (2) a registered agent of a ditch company, irrigation district, water users' association, or other water supply or delivery entity within whose system the water rights fall; and

iii. provide notice to all Persons on the ISF Subscription Mailing List for the relevant water division.

(c) Provided that the State Engineer has made a determination of no injury pursuant to section 37-83-105(2)(a)(III), C.R.S., the Board hereby delegates authority to the CWCB Director to accept expedited loans of water for instream flow use in accordance with the procedures and subject to the limitations set forth in section 37-83-105, C.R.S., to execute an agreement for the loan of the water, and to take any administrative action necessary to put the loaned water to instream flow use. The purpose of this delegation is to expedite the Board's exercise of a temporary loan of water for instream flow use under this Rule 6k.(1).

(d) The CWCB's use of loaned water for instream flows shall not exceed the CWCB's decreed instream flow rate(s), time period(s), and reach(es) at any time during the expedited loan term, and shall comply with any terms and conditions imposed by the State Engineer to prevent injury.

(e) At the first regular or special Board meeting after the Director accepts, or rejects over applicant's objection, an offer of an expedited loan of water to the Board for temporary instream flow use under (b) and (c) above, the Board shall vote either to ratify or overturn the Director's decision.

(f) The Board, Director and staff will expedite all actions necessary to implement Rule 6k.(1).

(2) Renewable Loans.

(a) A renewable loan approved to preserve or improve the natural environment must not be exercised for more than five years in a ten-year period and for no more than three consecutive years, for which only a single approval by the State Engineer is required. Instream flow use may not exceed 120 days in a single calendar year. The ten-year period begins when the State Engineer approves the loan. If an applicant for a renewable loan has previously been approved for and has exercised an expedited loan using the same water right(s) that are the subject of the pending application, the one-year loan period of the expedited loan counts as the first year of the five-year allowance for the subsequent renewable loan.

(b) The Board will use a two-Board meeting process to review, consider public comment, and direct Staff whether to move forward with proposed renewable loans of water for instream flow use to preserve or improve the natural environment to a reasonable degree.

(c) Any Person may request the Board to hold a hearing on a proposed renewable loan. Such a request must be submitted to the Board in writing within twenty days after the first Board meeting at which the Board considers the proposed renewable loan, and must include a brief statement, with as much specificity as possible, of why a hearing is being requested. The Board shall conduct all hearings on renewable loans pursuant to Rule 6m.(5).

(d) For renewable loans to improve the natural environment to a reasonable degree, the Board will:

i. request and review a biological analysis from CPW concerning the extent to which the proposed loan will improve the natural environment to a reasonable degree, and review any other biological or scientific evidence presented to the Board;

ii. make findings on flow rates appropriate to improve the natural environment to a reasonable degree with the loaned water; and

iii. give preference to loans of stored water, when made available, over loans of direct flow water.

(e) When evaluating a proposed renewable loan, the Board shall consider any potential injury to decreed water rights, decreed exchanges of water, or other water users' undecreed existing exchanges of water to the extent that the undecreed existing exchanges have been administratively approved before the date of the Board's consideration.

(f) If the Board directs Staff to move forward with a proposed renewable loan, staff will coordinate with the applicant to:

i. prepare and submit the necessary documentation to the State Engineer required by sections 37-83-105(2)(a)(I) and (2)(b)(I), C.R.S.;

ii. provide the written notice required by section 37-83-105(2)(b)(II), C.R.S., and access to all documentation provided to the State Engineer under Rule 6k.(2)(f)i, to: (1) all parties on the substitute water supply plan notification list established pursuant to section 37-92-308(6), C.R.S., for the water division in which the proposed loan is located; and (2) a registered agent of a ditch company, irrigation district, water users' association, or other water supply or delivery entity within whose system the water rights fall;

iii. provide notice to all Persons on the ISF Subscription Mailing List for the relevant water division; and

iv. make best efforts to publish notice of the proposed plan in an appropriate legal newspaper of general circulation in each county in which the loan will be implemented and from which the loaned water has been historically used.

(g) Board direction to Staff to move forward with a proposed renewable loan will include authorizing Staff to execute an agreement for the loan of water and to take any administrative action necessary to put the loaned water to instream flow use, provided that the State Engineer determines that no injury will result from the proposed loan.

(h) The CWCB's instream flow use of loaned water shall not extend beyond the CWCB's decreed instream flow reach(es) at any time during the renewable loan term, and shall comply with any terms and conditions imposed by the State Engineer to prevent injury.

(i) In each year that a renewable loan is exercised, the applicant, coordinating with Staff if necessary, shall provide the written notice described in section 37-83-105(2)(b)(II), C.R.S.

(j) The applicant may reapply for a renewable loan, and the State Engineer may approve such loan for up to two additional ten-year periods. Prior to any such reapplication, at a properly noticed public meeting, Staff will inform the Board about the exercise of the loan during the previous ten-year period and request approval for the loan to continue for the additional ten-year period. The Board shall consider any public comment and objections to the renewal provided at the public meeting. If the Board authorizes renewal of the loan, staff will coordinate with the applicant to: (1) prepare and submit the necessary documentation to the State Engineer required by sections 37-83-105(2)(a)(I) and (2)(b)(I), C.R.S.; and (2) provide the written notice required by section 37-83-105(2)(b)(II), C.R.S.

(3) Water rights loaned to the Board pursuant to expedited or renewable loans are not precluded from concurrent or subsequent inclusion in other programs, such as water conservation, demand management, compact compliance, or water banking programs or plans, as are or may be subsequently defined or described in statute. The applicant will inform the Board of inclusion of the loaned water right in any such program during the loan period.

6l. Funds for Water Right Acquisitions.

The Board may use any funds available to it for costs of the acquisition of water rights and their conversion to ISF use. The Board shall spend available funds for such costs in accordance with section 37-60-123.7, C.R.S. and any other applicable statutory authority, and with applicable Board policies and procedures.

6m. Public Input on Proposed Acquisitions.

The Board shall follow the public review process in Rules 11a. - 11c. when acquiring water, water rights or interests in water, except for expedited and renewable temporary loans or leases as provided in Rule 6k. above and except as provided below.

(1) Prior to Board consideration of any proposed acquisition, Staff shall mail notice of the proposed acquisition to all Persons on the ISF Subscription Mailing List and the State Engineer's Substitute Supply Plan Notification List for the relevant water division, and shall provide Proper Notice. Such notice shall include:

(a) The case number adjudicating the water right proposed to be acquired, and the appropriation date, adjudication date, priority, decreed use(s), and flow amount of the water right proposed to be acquired, and approximately how much of the water right the Board will consider acquiring;

(b) The location of the stream reach or lake that is the subject of the proposal, including, when available, the specific length of stream reach to benefit from the proposed acquisition;

(c) Any available information on the purpose of the acquisition, including the degree of preservation or improvement of the natural environment to be achieved;

(d) Any available scientific data specifically supporting the position that the acquisition will achieve the goal of preserving or improving the natural environment to a reasonable degree; and

(e) In addition to (a) - (d) above, for leases and loans of water, water rights or interests in water under section 37-92-102(3), C.R.S., such notice shall include the proposed term of the lease or loan and the proposed season of use of the water under the lease or loan.

(2) At every regularly scheduled Board meeting subsequent to the mailing of notice, and prior to final Board action, Staff will report on the status of the proposed acquisition and time will be reserved for public comment.

(3) Any Person may address the Board regarding the proposed acquisition prior to final Board action. Staff shall provide any written comments it receives regarding the proposed acquisition directly to the Board.

(4) Any Person may request the Board to hold a hearing on a proposed acquisition. Such a request must be submitted to the Board in writing within twenty days after the first Board meeting at which the Board considers the proposed acquisition, and must include a brief statement, with as much specificity as possible, of why a hearing is being requested.

(5) At its next regularly scheduled meeting after receipt of the request for a hearing, or at a special meeting, the Board will consider the request and may, in its sole discretion, grant or deny such a request. All hearings scheduled by the Board shall be governed by the following procedures:

(a) A hearing on a proposed acquisition, except for renewable loans, must be held within the 120 day period allowed for Board consideration of an acquisition pursuant to Rule 6b., unless the Person requesting the Board to consider the proposed acquisition agrees to an extension of time.

(b) The Board shall appoint a Hearing Officer to establish the procedures by which evidence will be offered.

(c) For hearings on acquisitions other than renewable loans, at least thirty days prior to the hearing date(s), the Board shall provide written notice of the hearing(s) to the Person proposing the acquisition, all interested parties known to the Board, and all Persons on the ISF Subscription Mailing List and the State Engineer's Substitute Supply Plan Notification List for the relevant water division. The Board also shall provide Proper Notice, as defined in ISF Rule 4n.

(d) For hearings on renewable loans, at least thirty days prior to the hearing date, the Board shall provide written notice of the hearing to the owner of the water right to be loaned and to: (1) all parties on the substitute water supply plan notification list established pursuant to section 37-92-308(6), C.R.S., for the water division in which the proposed loan is located; (2) a registered agent of a ditch company, irrigation district, water users' association, or other water supply or delivery entity within whose system the water rights fall; and (3) provide notice to all Persons on the ISF Subscription Mailing List for the relevant water division. Such notice shall include the process and deadlines for participating in the hearing.

(e) Any Person who desires party status shall become a Party upon submission of a written Notice of Party Status to the Board Office. The Notice shall include the name and mailing address of the Person and a brief statement of the reasons the Person desires party status. The Board Office must receive Notice of Party Status within seven days after notice of the hearing is issued.

(f) The Hearing Officer shall set timelines and deadlines for all written submissions. Prehearing statements will be required, and shall include, but not be limited to, the following: 1) a list of all disputed factual and legal issues; 2) the position of the Party regarding the factual and legal issues; 3) a list identifying all of the witnesses that will testify for the Party, and a summary of the testimony that those witnesses will provide; and 4) copies of all exhibits that the Party will introduce at the hearing(s).

(g) Any Party may present testimony or offer evidence identified in its prehearing statement regarding the proposed acquisition.

(h) The Hearing Officer shall determine the order of testimony for the hearing(s), and shall decide other procedural matters related to the hearing(s). The Hearing Officer does not have authority to rule on substantive issues, which authority rests solely with the Board.

(i) The Board will not apply the Colorado Rules of Evidence at hearings on proposed acquisitions.

(j) The Board may permit general comments from any Person who is not a Party; however, the Board may limit these public comments to five minutes per Person.

(k) The Board may take final action at the hearing(s) or continue the hearing and/or deliberations to a date certain.

(l) Board hearings may be recorded by a reporter or by an electronic recording device. Any Party requesting a transcription of the hearing(s) shall be responsible for the cost of the transcription.

(m) When necessary, the Board may modify this hearing procedure schedule or any part thereof as it deems appropriate.

6n. Board Action to Acquire Water, Water Rights or Interests in Water.

The Board shall consider the acquisition during any regular or special meeting of the Board. At the Board meeting, the Board shall consider all presentations or comments of Staff or any other Person. After such consideration, the Board may acquire, acquire with limitations, or reject the proposed acquisition.

7. INUNDATION OF ISF RIGHTS.

Inundation of all or a portion of an ISF stream reach or lake may be an interference with the Board's usufructuary rights that have been acquired by Board action. “Inundation” as used in this section is the artificial impoundment of water within an ISF or natural lake; “inundation” does not refer to the use of a natural stream as a conveyance channel as long as such use does not raise the waters of the stream above the ordinary high watermark as defined in §37-87-102 (1)(e), C.R.S.

7a. Small Inundations.

Staff may file a Statement of Opposition to inundations described in this section if it determines that the ISF right or natural environment will be adversely affected by the inundation. The Staff shall not be required to file a Statement of Opposition to applications proposing small inundations. Small inundations are those in which the impoundment is 100 acre-feet or less, or the surface acreage of the impoundment is 20 acres or less, or the dam height of the structure is 10 feet or less. The dam height shall be measured vertically from the elevation of the lowest point of the natural surface of the ground, where that point occurs along the longitudinal centerline of the dam up to the flowline crest of the spillway of the dam.

(1) All structures proposed by any applicant on a stream reach shall be accumulated for the purpose of determining whether the inundations proposed by the applicant are small inundations. In the event the cumulative surface acreage, volume impounded, or dam height of all impoundments exceed the definition of a small inundation, Staff may file a Statement of Opposition to that application.

(2) In the event that no Statement of Opposition is filed pursuant to the terms of this section, the Board shall be deemed to have approved the inundation proposed without a request by the applicant.

7b. Application of Rule 7.

The provisions of this rule will not be applied to the following water rights:

(1) any absolute or conditional water right that is senior to an ISF right;

(2) any senior conditional water right that seeks a finding of reasonable diligence;

(3) any junior absolute or conditional water right which was decreed prior to July 10, 1990, or had an application for decree pending prior to July 10, 1990, unless the Board had filed a Statement of Opposition to the absolute or conditional water right application prior to July 10, 1990; or

(4) any inundation of an ISF reach by water that does not have an absolute or conditional water right if the inundation occurred prior to July 10, 1990.

7c. Request to Inundate.

Any Person seeking permission to inundate shall timely submit a written request for permission to inundate to the Board Office. No requests for inundation will be considered or approved until the Person seeking permission to inundate files a water court application outlining their storage plans or files plans and specifications with the State Engineer for a jurisdictional dam pursuant to §37-87-105, C.R.S. The Board will consider the request to inundate in a timely manner.

7d. Staff Investigation.

After receiving the request to inundate, the Staff may seek the recommendations from Colorado Parks and Wildlife, Division of Water Resources, United States Department of Agriculture and United States Department of Interior.

7e. Required Information.

In any written request to inundate, the requesting Person shall at a minimum include information on the following factors: the location of the inundation, the size of the inundation, impact of the inundation on the natural environment, any unique or rare characteristics of the ISF water right to be inundated, any regulatory requirements or conditions imposed upon the applicant by federal, state and/or local governments, all terms and conditions included in applicant's water court decree, and any compensation or mitigation offered by the Person proposing the inundation.

7f. Determination of Interference.

In response to the request to inundate, the Board shall determine whether the proposed inundation interferes with an ISF right. When making this determination, the Board shall consider, without limitation, the extent of inundation proposed and the impact of the proposed inundation on the natural environment existing prior to the inundation.

7g. Consideration of Request to Inundate.

If the Board determines that a proposed inundation interferes with an ISF right, the Board may then approve, approve with conditions, defer, or deny the request to inundate. In making this decision, the Board shall consider all relevant factors, including, but not limited to (1) the extent of inundation proposed; (2) the impact of the proposed inundation on the natural environment existing prior to the inundation; (3) the degree to which the beds and banks adjacent to the ISF right subject to the inundation are publicly or privately owned; (4) the economic benefits arising from the inundation; (5) the benefits to recreation and downstream ISF segments arising from the inundation; (6) the degree to which the proposed inundation will allow development of Colorado's allotment of interstate waters as determined by compact or adjudication; and, (7) any mitigation or compensation offered to offset adverse impacts on the ISF right. After considering all relevant factors, the Board shall take one of the actions set forth in Rules 7h. - 7k. below.

7h. Approval.

If the Board approves the request to inundate, any Statement of Opposition filed by the Board shall be withdrawn.

7i. Conditional Approval.

The Board may require certain conditions to be performed prior to approval. Failure to perform any condition will be a reason for denial.

7j. Deferral.

When it appears that other governmental agencies may impose terms and conditions upon the issuance of a permit to construct a facility which will cause an inundation, the Board may defer consideration of the request to inundate until all other governmental bodies have finalized the permit or approval conditions.

7k. Denial of Request to Inundate.

Requests for permission to inundate may be denied if in the discretion of the Board the request is inconsistent with the goals of the ISF Program. The Board may decide to deny a request for permission to inundate if it finds:

(1) No compensation or mitigation would be adequate for the injury caused by the inundation; or

(2) No compensation or mitigation acceptable to the Board has been proposed by applicant; or

(3) The proposed inundation is inconsistent with the goals of the ISF Program.

7l. Remedies.

The Board may seek any administrative, legal or equitable remedy through state courts (including water courts), federal courts, city, county, state or federal administrative proceedings to resolve actual or proposed inundation of its ISF rights.

7m. Board Has Sole Right to Protect ISF Rights from Interference.

Only the Board may seek to prevent interference with an ISF right by inundation and only the Board may seek compensation or mitigation for such interference.

7n. Public Review Process.

The Board shall follow the public review process in Rules 11a. - 11c. prior to any Board decision on a request to inundate an ISF right.

8. PROTECTION OF ISF APPROPRIATIONS.

The Board delegates the day-to-day management and administration of the ISF Program to Staff. Staff shall seek ratification of its decisions as set forth in Rules 8c., 8e.(2), 8i., and 8j.

8a. Resume Review.

Staff shall review the monthly resumes of all water divisions. The Staff shall evaluate each resume entry for the possibility of injury or interference to an ISF right.

8b. Statement of Opposition.

In the event Staff identifies a water right application in the resume that may injure an ISF right, Staff shall file a Statement of Opposition to that application. In the event Staff identifies a water right application in the resume that may interfere with an ISF right as contemplated in Rule 7, Staff may file a Statement of Opposition to that application.

8c. Ratification of Statements of Opposition.

At a Board meeting following the filing of the Statement of Opposition, Staff shall apprise the Board of the filing of a Statement of Opposition and the factual basis for the Staff action. At that time, the Board shall ratify the filing, disapprove the filing, or table the decision to a future meeting if more information is needed prior to making a decision.

8d. Notice.

Prior to ratification of a Statement of Opposition, the Staff shall mail the applicant a copy of the Board memorandum concerning the ratification and a copy of the agenda of the meeting in which the ratification will be considered. Following a Board action considering a Statement of Opposition, the Staff shall notify the applicant and/or its attorney in writing of the Board's action.

8e. De Minimis Rule.

In the event that Staff determines a water court application would result in a 1 percent depletive effect or less on the stream reach or lake subject of the ISF right, and the stream reach or lake has not been excluded from this rule pursuant to Rules 8f. or 8h., Staff shall determine whether to file a Statement of Opposition. Staff's decision not to file a Statement of Opposition does not constitute: (1) acceptance by the Board of injury to any potentially affected ISF water right; or (2) a waiver of the Board's right to place an administrative call for any ISF water right.

(1) If Staff does not file a Statement of Opposition, Staff shall notify the Division Engineer for the relevant water division that it has not filed a Statement of Opposition, but that it may place an administrative call for the potentially affected ISF water right(s). Such a call could be enforced against the water right(s) subject of the application by the Division Engineer in his or her enforcement discretion. Staff also shall mail a letter to the applicant at the address provided on the application notifying the applicant: (a) of Staff's decision not to file a Statement of Opposition pursuant to this Rule; (b) that the CWCB may place a call for its ISF water rights to be administered within the prior appropriation system; and (c) that the Division Engineer's enforcement of the call could result in curtailment or other administration of the subject water right(s).

(2) If Staff files a Statement of Opposition, Staff shall seek Board ratification by identifying and summarizing the Statement of Opposition on the Board meeting consent agenda pursuant to Rule 8c.

8f. Cumulative Impact.

In determining existence of a de minimis impact, Staff shall consider the existence of all previous de minimis impacts on the same stream reach or lake. If the combined total of all such impacts exceeds 1 percent, then Staff will file a Statement of Opposition regardless of the individual depletive effect of an application.

8g. Notification of Staff Action.

At a Board meeting following a Staff determination to apply the De Minimis rule, the Staff shall notify the Board about the factual basis leading to its application of the De Minimis rule.

8h. Exclusion from De Minimis Rule.

The Board may at any time exclude any stream reach or lake, or any portion thereof, from application of the De Minimis rule.

8i. Pretrial Resolution.

Staff may negotiate a pretrial resolution of any injury or interference issue that is the subject of a Statement of Opposition. The Board shall review the pretrial resolution pursuant to the following procedures:

(1) No Injury.

In the event the pretrial resolution includes terms and conditions preventing injury or interference and does not involve a modification, or acceptance of injury or interference with mitigation, the Board is not required to review and ratify the pretrial resolution. Staff may authorize its counsel to sign any court documents necessary to finalize this type of pretrial resolution without Board ratification.

(2) No Injury/Modification.

In the event the pretrial resolution addresses injury or interference through modification of the existing ISF decree, the process set forth in Rule 9 shall be followed prior to any Board decision to ratify the pretrial resolution.

(3) Injury Accepted with Mitigation.

In the event a proposed pretrial resolution will allow injury to or interference with an ISF or natural lake level (NLL) water right, but mitigation offered by the applicant could enable the Board to accept the injury or interference while continuing to preserve or improve the natural environment to a reasonable degree, and if the proposed pretrial resolution does not include a modification under ISF Rule 9, the Board shall:

(a) Conduct a preliminary review of the proposed pretrial resolution during any regular or special meeting to determine whether the natural environment could be preserved or improved to a reasonable degree with the proposed injury or interference if applicant provided mitigation; and

(b) At a later regular or special meeting, take final action to ratify, refuse to ratify or ratify with additional conditions.

(c) No proposed pretrial resolution considered pursuant to this Rule 8i.(3) may receive preliminary review and final ratification at the same Board meeting.

(d) The Board shall not enter into any stipulation or agree to any decretal terms and conditions under this Rule that would result in the Division of Water Resources being unable to administer the affected ISF or NLL water right(s) in accordance with the priority system or with Colorado water law.

(e) To initiate CWCB staff review of an Injury with Mitigation proposal, the proponent must provide the following information in writing:

i. Location of injury to ISF or NLL water right(s) (stream(s) or lake(s) affected, and length of affected reach(es));

ii. Quantification of injury (amount, timing and frequency);

iii. Type of water use that would cause the injury;

iv. Analysis showing why full ISF or NLL protection is not possible;

v. Detailed description of the proposed mitigation, including all measures taken to reduce or minimize the injury;

vi. Detailed description of how the proposed mitigation will enable the Board to continue to preserve or improve the natural environment of the affected stream of lake to a reasonable degree despite the injury;

vii. Identification and feasibility analysis of: (1) all water supply alternatives considered by the proponent in the context of this proposal; (2) all alternatives evaluated by the proponent to fully protect the potentially affected ISF or NLL water right, but rejected as infeasible; and (3) all alternatives evaluated by the proponent and designed to mitigate the injury to or interference with the affected ISF or NLL water right. This information shall address the environmental and economic benefits and consequences of each alternative; and

viii. A discussion of the reasonableness of each alternative considered.

(f) After receipt and review of the required information, staff will consult with CPW and with the entity that originally recommended the affected ISF or NLL water rights(s) (if other than CPW) to determine whether additional field work is necessary and to identify any scheduling concerns. Staff will request a recommendation from CPW as to whether the proposed mitigation will enable the Board to continue to preserve or improve the natural environment of the affected stream or lake to a reasonable degree despite the injury, including a discussion of the reasonableness of the alternatives considered. CWCB staff will use best efforts to consult with affected land owners and managers regarding the proposal.

(g) Prior to bringing the proposal to the Board for preliminary consideration, staff will consult with the Division of Water Resources on whether the proposal would result in the Division of Water Resources being unable to administer the affected ISF or NLL water right(s) in accordance with the priority system or with Colorado water law.

(h) At the first meeting of the two-meeting process required by this Rule, staff will bring the proposal to the Board for preliminary consideration after completing its review of the proposal and its consultation with CPW. Staff will work with the proponent and interested parties to address any preliminary concerns prior to bringing a proposal to the Board. Preliminary consideration by the Board may result in requests for more information or for changes to the proposal. Staff will work with the proponent and interested parties to finalize the proposal and bring it back to the Board for final action at a subsequent Board meeting.

(i) The Board will consider the following factors when evaluating Injury with Mitigation proposals. Because Injury with Mitigation proposals may involve unique factual situations, the Board may consider additional factors in specific cases. Further, evaluation of each Injury with Mitigation proposal will require the exercise of professional judgment regarding the specific facts of the proposal.

i. Extent of the proposed injury:

1. Location of injury – affected stream(s) or lake and length of affected reach(es);

2. Amount, timing and frequency of shortage(s) or impacts to the affected ISF of NLL water right(s); and

3. Potential impact to the natural environment of the affected stream reach(es) or lake from the proposed injury.

ii. Benefits of the mitigation to the natural environment:

1. The nature and extent of the benefits the mitigation will provide to the existing natural environment of the affected stream or lake;

2. The scientific justification for accepting the mitigation; and

3. Whether the mitigation will enable the Board to continue to preserve or improve the natural environment of the subject stream or lake to a reasonable degree.

(j) Evaluation of proposed alternatives. The Board shall evaluate: (1) all water supply alternatives considered by the proponent in the context of this proposal; (2) all alternatives evaluated by the proponent to fully protect the potentially affected ISF or NLL water right, but rejected as infeasible; and (3) all alternatives evaluated by the proponent and designed to mitigate the injury to or interference with the affected ISF or NLL water right. In its evaluation, the Board shall consider the following factors:

i. Availability of on-site mitigation alternatives;

ii. Technical feasibility of each alternative;

iii. Environmental benefits and consequences of each alternative;

iv. Economic benefits and consequences of each alternative;

v. Reasonableness of alternatives;

vi. Administrability of proposed alternatives by the Board and the Division Engineer; and

vi. For mitigation alternatives, whether the mitigation was or will be put in place to satisfy a requirement or need unrelated to the Injury with Mitigation proposal.

(k) The Board will consider mitigation on a different reach of stream or another stream (“off-site mitigation”) as a last resort and will only consider mitigation in an area other than the affected stream reach if no reasonable alternative exists for mitigation on the affected stream reach. The Board only will consider off-site mitigation on stream(s) located in the same drainage as the affected stream. Factors that the Board may consider in looking at such a proposal include, but are not limited to, the degree and frequency of impact to the affected stream; the environmental benefits provided to the off-site stream by the mitigation; whether the proposal could, in effect, constitute a modification of the ISF water right on the affected stream; or whether the proposal could result in the Division of Water Resources being unable to administer the affected ISF water right(s) in accordance with the priority system or with Colorado water law.

(l) Stipulations and water court decrees that incorporate Injury with Mitigation shall include, but not be limited to inclusion of, the following terms and conditions:

i. A provision that the proponent will not divert water or take any other action that would reduce flows in the affected stream or levels in the affected lake below the decreed ISF or NLL amount until the agreed-upon mitigation measures are in place and fully operational;

ii. A requirement that the structural components of the mitigation be maintained permanently;

iii. A provision allowing CWCB or CPW staff access to the property on which structural components of the mitigation are located to inspect the structures at certain time intervals, and, if necessary, to perform biological stream or lake monitoring. This provision shall clearly define the reasonable nature, extent and timing of such access (i.e, advance notice, dates, times or season of access, coordination with proponent, and location and routes of access);

iv. A term providing that if the proponent ceases to provide the agreed upon mitigation (such as removing structural components or failing to maintain them to a specified level, or ceasing to implement non-structural components), that the proponent will not divert water or take any other action that would reduce flows in the affected stream or levels in the affected lake below the decreed ISF or NLL amount because the Board will no longer accept the injury based upon the mitigation no longer being in effect -- in such case, if the Board places a call for the affected ISF or NLL water right, the Board will notify the Division Engineer that this provision of the decree now is in effect and that the Board is not accepting the injury;

v. A requirement that the proponent install and pay operation and maintenance costs of (or commit to pay operation and maintenance costs if the CWCB installs) any measuring devices deemed necessary by the Division Engineer to administer the terms of the stipulation and decree implementing the Injury with Mitigation pretrial resolution; and

vi. A term providing that the water court will retain jurisdiction to enforce the terms and conditions set forth above in subsections (i) - (vi), and any other terms and conditions specific to the Injury with Mitigation pretrial resolution, as a water matter.

8j. Authorization to Proceed to Trial.

In the event that a Statement of Opposition filed by the Board is not settled prior to the last regularly scheduled Board meeting prior to the trial date, Staff shall seek Board authorization to proceed to trial. In the event that Staff is authorized to proceed to trial, the Board may adjourn to executive session to discuss settlement parameters with its counsel. Staff is authorized to settle any litigation without Board ratification if the settlement terms are consistent with instructions given by the Board to its counsel.

8k. Public Review Process.

The Board shall follow the public review process in Rules 11a. - 11c. prior to consideration of a request to ratify a pretrial resolution pursuant to Rule 8i.(3).

8l. Notice.

At any time Staff verifies that an ISF water right is not being fulfilled as a result of water use against which the ISF water right is entitled to protection, the Staff shall provide Proper Notice, including a description of what the Board is doing in response to the situation.

9. MODIFICATION OF ISF RIGHTS.

The Board may modify any existing decreed ISF right according to the procedures set forth in this Rule. “Modification” of an ISF right within the meaning of this Rule includes a decrease in the rate of flow described in the existing ISF decree, segmenting an existing ISF reach into shorter reaches with the result of decreasing the rate of flow in any portion of an ISF reach, or subtracting water from an ISF right during any particular time period or season.

9a. Need for Modification.

Modification may be requested by the Staff or by any Person who has filed a water right application on an ISF reach or who has applied for any governmental permit for facilities located in or near an ISF reach and who complies with Rules 9b. and 9c. Any request for modification, except by staff, shall be made in writing, submitted to Staff and such writing shall contain the following information:

(1) name, address and telephone number of the Person seeking modification;

(2) stream or lake subject of request;

(3) modification requested;

(4) reason for modification; and

(5) the scientific data supporting the request.

9b. Need for Water.

Any Person who requests a modification of an ISF right must, as a precondition to the Board's consideration of the request, establish a need for the water made available by the modification. Staff does not have to comply with this rule and any governmental entity seeking to implement the terms of an agreement specified in Rule 9f. does not have to comply with this section.

9c. Grounds for Modification.

No request for modification may be considered until the applicant establishes that one of the following reasons for modification exists:

(1) Mistake.

An ISF right may be considered for modification if the requesting Person establishes that an error was made in the calculations upon which the original or supplemental appropriation or enlargement to an original appropriation was made.

(2) Excessive Flow.

An ISF right may be considered for modification if the requesting Person establishes that the ISF flow rate is in excess of the amount of water necessary to accomplish the purpose of the original, supplemental or enlarged ISF right when that right was appropriated.

9d. Recovery Implementation or Other Intergovernmental Agreement.

An ISF right may be modified if such modification was agreed upon by the Board as part of the Recovery Implementation Program for the Endangered Fishes of the Colorado River Basin or any other agreement between the Board and another governmental entity. Modifications made as a part of the Recovery Implementation Program for the Endangered Fishes of the Colorado River Basin need not be subject to the public review process in Rule 9e. Criteria for modifications made in the ISF rights decreed as part of the Recovery Implementation Program for the Endangered Fishes of the Colorado River Basin will be established in the decrees governing such appropriations.

9e. Public Review Process of Requests for Modification.

The Board shall adhere to the following public review process when considering requests for modification:

(1) Notice.

Notice of the proposed modification and the date of the public meeting at which it will first be considered shall be printed in the resume in the Water Court having jurisdiction over the decree that is the subject of the modification. The first public meeting of the Board at which the modification is to be considered shall occur at least sixty days after the month in which the resume is published. Notice shall also be published in a newspaper of statewide distribution within thirty to forty-five days prior to such first public meeting.

(2) Public Meeting.

If the Board decides at such first public meeting to give further consideration to the proposed modification, the Board shall announce publicly the date of a subsequent public meeting for such purpose. If the Board decides that it will not give further consideration to the proposed modification, it shall state, in writing, the basis for its decision.

(3) Request for Delay.

On the written request of any Person made within thirty days after the date of the first public meeting, the Board shall delay the subsequent public meeting for up to one year to allow such Person the opportunity for the collection of scientific data material to the proposed modification. The Board need not grant the request if it determines that the request is made solely to delay the proceedings.

(4) Procedures.

On the written request of any Person made within thirty days after the date of the first public meeting, the Board shall, within sixty days after such request, establish fair and formal procedures for the subsequent public meeting, including the opportunity for reasonable disclosure, discovery, subpoenas, direct examination, and cross examination. Subject to these rights and requirements, where a meeting will be expedited and the interests of the participants will not be substantially prejudiced thereby, the Board may choose to receive all or part of the evidence in written form.

(5) Final Determination.

The Board shall issue a final written determination regarding the modification that shall state its effective date, be mailed promptly to the Persons who appeared by written or oral comment at the Board's proceeding, and be filed promptly with the water court.

10. ENFORCEMENT AGREEMENTS.

The Board may attach conditions to an appropriation, decreased appropriation, or acquisition, and may enter into any enforcement agreements that it determines will preserve or improve the natural environment to a reasonable degree. The Board may enter into enforcement agreements that limit the Board's discretion in the protection, approval of inundation, modification or disposal of ISF right, and/or may delegate limited authority to act on the Board's behalf.

10a. Ratification of Enforcement Agreements.

No enforcement agreement shall be effective to limit the discretion of the Board until that agreement and all of its terms are reviewed and ratified by the Board. Upon ratification, the Director may execute the agreement and the agreement shall be binding upon the Board for the term set forth in the enforcement agreement.

10b. Public Review Process.

The Board shall follow the public review process set forth in Rules 11a. - 11c. prior to any Board decision to ratify an Enforcement Agreement.

11. PUBLIC REVIEW PROCESS.

Except as otherwise provided in the ISF Rules, the Board shall follow the public review process set forth below prior to any Board decision requiring public review.

11a. Public Notice.

Public notice of all Board actions under these Rules shall be provided through the agenda of each regular or special Board meeting.

11b. Public Comment.

Except as otherwise provided in Rules 5k. and 6m., at a regular or special meeting, the Board shall consider public comment on the recommended ISF action prior to the Board action on the recommendation in any or all of the following manners:

(1) Oral and/or written comments may be directed to Staff. When such comments are made, Staff may summarize these comments to the Board.

(2) Oral and/or written comments, subject to reasonable limitations established by the Board, may be made directly to the Board during the public meeting.

11c. Public Agency Recommendations.

Prior to taking an ISF action pursuant to Rules 5 or 6, the Board shall request recommendations from Colorado Parks and Wildlife. The Board shall also request recommendations from the United States Department of Agriculture and the United States Department of Interior. The Board may also request comments from other interested Persons or agencies as it deems appropriate.

Prior to taking an ISF action pursuant to Rules 7, 8, 9, or 10, the Board may request recommendations from Colorado Parks and Wildlife, the Division of Water Resources, the United States Department of Agriculture, the United States Department of Interior or other Persons as it deems appropriate.

11d. Board Procedures.

At a regular or special Board meeting, the Board may, as necessary, adopt or amend procedures to supplement these rules.

12. SEVERABILITY.

In the event that any section or subsection of these Rules are judged to be invalid by a court of law or are allowed to expire by the General Assembly, the remaining Rules shall remain in full force and effect.

Editor's Notes

History

Entire rule eff. 03/02/2009.

Rules 4c, 6f.(2), 6k, 6m, 7d, 8i(3), 11c eff. 03/17/2021.

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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Jared Polis, Governor
Dan Gibbs, DNR Executive Director
Lauren Ris, CWCB Director

TO: Colorado Water Conservation Board Members

FROM: Rob Viehl, Chief
Kaylea White, Senior Water Resource Specialist
Stream and Lake Protection Section

DATE: May 21-22, 2025

SUBJECT: 10.d Proposed Acquisition of an Interest in the Shoshone Water Rights for Instream Flow Use on the Colorado River

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I. Staff Recommendation

Pursuant to instream flow Rule 6b, the Board's consideration of this proposal at this meeting will initiate the 120-day period for Board review. **No formal action is required at this time**. Staff believe that this proposal for instream flow use is a valuable additional beneficial use of the historical Shoshone Power Plant water rights to preserve and improve the natural environment by restoring flows in the depleted reach of stream and improving river connectivity and habitat. This initial presentation of this proposal provides an opportunity for the Board and the public to identify questions or concerns that Staff and project partners can address at this or a subsequent meeting. Ultimately, the Board will be required to evaluate the appropriateness of the acquisition and, if accepted, to determine how best to utilize the acquired water to preserve and improve the natural environment, which will be subject to any terms and conditions imposed by the final change of water right decree.

II. Background

The proposed acquisition represents a rare opportunity for an important public-private partnership regarding operation of a large water right that has been, and will continue to be, important to most of the major water providers and water users in both the west slope and east slope of Colorado. This opportunity has come to CWCB after several decades of discussions and considerations of various options (both temporary and permanent) for managing the situation if the Shoshone Power Plant ceases to generate hydropower, and thus ceases use of the water rights. The Shoshone Water Rights, although physically impacting a relatively short reach of stream, because of its magnitude and location of operation can have an effect on a large part of the entire state of Colorado. Because of the magnitude of potential impacts, project partners are dedicated to maintaining river operations upon which water users statewide have historically relied and planned. Project partners will continue to

coordinate with the many other statewide water users during the water court process to ensure non-injury to other water rights, as is required by Colorado water law.

(1) Key Drivers of Colorado River Administration

A number of features drive the complex administration of the Colorado River within the state of Colorado**.** Multiple transmountain water diversions (TMDs) divert an average of nearly 500,000 acre-feet from the Colorado River and its tributaries on the "west slope" for front-range uses on the "east slope". The large **upstream** TMDs include: Adams Tunnel (Colorado-Big Thompson and Windy Gap projects managed by USBR and Northern Water); Robert's Tunnel (Denver Water); Moffat Tunnel (Denver Water); and Homestake Tunnel (Aurora and Colorado Springs). The large **downstream** TMDs include: Boustead Tunnel (Fry-Ark Project managed by SEWCD, CPW, and USFS); and Twin Lakes Tunnel (Twin Lakes Canal Company). In addition to the large TMDs, several large reservoirs are used to store water for east slope use, to replace east slope uses on the west slope, or as compensatory water for west slope use. The large **upstream** reservoirs include: the four reservoirs of the Colorado Big Thompson project (Lake Granby, Shadow Mountain Reservoir, Grand Lake, and Willow Creek Reservoir); Windy Gap Reservoir; Dillon Reservoir; Green Mountain Reservoir; Williams Fork Reservoir; Wolford Mountain Reservoir; and Homestake Reservoir. The main **downstream** reservoir is: Ruedi Reservoir. See the maps at **Enclosure A**. The large and dominant calling water rights are the Shoshone Water Rights (described below in **Section II (2))**, and the Cameo water rights demand for Grand Valley irrigators.

(2) State-based Planning and Management Efforts

State-funded planning efforts and processes have identified permanent protection of the Shoshone water rights as critical to the Colorado River. The Colorado Basin Roundtable's Basin Implementation Plan[1] states that, "Protecting the Shoshone Hydroelectric Plant [water rights], Grand Valley irrigators' water rights (Cameo Call), and the 15-Mile Reach are vital to both consumptive and nonconsumptive needs." It encourages all entities to "work together to ensure the Shoshone Hydroelectric Plant water rights are maintained in perpetuity to ensure downstream water deliveries are made." The Upper Colorado Wild and Scenic Alternative Management Plan[2] (W&S Plan) is a state-supported effort to develop an alternative to a Wild and Scenic designation to protect the Outstandingly Remarkable Values (ORVs) in the Colorado River from the confluence with the Blue River downstream to a location near No Name Creek, just downstream of Shoshone. This stakeholder-led plan, formally federally adopted in 2015, identifies the Shoshone and Cameo Water Rights as long-term protective measures that are "expected to provide significant protection of the ORVs." ORVs include

[1] Colorado Basin Implementation Plan, Volume 1, January 2022, https://dnrweblink.state.co.us/cwcbsearch/0/edoc/216707/Colorado_BIP_Volume1_2022.pdf

[2] Amended and Restated Upper Colorado River Wild and Scenic Stakeholder Group Management Plan, Adopted January 2012, Amended and Restated June 2020 Last revised July 2024 https://www.upcowildandscenic.com/uploads/1/3/5/3/135388668/amended_and_restated_sg_plan_july_2024.pdf

scenic, recreational fishing, recreational float-boating, geological, wildlife, historical, and paleontological values. According to the W&S Plan, the administrative call from these water rights "generally results in stream flow through the subject stream segments in amounts greater than would exist in the absence of the administrative call." Lastly, the Middle Colorado River Integrated Water Management Plan[3] (2021), which evaluated the Colorado River from Glenwood Canyon to De Beque Canyon, identified securing the permanent acquisition of the Shoshone Water Rights with the addition of an instream flow use as an important action that can benefit irrigation, municipal, recreational, and environmental interests.

III. The Proposal

The Colorado River Water Conservation District ("River District") and Public Service Company of Colorado ("PSCo") have offered to the Colorado Water Conservation Board ("CWCB") an interest in the Shoshone Water Rights for instream flow ("ISF") purposes on the mainstem of the Colorado River in Glenwood Canyon. See the maps at **Enclosure A,** the offer letter at **Enclosure B**. The Shoshone Water Rights are decreed for non-consumptive hydropower generation use at the Shoshone Hydroelectric Power Plant, currently owned by PSCo, a subsidiary of Xcel Energy. Through a December 2023 Purchase and Sale Agreement ("PSA), the River District agreed to purchase, and PSCo agreed to sell, the Shoshone Water Rights, so long as the water rights will be used for instream flow purposes to the extent they are not being used for power generation, contingent on a number of conditions including a PSCo lease for continued hydroelectric power generation while the power plant remains operable.

Under this proposal, the River District would purchase and maintain ownership of the water rights, while CWCB would hold perpetual ISF use rights, and PSCo would hold a lease for hydropower use. See draft ISF Agreement as **Enclosure C**. The Shoshone Water Rights offered to CWCB total 1,408 cfs, comprised of the Senior Shoshone Water Right in the amount of 1,250 cfs, and the Junior Shoshone Water Right in the amount of 158 cfs, (together, the "Shoshone Water Rights"), as further described below in **Section VI**. The CWCB would use these water rights, pursuant to their individual priorities, in the combined amount of up to 1,408 cfs, as recommended by Colorado Parks and Wildlife (see CPW recommendation as **Enclosure D**), to preserve and improve the natural environment to a reasonable degree in a 2.4 mile reach of the Colorado River between the Shoshone Power Diversion Dam and Tunnel and the Shoshone Power Plant Discharge Outlets ("Shoshone Reach"), as shown on the maps at **Enclosure A**.

To effectuate the proposal, a joint water court application will be required, in which CWCB, PSCo, and the River District will be co-applicants. In the water court application, the co-applicants will request a change of the beneficial use of the water rights to add instream flow use by the CWCB when the rights are not being used, or only partially being used, to generate hydropower. See draft water court application, as **Enclosure E.** The River District's proposed

[3] Middle Colorado River Integrated Water Management Plan, 2021
https://www.midcowatershed.org/iwmp

dedication of the exclusive right to use the Shoshone Water Rights for instream flow purposes to the CWCB is in accordance with section 37-92-102(3), C.R.S., and the Rules Concerning the Colorado Instream Flow and Natural Lake Level Program, 2 CCR 408-2 ("ISF Rules").

IV. The Board's ISF Acquisition Procedures

ISF Rule 6 governs the Board's procedures to acquire water for ISF use. ISF Rule 6b gives the Board 120 days from the Board's first consideration of the proposed acquisition to determine what terms and conditions it will accept in an acquisition agreement for an interest in water to preserve and improve the natural environment. ISF Rule 6 requires a minimum of two Board meetings to allow for public input prior to taking final action on a proposed acquisition. The Board's initial consideration of this proposal at its May 2025 meeting initiates the 120-day time period for the Board to consider the proposed acquisition. ISF Rule 6e requires the Board to evaluate the appropriateness of the acquisition and, if accepted, to determine how best to utilize the acquired water to preserve or improve the natural environment. ISF Rule 6e lists several factors the Board shall consider in its evaluation of the acquisition, which are addressed in **Section VIII** of this memo.

The Board can take final action on the proposal at the following Board meeting in July 2025. However, ISF Rule 6m(4) provides that any person may request the Board to hold a hearing on the proposed acquisition, so long as such request is filed within 20 days after the first consideration, which is this May 2025 Board meeting. In the event a hearing is requested, the Board will need to take action to consider the request, and if granted, to appoint a Hearing Officer and schedule a hearing to occur within 120 days of this first consideration. Such hearing and final decision on the proposal could occur at the Board meeting in September 2025.

The Board can accept several types of ISF acquisitions for water, water rights, or interests in water, for various durations including temporary, long-term, and permanent acquisitions. Two different statutes govern the required processes after CWCB approval: (a) permanent acquisitions fall under 37-92-102(3) C.R.S., which operate under the jurisdiction of the Water Court; and (b) temporary loan acquisitions fall under 37-83-105 C.R.S., which operate under the jurisdiction of the Division of Water Resources. This proposal is for a permanent acquisition of an interest in water under 37-92-102(3) that requires judicial action by the water court to allow a new beneficial use under Colorado water rights law. The Board can accept the interest in the water right, but the water right must be changed in water court to allow the additional ISF use under a final decree before the ISF use can occur. Acceptance of the full decreed amount by the CWCB Board is essential so that the full decreed water right may be changed in water court; however, the future use of the Shoshone Water Right shall be subject to any terms and conditions imposed by the change of water right final water court decree. See generally 37-92-305(3) C.R.S. (regarding changes of water rights by the water courts). The water court process is required, as a standard procedure under the Water Rights and Determination Act of 1969, 37-92-101 C.R.S. ("the 1969 Act"), and so long as proper

notice is given, the water court shall have jurisdiction over all parties affected thereby, whether or not they chose to appear.

As required by statutes and regulations, CWCB staff has provided proper notice and requests for recommendations regarding this proposal. CWCB staff has requested recommendations from the Colorado Division of Parks and Wildlife (CPW), the U.S. Department of Agriculture, and the U.S. Department of Interior. Pursuant to ISF Rule 6m(1), CWCB staff has provided notice of the proposed acquisition to all persons on the appropriate ISF Subscription Mailing Lists and provided notice to the State Engineer's Substitute Supply Plan Notification List for Water Division 5.

V. The Board Actions to Date

In response to the River District's September 2023 application to the CWCB for a Non-Reimbursable Investment Project seeking funding toward the purchase of the water rights associated with the Shoshone Power Plant, on January 25, 2024, the CWCB held a virtual workshop. At the workshop, presentations and discussions on the Shoshone Water Right Permanency Project included reviews of agreements and the ISF acquisition process with a general timeline. Board action followed during the January 29, 2024 CWCB Board meeting, in which the CWCB Board unanimously approved the request to partially fund the River District's purchase of the Shoshone Hydro Plant water rights. The 2024 Project's Bill (HB 24-1435) Section 14(2), states:

> (2) (a) For the 2024-25 state fiscal year, $20,000,000 is appropriated to the department of natural resources for use by the Colorado water conservation board. This appropriation is from the Colorado water conservation board construction fund created in section 37-60-121, C.R.S. To implement this subsection (2)(a), the Colorado water conservation board may use this appropriation to partner with the Colorado river water conservation district in the purchase of the water rights owned by the public service company of Colorado and currently used for the operation of the Shoshone power plant. The Colorado water conservation board shall vote to release the money to the Colorado river water conservation district after confirming that the closing conditions of the purchase and sale agreement between the Colorado river water conservation district and the public service company of Colorado have been met.
>
> (b) The money appropriated in subsection (2)(a) of this section remains available for the designated purposes until June 30, 2031.

VI. The Shoshone Water Rights

The Shoshone Water Rights are currently used as decreed, for power generation by PSCo at the hydroelectric power plant (the "Shoshone Power Plant") located on the mainstem of the Colorado River in Glenwood Canyon, approximately six miles upstream of the City of

Glenwood Springs. The Shoshone Power Plant produces hydroelectric energy by means of PSCo's diversion of the Shoshone Water Rights (consisting of the 1905 senior priority water right in the amount of 1,250 cfs, and a 1940 junior priority water right in the amount of 158 cfs), further described as follows:

(i) The Glenwood Power Canal and Pipeline water right, decreed on December 9, 1907, in Civil Action No. 466, Eagle County District Court, in the amount of 1,250 cfs with an appropriation date of January 7, 1902, for power, mining, milling, manufacturing, lighting, heating, and traction purposes; and as decreed absolute by the Eagle County District Court on February 27, 1911, in Civil Action No. 553 (the "Senior Shoshone Water Right"); and

(ii) The Shoshone Hydro Plant Diversion No. 2 water right, decreed absolute on February 7, 1956, in Civil Action No. 1123, Eagle County District Court, in the amount of 158 cfs, with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy (the "Junior Shoshone Water Right").

See Shoshone decrees as **Attachment 2 to Enclosure F.** The water diverted by PSCo for hydropower generation use is returned to the Colorado River after such water is conveyed through the Shoshone Power Plant's penstocks and turbines to the river at the plant's discharge outlets, approximately 2.4 miles downstream of the point of diversion at the Shoshone Diversion Dam and Tunnel, as depicted on the maps attached as **Enclosure A**.

Administration and measurement of the Shoshone Water Rights has historically occurred using the streamflow gauge (USGS 09070500) located on the Colorado River near Dotsero, Colorado ("Dotsero Gage"). Consistent with historical administration, the "Natural Flow" is the amount of water in the Colorado River measured at the Dotsero Gage, including the amount of water usable under by the Shoshone Water Rights when those water rights are in priority, except that the Natural Flow does not include any water released from storage and conducted into the Colorado River upstream of the Dotsero Gage (accounting for evaporation and transit loss), which water is intended for delivery for use downstream of the discharge outlets for the Shoshone Power Plant.

VII. Summary of Proposed ISF Use

Under this proposal, CWCB would enter into a Water Right Dedication and ISF Agreement ("ISF Agreement") with the River District and PSCo, which dedicates to CWCB a perpetual ISF use of the Shoshone Water Rights. See draft ISF Agreement as **Enclosure C**. Pursuant to the PSA between the River District and PSCo, with an effective date of January 1, 2024, the River District is the contract purchaser of the Shoshone Water Rights. The PSA provides that PSCo, and its successors and assigns, is entitled to a leasehold interest in the Shoshone Water Rights for continued use of the Shoshone Water Rights for hydropower generation at the Shoshone Power Plant. See the "Lease," the form of which is attached to the PSA at **Attachment 3 to Enclosure F**.

CWCB would apply its acquired exclusive right for ISF use in the Shoshone Reach through approximately 2.4 miles on the Colorado River. The ISF use serves to preserve and improve the natural environment to a reasonable degree using the acquired interest in the Shoshone Water Rights for a combined rate of ***up to*** 1,408 cfs (under the 1902 senior right of 1250 cfs, and the 1929 junior right of 158 cfs), as further described above in **Section VI**. The water rights would retain their original individual priority dates with respect to water rights administration. Downstream of the Shoshone Reach, the return flows from use of the Shoshone Water Rights become part of the natural stream flow in the Colorado River and are available for appropriation and use by water rights holders. The CWCB would accept the proposed interest in the full decreed amount of the Shoshone Water Rights, which ISF use will then be subsequently limited by any terms and conditions imposed by the change of water right final water court decree, as required to prevent injury to other water users, both upstream and downstream of the Shoshone Reach. CPW analysis indicates that the best use of the acquired water rights is to preserve and improve the natural environment in the Shoshone Reach of the Colorado River at any rate up to full decreed amount of 1,408 cfs, and that fish habitat will also be improved in the Shoshone Reach at streamflows up to at least 3,000 cfs. See CPW's recommendation letter and report as **Enclosure D**. CPW evaluated the higher flow rates partly because, at times, there has been, and will continue to be, other water in the stream, including shepherded reservoir releases flowing through this stream reach for delivery to downstream uses. These higher flow rates consist of Natural Flow available to the Shoshone Water Rights combined with the shepherded water.

Because this acquisition is for non-consumptive water rights, and has no associated historical consumptive use, the provisions of sections 37-92-102(3) and 305(3)(b), C.R.S. (requiring that all contracts or agreements for interests in water, and the water court decree implementing the contracts or agreements, to state that the board or the lessor, lender, or donor may bring about beneficial use of the historical consumptive use of the leased, loaned, or donated water right downstream of the instream flow reach as fully consumable water) are not relevant and do not apply to this acquisition.

The Shoshone Water Rights influence flow in the Colorado River and its tributaries both upstream and downstream of the Shoshone Reach. Administration and use of the Shoshone Water Rights for ISF use in the Shoshone Reach is intended to replicate the historical administration and use of the Shoshone Water Rights. Administration and use of the water rights for ISF purposes in the Shoshone Reach will allow for the continuance of administrative practices and water availability scenarios upon which water users have relied, and for the continuance of water supply plans for many entities both upstream and downstream of the Shoshone Reach. **Upstream,** this will help maintain the historical stream flow conditions in the Colorado River mainstem and its tributaries upon which upstream water users have relied, including conditions for CWCB's many upstream ISF water rights. **Downstream**, because administration and use of the Shoshone Water Rights for ISF use in the Shoshone Reach should not change, this use will maintain required historical return flows in the Colorado River mainstem upon which downstream water users have relied, including downstream ISF water rights. Maintaining such downstream return flow conditions is a standard requirement in

water court for water rights change cases. Factors the Board is required to consider are discussed below in **Section VIII**.

VIII. Factors Required for CWCB to Consider

Pursuant to ISF Rule 6e, the Board shall evaluate the appropriateness of any acquisition of water, water rights, or interests in water to preserve or improve the natural environment. Such evaluation shall include, but need not be limited to consideration of the following factors, as discussed under each of the enumerated factors:

> ***(1) The reach of stream or lake level for which the use of the acquired water is proposed, which may be based upon any one or a combination of the following: the historical location of return flow; the length of the existing instream flow reach, where applicable; whether an existing instream flow water right relies on return flows from the water right proposed for acquisition; the environment to be preserved or improved by the proposed acquisition; or such other factors the Board may identify;***

The proposed reach for ISF use of the Shoshone Water Rights, the Shoshone Reach, is an approximately 2.4-mile reach of the Colorado River in Glenwood Canyon between the Shoshone Power Diversion Dam and Tunnel ("Upstream Terminus"), and the Shoshone Power Plant Discharge Outlets ("Downstream Terminus"). See maps in **Enclosure A**. The Shoshone Reach is defined by the Shoshone Water Rights decrees and historical operations. The Shoshone Power Plant takes water from the Colorado River via the Shoshone Diversion Dam and Tunnel, which is located upstream of the Shoshone Power Plant. This historical use of the Shoshone Water Rights for power generation depletes the Shoshone Reach by the full diversion amount during plant operation. Once water is diverted from the river at the Shoshone Diversion Dam, it is conveyed through a tunnel in the canyon walls, before dropping through two turbines and returning to the Colorado River via discharge outlets located just beneath the Shoshone Power Plant, which is the historical location of return flows. There is not an existing ISF water right in this reach, and no existing ISF relies on the return flows except to the extent that return flows may flow, if not consumed, to the 15-Mile Reach ISF water rights decreed in Case Nos. 92CW286 and 94CW330. The natural environment to be preserved and improved is within this 2.4-mile reach of the Colorado River in Glenwood Canyon, as further discussed in **Section VIII (5)** below.

Upstream of the Shoshone Reach, the CWCB holds over 300 decreed ISF water rights that protect nearly 1,500 miles of streams and rivers. See maps in **Enclosure A.** These ISFs, held on behalf of the people of Colorado, preserve headwater streams tributary to the mainstems, as well as mainstem reaches of the Colorado, Blue, and Eagle Rivers. These ISF water rights protect values that range from conserving native Colorado Cutthroat Trout to recreationally important Gold Medal sport fisheries throughout the upper basin. The ISFs above the Shoshone Reach were appropriated based on the stream conditions that existed at the time of the appropriation. When calling, the Shoshone Water Rights have historically curtailed junior diverting water rights on the tributaries, effectively bringing streamflow through these

upstream ISF reaches, particularly during low-flow conditions when calls are necessarily placed. For example, in 2023, Fraser River streamflow dropped significantly, and upon investigation, it was found that when the Shoshone call was abruptly turned off, diverters were able to take an additional 9-10 cfs from two different tributaries to the Fraser River. DWR could not curtail the water rights without a senior call in effect. This dried up Vasquez Creek and reduced streamflow below the decreed ISF rates on the Fraser River. This is just one example to demonstrate that without maintenance of the historical flow regime, there is potential for stream conditions to change significantly in the upper portion of the basin, both on the mainstem and on the tributaries, resulting in less streamflow for existing ISF water rights.

Downstream from the Shoshone Reach, the CWCB holds numerous decreed ISF water rights in the headwater streams tributary to the mainstems, as well as in mainstem reaches of the Roaring Fork, Crystal, and Colorado Rivers that are indirectly impacted by operations of the Shoshone Water Rights. See maps in **Enclosure A.** Potential impacts to these downstream ISF water rights by Shoshone operations are complex and depend on operations of both large and small individual water rights, which is difficult to parse, demonstrating the degree of entanglement of ISF water rights with other operations over several different river basins.

(2) The natural flow regime;

The headwaters of the Colorado River originate in the State of Colorado in Rocky Mountain National Park along the continental divide at about ~14,300 feet in elevation. The Colorado River flows for about 166 miles through Grand Lake, Kremmling, and Glenwood Canyon before reaching the Shoshone Powerplant Diversion Dam. Flows in the Shoshone Reach are the result of a natural snowmelt runoff flow regime, together with significant flow alteration due to water uses throughout the 4,470 square mile basin.

Streamflow in the Colorado River is highly variable year to year and seasonally due to natural differences in snowpack, rain events, and baseflow processes. There are also many sources of flow alteration in the upstream basin including multiple TMDs, large reservoirs, smaller reservoirs, in-basin diversions, and other releases to the 15-Mile Reach. These different water uses have a variety of effects from reducing the total flow volume to changing the magnitude or timing of water reaching the Shoshone Reach.

The USGS measures streamflow at the Colorado River Dotsero Gage, USGS 09070500), approximately 8.5 miles upstream from the Shoshone Reach. The Dotsero Gage, which includes effects from upstream water uses, indicates that for the full gage period of record from 1940 to 2024, monthly mean flows are between 4,600 and 6,100 cfs during runoff and between 850 cfs and 1,200 cfs during winter months. Peak streamflow during snowmelt runoff can be as low as 2,000 cfs in drought years such as 2002 and over 22,000 cfs in extreme runoff years like in 1984.

(3) Any potential material injury to existing decreed water rights;

Within the Shoshone Reach, there are no other water rights or diversions. However, a number of augmentation plans and exchanges extend through this reach. By maintaining the non-consumptive nature of the water rights, along with continuing operation of the water rights in their historical manner, the exchanges and augmentation plans should be unaffected by the new ISF use. This proposed acquisition is intended to maintain historical use and replicate historical return flows.

There are many existing decreed junior and senior water rights located both upstream and downstream of the Shoshone Water Rights and the associated Shoshone Reach. Many junior upstream users can continue to divert during a Shoshone call because they operate under either individual augmentation plans or are covered by the Green Mountain Reservoir historic user pool releases ("HUP"). Downstream users rely on the return flows from the Shoshone operation. Because the historical operation is to be maintained with the proposed ISF use, both the upstream and downstream water rights will be protected against injury. The upstream water rights should experience the same operation of their water rights, which will continue to rely on the existing augmentation plans and HUP protections. The downstream users can continue to rely on maintenance of historical return flows from this new non-consumptive ISF use. The details of the historical use that is to be replicated will appropriately be analyzed during the required water court process, is designed to investigate such details. Use of the Shoshone Water Rights for ISF and hydropower purposes shall be subject to any terms and conditions imposed by the change of water right decree to be entered by the water court.

(4) The historical consumptive use and historical return flows of the water right proposed for acquisition that may be available for instream flow use;

The Shoshone Water Rights have been used throughout most of the 20th century and are still in operation today. This long period of hydropower plant operation provides a robust historical use period that will result in acquired water rights that can be used for ISF beneficial use upon completion of a change case. The exact amount and timing of water that can be put to ISF use will be determined during the water court change case. It is the intent of the proposed acquisition to replicate the historical use and historical return flows while applying this non-consumptive water right to ISF use within the historically depleted stream reach. Because the historical use is for non-consumptive power generation, the measure of the water right is its historical use, rather than a historical consumptive use. Pursuant to any restrictive terms and conditions in the final water court decree, so long as the return flows are maintained to the stream downstream of the Shoshone Reach, the full historical diversion amount will become available for ISF use within the Shoshone Reach, to the extent the water rights are not being used to generate hydropower. As with any change of water rights, determining the historical use amount can be a complicated, time-consuming, and potentially controversial endeavor. During the water court process, parties to the change case will present and discuss their engineering analyses and legal positions regarding the historical use

of the Shoshone Water Rights using various types of measures, models, and operations regarding historical stream flow, diversions, administration, reservoir releases, water rights analysis, and power generation. Several numerical and conceptual models will likely be discussed as part of the water court process, which will rely on water rights experts and will be a multi-year process to develop decree terms and conditions regarding the amount of water that will be available for ISF use under the Shoshone Water Rights. Interested parties to date have expressed support for this proposal in general but have expressed hesitation on the historical use analysis and resulting amount of water that will be available for ISF use. Details regarding limits on timing and amounts will be evaluated during the water court process and will be imposed by the final water court decree.

(5) The natural environment that may be preserved or improved by the proposed acquisition, and whether the natural environment will be preserved or improved to a reasonable degree by the water available from the proposed acquisition;

The Shoshone Reach of the Colorado River runs through the central portion of Glenwood Canyon, a confined canyon where the river over time carved a deep gorge that runs nearly 15 miles between 2,500 feet high walls of sedimentary rock. The canyon is a heavily trafficked corridor, the river and its floodplain are confined by Interstate 70, a streamside recreational path, and railroad. The Shoshone Reach of the Colorado River in Glenwood Canyon supports a high-quality fishery, even in its dewatered state with limited available habitat. The legal diversion by the Shoshone Water Rights of the entirety of the Colorado River when flows are less than 1,408 cfs leaves the Shoshone Reach in a dewatered state. Under seasonally low flows with diminished conditions, aquatic habitat persists, specifically in deep pools and glides isolated by steep boulder drops or shallow riffles. Despite the anthropogenic alteration of the Colorado River through Glenwood Canyon, the Shoshone Reach continues to support a variety of native and sport fisheries and some limited riparian areas. Wildlife commonly encountered include bighorn sheep, river otters, beaver, Mule Deer, elk, Peregrine Falcons, and eagles. Riparian and upland plant communities generally consist of cottonwood and alder in the riparian areas, and oak, pine, spruce, fir, and aspen trees in the uplands. The unique canyon geology includes caves, springs, and geothermal outputs. Consistent base flows and periodic high flows would provide major benefits in the Shoshone Reach that include maintenance of food webs and sediment dynamics, dampening of temperature extremes, and increased aquatic habitat. See GEI's report as **Enclosure G**.

Given the demonstrated biological benefits within the Shoshone Reach, to the Colorado River headwaters and tributaries, and to the mainstem Colorado River below the power plant, CPW staff believe this is an appropriate acquisition and recommends the CWCB accept the interest in the acquired water. CPW's analysis indicates that the best use of the acquired water rights is to preserve and improve the natural environment in the Shoshone Reach of the Colorado River at any rate up to the full decreed amount of 1,408 cfs, and that fish habitat will also be improved in the Shoshone Reach at streamflows up to at least 3,000 cfs. See CPW's recommendation letter and report as **Enclosure D**. CPW evaluated the higher flow rates because, at times, there has been, and will continue to be, other water in the stream,

including shepherded reservoir releases flowing through this stream reach for delivery to downstream uses. These higher flow rates consist of Natural Flow available to the Shoshone Water Rights combined with the shepherded water.

(6) The location of other water rights on the subject stream(s);

Within the Shoshone Reach, there are no other water rights or diversions. However, a number of augmentation plans, exchanges, and water deliveries extend through the Shoshone Reach. There are many decreed junior and senior water rights located both upstream and downstream of the Shoshone Reach. See **Section II (1)** above, for a list of the main structures. See the discussion regarding protection from injury above, in **Section VIII (3)**.

(7) The effect of the proposed acquisition on any relevant interstate compact issue, including whether the acquisition would assist in meeting or result in the delivery of more water than required under compact obligations;

CWCB will ensure that the change of the Shoshone Water Rights to allow ISF uses will not expand the historical use of the water right and will not reduce the return flows that were maintained by the historical diversions. Use of the Shoshone Water Rights for ISF and hydropower purposes shall be subject to terms and conditions imposed by the change of water right decree to be entered by the water court, which will restrict the future use. Downstream of the Shoshone Reach, the return flows from use of the Shoshone Water Rights will become part of the natural stream flow in the Colorado River and will be available for other uses as it was historically. CWCB will ensure that this acquisition will not have an effect on interstate compact issues.

(8) The effect of the proposed acquisition on the maximum utilization of the waters of the state;

The beneficial use of the Shoshone Water Right under this acquisition will be for non-consumptive ISF use in the Shoshone Reach. Because the water right is non-consumptive, any other use of this water right must also be non-consumptive, which includes very few types of other water uses. CWCB will ensure that changing these water rights to include ISF use will allow the same level of utilization of the non-consumptive Shoshone Water Rights, which will not alter water available for other uses. Therefore, CWCB will ensure that use of the Shoshone Water Rights for instream flow to preserve and improve the Colorado River in the Shoshone Reach will continue to allow maximum utilization of the waters of the State of Colorado. At the lower terminus of the Shoshone Reach, the historical return flow will be maintained and will become part of the natural stream flow available for downstream water uses, both consumptive and nonconsumptive. There are several large diversions downstream of the Shoshone Reach which rely on the historical return flows. Furthermore, for any return flows that remain in the river, that are not diverted and consumed between Shoshone and the 15-Mile Reach, have been used, and may continue to be used, by the ISF water right held by CWCB in 15-Mile Reach as another non-consumptive use. Consequently, by not expanding the

historical use, and by continuing the utilization of the Shoshone Water Rights, CWCB will ensure that this acquisition will not have a negative effect on the maximum utilization of the waters of the state.

(9) Whether the water acquired will be available for subsequent use or reuse downstream;

The River District and PSCo will not claim any right of use of the Shoshone Water Rights downstream of the Shoshone Reach in the change case filed for this acquisition. CWCB will not claim any such right, but rather any right of use in the Shoshone Water Rights ends at the Lower Terminus of the Shoshone Reach. Downstream of the Shoshone Reach, the return flows from use of the Shoshone Water Rights will become part of the natural stream flow in the Colorado River and will be available for appropriation and use by water rights holders.

Because this acquisition is for non-consumptive water rights, for which the return flow from use of these water rights will become part of the natural stream flow downstream of the Shoshone Reach, the provisions of §§37-92-102(3) and 305(3)(b), C.R.S. (requiring that all contracts or agreements for interests in water, and the water court decree implementing the contracts or agreements, to state the board or the lessor, lender, or donor may bring about beneficial use of the historical consumptive use of the leased, loaned, or donated water right downstream of the instream flow reach as fully consumable water) are not relevant and do not apply to this acquisition.

(10) The cost to complete the transaction or any other associated costs;

The River District has applied for a non-reimbursable grant in the amount of $20 million from CWCB, which CWCB has approved to help pay for a portion of their $99 million purchase of this water right from PSCo. This acquisition for ISF use is part of the grant process and does not require additional payments from the funds specifically allocated for ISF acquisitions from the construction fund. Other funds for the purchase include $20 million committed by River District's Board of Directors, over $16 million committed by west slope supporters, and $40 million awarded but not yet contracted by the U.S. Bureau of Reclamation as part of the Inflation Reduction Act's Upper Basin Environmental Drought Mitigation, Bucket 2 Ecosystem ("B2E") Financial Assistance Program. CWCB's other associated costs to complete the transaction include time commitments by staff and the Attorney General's Office for the Board process and water court processes, followed by operational needs with record keeping, which are all part of CWCB's normal operating budget.

(11) The administrability of the acquired water right when used for instream flow purposes;

The Colorado Division of Water Resources ("DWR") administers calls for the Shoshone Water Rights which have resulted in the curtailment of junior water rights upstream of the Shoshone Power Plant. The administration of the water rights, whether for hydropower use or for ISF

use, should remain the same as the historical practice and should be unaffected by this additional ISF use. The Senior Shoshone Water Right is one of the most senior water rights on the Colorado River. During significant periods of the year, there is not sufficient water to satisfy all water rights decreed on the Colorado River and its tributaries within the State of Colorado, thus administration of calls against junior water rights have been placed, by both the senior and the junior Shoshone Water Rights. Administration and measurement of the Shoshone Water Rights has historically occurred using the Dotsero Gage. Consistent with historical administration, the Natural Flow is the amount of water in the Colorado River measured at the Dotsero Gage, including the amount of water usable by the Shoshone Water Rights when those water rights are in priority, except that the Natural Flow does not include any water released from storage and conducted into the Colorado River upstream of the Dotsero Gage (accounting for evaporation and transit loss), which water is intended for delivery for use downstream of the discharge outlets for the Shoshone Power Plant.

IX. Conclusion

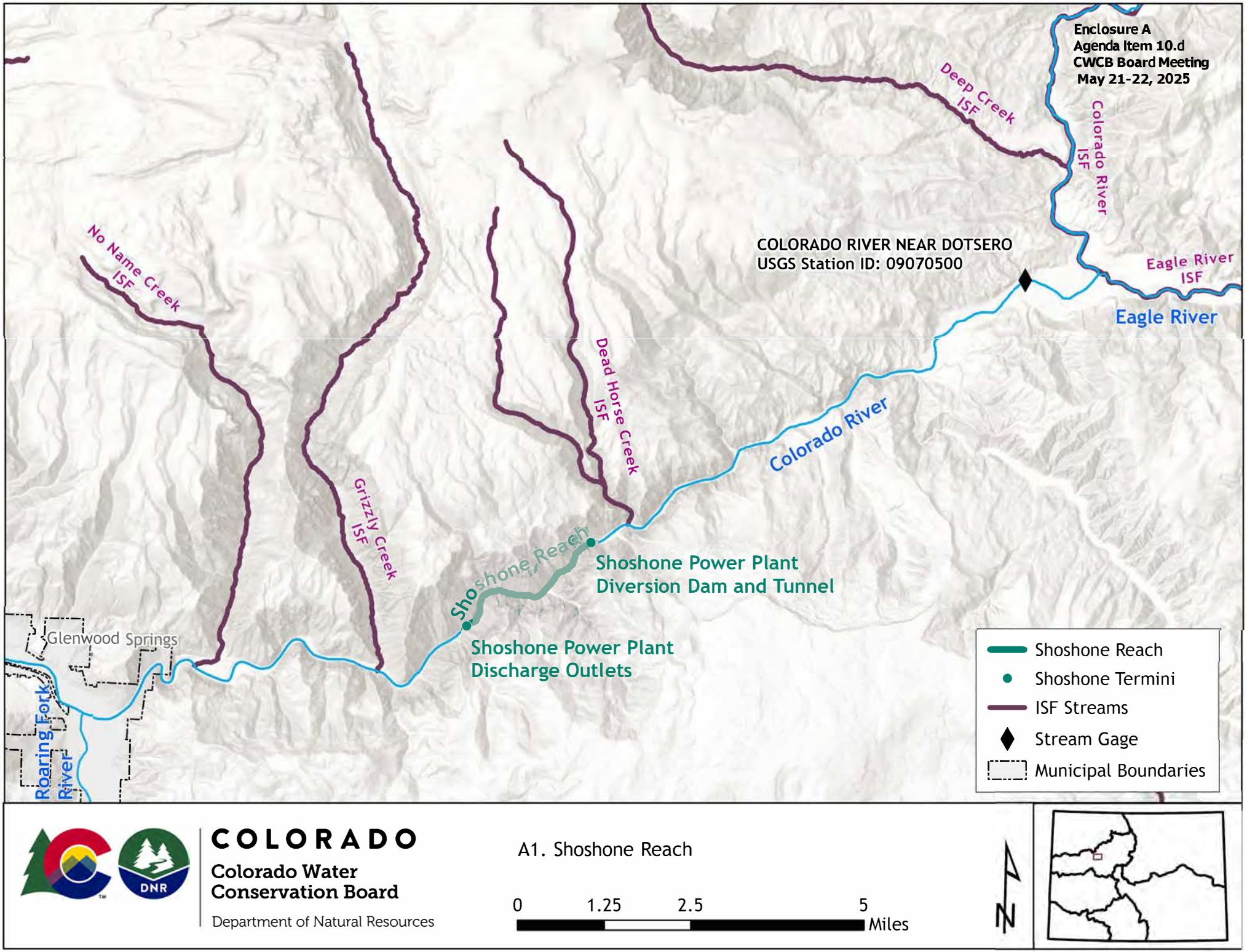
At a future Board meeting in which the Board will be asked to take final action, it is anticipated that Staff will recommend that the Board take the following actions:

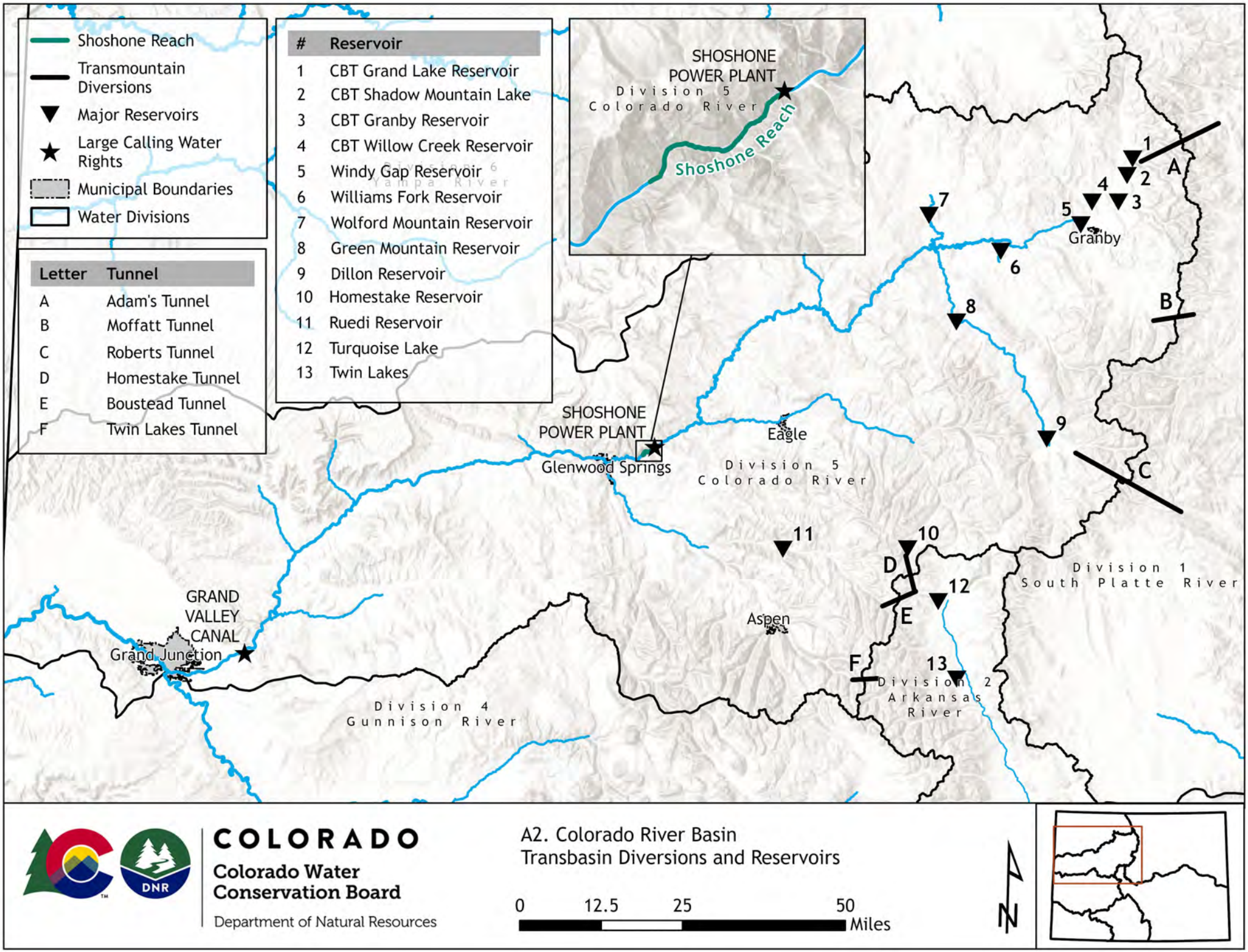
- Determine that the CWCB accepts a perpetual interest in the Shoshone Water Rights for instream flow use up to the full decreed amounts to preserve and improve the natural environment to a reasonable degree;
- Direct the CWCB Director to sign the ISF Agreement, so long as it is substantially similar to the draft ISF Agreement attached to the Board memo;
- Determine that the best use of the acquired interest in the Shoshone Water Rights is to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach of the Colorado River, up to the flow rates recommended by CPW, which will be included in the water court application; and
- Direct Staff to work with the Attorney General's Office and the Co-Applicants to file a water court application requesting to add an instream flow use to the Shoshone Water Rights in accordance with 37-92-102(3).

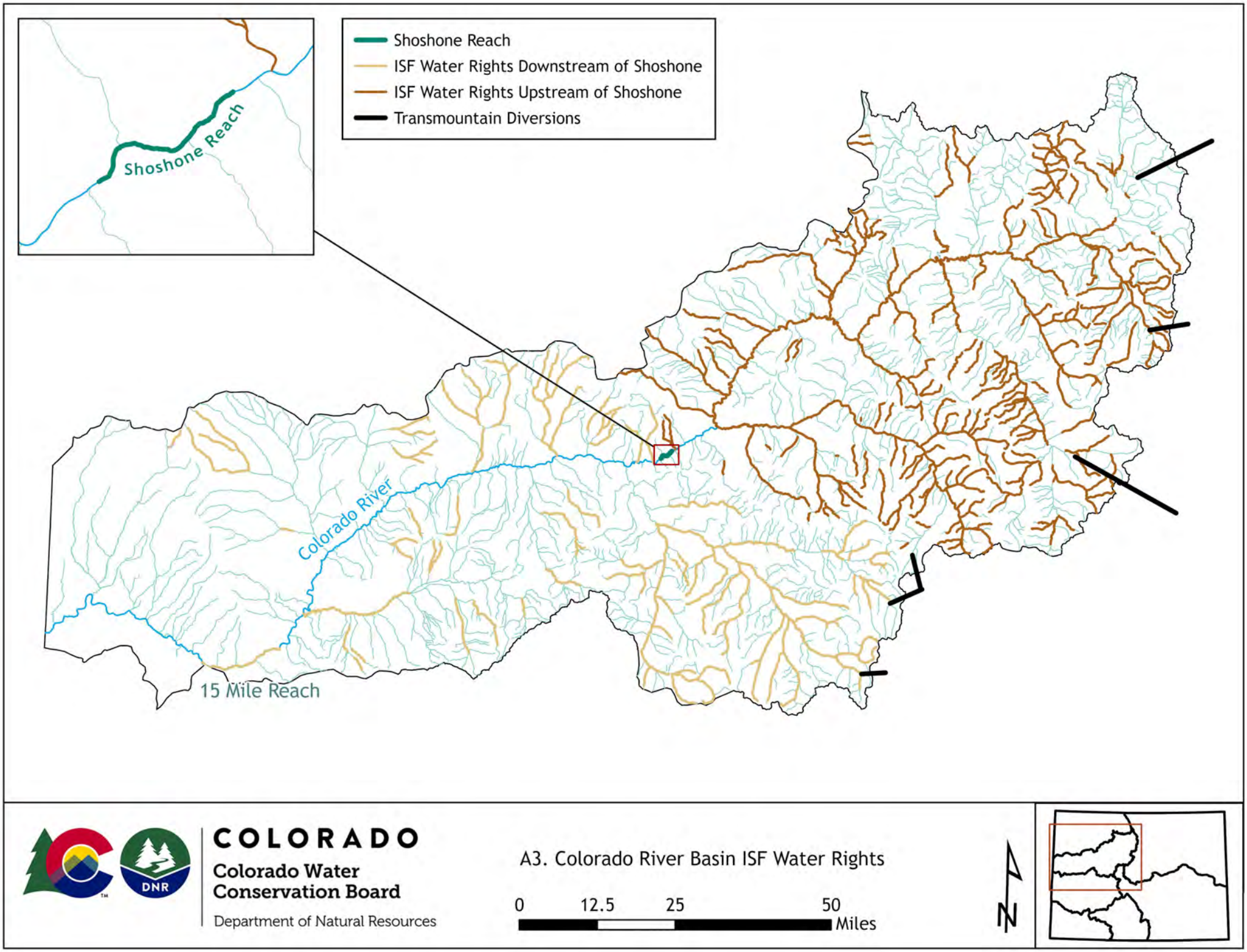
The Board can take final action on this proposal at the following Board meeting in July 2025 if no hearing is requested. However, if a hearing is requested within 20 days of the day the Board hears the proposal, and the Board grants the request, the hearing must be held within 120 days of May 21, 2025. The hearing and final action could occur at the September 2025 Board meeting. If the Board accepts the acquisition, a water court application would be filed, and the multi-year water court process could begin.

Enclosures:

A. Maps
    A1. Shoshone Reach
    A2. Colorado River Basin Transbasin Diversions and Reservoirs
    A3. Colorado River Basin ISF Water Rights
B. River District & PSCo's Offer Letter
C. Draft ISF Agreement
D. CPW's Recommendation Letter and Report
    D1. CPW's Letter of Recommendation
    D2. CPW's Biological Evaluation Report
E. Draft Water Court Application
F. River District's Technical Memorandum - with Attachments
    Attachment 1. Shoshone Water Rights Decrees
    Attachment 2. Maps
    Attachment 3. 2016 Shoshone Outage Protocol Agreement
    Attachment 4. Draft Instream Flow Agreement
    Attachment 5. 2024 Miller Report
    Attachment 6. 2025 Ecosystem Report
    Attachment 7. USFS-BLM Report
    Attachment 8. HU Assessment
    Attachment 9. Check Case Memo
    Attachment 10. Purchase and Sale Agreement
    Attachment 11. Hydros Yield Assessment
    Attachment 12. Hydros Yield Addendum
    Attachment 13. ISF Benefits Memorandum
    Attachment 14. Draft Water Court Application
G. GEI Report - GEI Consultants, Inc., April 2025 "Review of the Effects of Flow on Biology and Stream Processes, Glenwood Canyon"
H. Public Comment Letters (Aurora & Colorado Springs Utilities)


Enclosure A
Agenda Item 10.d
CWCB Board Meeting
May 21-22, 2025
Deep Creek ISF
Colorado River ISF
No Name Creek ISF
COLORADO RIVER NEAR DOTSERO
USGS Station ID: 09070500
Eagle River ISF
Eagle River
Dead Horse Creek ISF
Colorado River
Grizzly Creek ISF
Shoshone Reach
Shoshone Power Plant
Diversion Dam and Tunnel
Shoshone Power Plant
Discharge Outlets
Glenwood Springs
Roaring Fork River
Shoshone Reach
Shoshone Termini
ISF Streams
Stream Gage
Municipal Boundaries
COLORADO
Colorado Water
Conservation Board
Department of Natural Resources
A1. Shoshone Reach
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1.25
2.5
5
Miles
N


Shoshone Reach
Transmountain Diversions
Major Reservoirs
Large Calling Water Rights
Municipal Boundaries
Water Divisions
Letter Tunnel
A Adam's Tunnel
B Moffatt Tunnel
C Roberts Tunnel
D Homestake Tunnel
E Boustead Tunnel
F Twin Lakes Tunnel
Reservoir
1 CBT Grand Lake Reservoir
2 CBT Shadow Mountain Lake
3 CBT Granby Reservoir
4 CBT Willow Creek Reservoir
5 Windy Gap Reservoir
6 Williams Fork Reservoir
7 Wolford Mountain Reservoir
8 Green Mountain Reservoir
9 Dillon Reservoir
10 Homestake Reservoir
11 Ruedi Reservoir
12 Turquoise Lake
13 Twin Lakes
SHOSHONE POWER PLANT
Division 5 Colorado River
Shoshone Reach
Granby
Eagle
Glenwood Springs
Aspen
GRAND VALLEY CANAL
Grand Junction
Division 4 Gunnison River
Division 1 South Platte River
Division 2 Arkansas River
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
A2. Colorado River Basin
Transbasin Diversions and Reservoirs
0 12.5 25 50 Miles
N


Shoshone Reach
ISF Water Rights Downstream of Shoshone
ISF Water Rights Upstream of Shoshone
Transmountain Diversions
Shoshone Reach
Colorado River
15 Mile Reach
COLORADO
Colorado Water Conservation Board
Department of Natural Resources
A3. Colorado River Basin ISF Water Rights
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12.5
25
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Miles
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COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

Xcel Energy®

May 6, 2025

Via electronic mail
Colorado Water Conservation Board
Attn: Director Lauren Ris
1313 Sherman Street, Room 721
Denver, Colorado 80203

RE: Proposed Acquisition of an Interest in the Shoshone Water Rights for Instream Flow Use

Dear Members of the Board:

The Colorado River Water Conservation District (the "River District"), on behalf of a large coalition of West Slope governments and water user organizations, and Public Service Company of Colorado ("PSCo"), are pleased to offer to the Colorado Water Conservation Board ("CWCB") a proposal for the permanent dedication to the CWCB of the exclusive right to use the Shoshone Water Rights for instream flow purposes through an acquisition agreement with the River District and PSCo.

The Shoshone Water Rights.

For over a century, the Shoshone Power Plant, a "run-of-river" hydroelectric power plant located in Glenwood Canyon, Colorado, has commanded the waters of the Colorado River to generate hydroelectric power by means of two direct flow non-consumptive water rights: a 1905 senior priority water right in the amount of 1,250 cubic feet per second ("cfs"), and a 1940 junior priority water right in the amount of 158 cfs (together, the "Shoshone Water Rights"). PSCo owns and operates the Shoshone Power Plant and exercises the Shoshone Water Rights to generate hydroelectricity by diverting up to 1,408 cfs (the sum of the 1,250 cfs senior priority and the 158 cfs junior priority). PSCo diverts water from the Colorado River via the "Shoshone Diversion Dam," which is located upstream of the Shoshone Power Plant near the Hanging Lake Tunnel. After such water is diverted, it is conveyed approximately 2.4 miles through a tunnel in the canyon walls, before dropping 167 feet through two turbines and returning to the Colorado River via discharge outlets located just below the Shoshone Power Plant.

Summary of the Proposed Instream Flow Agreement.

The River District and PSCo, in consultation with the CWCB's Stream and Lake Protection Section and the Colorado Attorney General's Office, developed the proposed "Shoshone Water

Rights Dedication and ISF Agreement" (the "ISF Agreement"), which is enclosed hereto for your reference. As described in the ISF Agreement, the proposed instream flow use of the Shoshone Water Rights will preserve and improve the natural environment within the defined "Shoshone Reach" (a distance of approximately 2.4 miles of the Colorado River) between the Shoshone Diversion Dam and the outfall of the Shoshone Power Plant.

The ISF Agreement does not contemplate any new instream flow appropriation by the CWCB nor is such an appropriation necessary. Instead, the ISF Agreement provides that the CWCB will acquire the exclusive right to use the Shoshone Water Rights for instream flow purposes within the Shoshone Reach to the extent that the rights are not being used by PSCo to generate hydropower. The Shoshone Water Rights will be used for instream flow purposes at the decreed 1,408 cfs rate of natural flow, subject of course to the availability of natural flow in priority and consistent with the terms and conditions to be contained in the change of water rights decree.

The ISF Agreement is consistent with the CWCB's legal authority to acquire interests in water pursuant to C.R.S. § 37-92-102(3). Under the ISF Agreement, the CWCB will acquire the exclusive right to use the Shoshone Water Rights for instream flow purposes and the River District will retain fee title to the water rights. This type of acquisition is not unusual nor without precedent, and is specifically recognized as a lawful acquisition pursuant to section 37-92-102(3), C.R.S. Among other examples, this acquisition concept has been utilized by the CWCB several times in acquisition agreements with multiple parties, including the Colorado Water Trust, Denver Water, the City and County of Boulder, and Pitkin County. Most importantly, the use of the Shoshone Water Rights for instream flow purposes will result in the preservation and improvement of the natural environment within the Shoshone Reach of the Colorado River.

Additional Benefits of the Proposed Instream Flow Use of the Shoshone Water Rights.

The operation of the Shoshone Power Plant for over a century has resulted in a historical flow regime that provides numerous and diverse benefits to water users and the natural environment. Given the seniority of the Shoshone Water Rights, their non-consumptive use, and the physical location of the Shoshone Power Plant upstream of the Grand Valley, the Shoshone Water Rights are the primary basis upon which the Colorado River and its tributaries in Water Division No. 5 are administered. These incidental benefits, however, are not limited to agricultural, recreational, municipal, and economic factors. The historical exercise and administration of the Shoshone Water Rights has also resulted in direct ecological benefits on the Colorado River from its headwaters to the location of the Shoshone Reach by sustaining vital aquatic habitat, improving stream temperatures, and benefitting fish habitat during seasonal low-flow periods. Additionally, the exercise of the Shoshone Water Rights moderates the impacts of upstream diversions in a way that preserves the health of our state's namesake river.

In recent years, the Shoshone Water Rights and their associated benefits have been threatened by a series of natural hazards prompting unplanned outages at the Shoshone Power Plant. To ensure the permanent protection of the historical flow regime created by the Shoshone Water Rights, the

River District signed a Purchase and Sale Agreement ("PSA") with PSCo in December 2023 to acquire the Shoshone Water Rights. The guiding principle of the PSA and of the proposed ISF Agreement is that the Shoshone Water Rights will be used for instream flow purposes by the CWCB to the extent they are not used by PSCo for hydropower generation. Once the beneficial use of instream flow is added to the existing decreed uses, the water rights will be used in perpetuity in a manner that mimics the historical use of the water rights for hydropower generation, thereby continuing to protect critical resources for future generations across the state while simultaneously preserving and improving the natural environment.

Supporting Memorandum and Request for CWCB Approval of the Proposed ISF Agreement.

We have included a supporting memorandum and technical reports with this letter providing additional explanation and support of the proposed instream flow use of the Shoshone Water Rights. We believe the memorandum and technical reports provide ample support for the CWCB to determine that the CWCB's acquisition of the exclusive right to use the Shoshone Water Rights for instream flow purposes in the Shoshone Reach is appropriate to preserve and improve the natural environment to a reasonable degree and that the proposed ISF Agreement should be approved.

The River District and PSCo respectfully request that the CWCB initiate its consideration of the proposed ISF Agreement at its regular meeting on May 21, 2025. Representatives from PSCo and the River District will attend the May 21 meeting to provide more information regarding the proposed ISF Agreement and to answer any questions the CWCB may have. The River District and PSCo enthusiastically look forward to continuing to work with the CWCB, its staff, and the Office of the Attorney General on this important project.

Sincerely,

COLORADO RIVER WATER CONSERVATION DISTRICT

By: _____
Andrew A. Mueller
General Manager

PUBLIC SERVICE COMPANY OF COLORADO

By: _____
Robert S. Kenney
President

Enclosures: Shoshone Water Rights Dedication and ISF Agreement [draft]
Technical Memorandum and Attachments

DRAFT
SHOSHONE WATER RIGHTS DEDICATION AND ISF AGREEMENT

(Shoshone Water Rights)

This WATER RIGHT DEDICATION and ISF AGREEMENT ("Agreement"), is made as of this ____ day of _____, 2025, by and between the Colorado Water Conservation Board ("CWCB"), an agency of the State of Colorado, the Colorado River Water Conservation District ("River District"), a political subdivision of the State of Colorado, and Public Service Company of Colorado, a Colorado corporation ("PSCo"). The CWCB, the River District, and PSCo may be hereinafter referred to individually as a "party," and together as the "parties."

RECITALS

A. The CWCB is an agency of the State of Colorado created to aid in the protection and development of the waters of the state for the benefit of its present and future inhabitants. In 1973, the General Assembly vested the CWCB with the exclusive authority to appropriate waters of the natural stream for minimum stream flows between specific points on a stream to preserve the natural environment to a reasonable degree.

B. Pursuant to section 37-92-102(3), C.R.S., the General Assembly has also vested the CWCB with the ability to acquire, by grant, purchase, donation, lease, or other contractual agreement, such water, water rights, and interests in water that are not on the division engineer's abandonment list in such amount as the CWCB determines is appropriate for stream flows to preserve and/or improve the natural environment to a reasonable degree.

C. The River District was created by the provisions of sections 37-46-101, C.R.S., *et seq*., to promote the health and general welfare of the State of Colorado by the conservation, use, and development of the water resources of the Colorado River and its principal tributaries. The River District constituents include West Slope governmental entities and water interests that desire to maintain in perpetuity the flow regime within Water Division 5 created by the historical exercise of the water rights that are the subject of this Agreement.

D. PSCo is a Colorado corporation and is the owner and operator of the hydroelectric power plant (the "Shoshone Power Plant") located on the mainstem of the Colorado River in Glenwood Canyon, approximately six miles upstream of Glenwood Springs, Colorado. The Shoshone Power Plant produces hydroelectric energy by means of PSCo's diversion of the following water rights:

(i) The Glenwood Power Canal and Pipeline water right, decreed on December 9, 1907, in Civil Action No. 466, Eagle County District Court, in the amount of 1,250 cubic feet per second of time ("c.f.s.") with an appropriation date

of January 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as decreed absolute by the Eagle County District Court on February 27, 1911, in Civil Action No. 553 (the "Senior Shoshone Water Right"); and

(ii) The Shoshone Hydro Plant Diversion No. 2 water right, decreed absolute on February 7, 1956, in Civil Action No. 1123, Eagle County District Court, in the amount of 158 c.f.s. with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy (the "Junior Shoshone Water Right").

Together, these two water rights are referred-to as the "Shoshone Water Rights".

E. The Senior Shoshone Water Right is one of the most senior water rights on the Colorado River. During significant periods of the year, there is not sufficient water to satisfy all water rights decreed on the Colorado River and its tributaries within the State of Colorado. At such times, when the measurable Natural Flow of the Colorado River drops below 1,408 c.f.s. (the sum of 1,250 c.f.s. attributable to the Senior Shoshone Water Right and 158 c.f.s. attributable to the Junior Shoshone Water Right) at the streamflow gauge (USGS 09070500) located on the Colorado River near Dotsero, Colorado ("Dotsero Gage"), the Colorado Division of Water Resources ("DWR") administers a call for the Shoshone Water Rights which results in the curtailment of junior water rights upstream of the Shoshone Power Plant. The Dotsero Gage is the location where the administration and measurement of the Shoshone Water Rights has historically occurred. The "Natural Flow" is the amount of water in the Colorado River measured at the Dotsero Gage, including the amount of water usable by the Shoshone Water Rights when those water rights are in priority, except that the "Natural Flow" does not include any water released from storage and conducted into the Colorado River upstream of the Dotsero Gage (accounting for evaporation and transit loss), which water is intended for delivery for use downstream of the discharge outlets for the Shoshone Power Plant.

F. The Shoshone Water Rights are decreed for non-consumptive hydropower generation use at the Shoshone Power Plant. All of the water diverted by PSCo for hydropower generation use is returned to the Colorado River after such water is conveyed through the Shoshone Power Plant's penstocks and turbines, to a point of return at the plant's discharge outlets that is approximately 2.4 miles downstream of the point of diversion at the Shoshone Diversion Dam and Tunnel, as depicted on the map attached as **Exhibit A**. The approximate locations of the "Shoshone Diversion Dam and Tunnel" and the outfall for the "Shoshone Power Plant Discharge Outlets" are as follows:

i. **Shoshone Power Plant Diversion Dam and Tunnel:** on the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

ii. **Shoshone Power Plant Discharge Outlets:** on the right bank, being the northerly bank, of the Colorado River whence the Southeast corner of Section Thirty-five (35), Township Five (5) South, Range Eighty-Eight (88) West of the 6th Principal Meridian bears South 29° 24' 14" East, 1,771 feet, in Garfield County, Colorado.[1]

The reach of stream between the Shoshone Power Diversion Dam and Tunnel and the Shoshone Power Plant Discharge Outlets is referred to herein as the "Shoshone Reach." Through this Agreement, the parties seek to preserve and improve the natural environment of the Colorado River within the Shoshone Reach to a reasonable degree.

G. Pursuant to the Purchase and Sale Agreement between the River District and PSCo, with an effective date of January 1, 2024 (the "PSA"), the River District is the contract purchaser of the Shoshone Water Rights. The PSA provides that PSCo, and its successors and assigns, is entitled to a perpetual leasehold interest in the Shoshone Water Rights for continued use of the Shoshone Water Rights for hydropower generation at the Shoshone Power Plant (the "Lease," the form of which is attached to the PSA as "Exhibit D"). The PSA (including all its Exhibits and Attachments) is attached and incorporated hereto as **Exhibit B**.

H. PSCo's historical exercise of the Shoshone Water Rights has resulted in a streamflow regime that has benefitted the natural environment of the Colorado River basin both upstream and downstream of the Shoshone Power Plant. In addition, the historical exercise of the Shoshone Water Rights has provided benefits to water users throughout the Colorado River basin by providing a relatively predictable water rights administration regime both upstream and downstream of the Shoshone Power Plant.

I. The parties wish to continue the general historical call operations and maintain the flow regime of the Colorado River, both upstream and downstream of the Shoshone Power Plant. In furtherance of that effort, and subject to the terms of this Agreement, the River District wishes to dedicate to the CWCB, at no additional cost to the CWCB, the exclusive right to use the Shoshone Water Rights for instream flow purposes within the proposed Shoshone Reach to the extent the water rights are not being used for hydropower generation purposes at the Shoshone Power Plant, subject to the requirements of this Agreement. To that end, and subject to the terms set forth herein, the River District, PSCo, and the CWCB agree to jointly file an application to adjudicate a change of the Shoshone Water Rights in Garfield County District Court, Water Division No. 5, (the "Water Court") to add instream flow use to preserve and improve the natural environment of the Shoshone Reach of the Colorado River to a reasonable degree as an additional beneficial use of the Shoshone Water Rights. Use of the Shoshone Water Rights for instream flow and hydropower purposes shall be subject to any terms and conditions imposed by the change of water right decree to be entered by the Water Court, further described in Paragraphs XX and XX below (the "Decree").

[1] The legal description set forth above for the Downstream Terminus (Shoshone Power Plant Discharge Outlets) is an approximate location developed by River District staff and may be supplemented or modified at the time a water court application is filed in Water Division No. 5.

J. At two regularly scheduled public meetings of the CWCB held on [date], and [date], the CWCB considered the River District's proposed dedication of the exclusive right to use the Shoshone Water Rights for instream flow purposes to the CWCB in accordance with section 37-92-102(3), C.R.S., and the Rules Concerning the Colorado Instream Flow and Natural Lake Level Program ("ISF Rule(s)"), 2 CCR 408-2. At its regularly scheduled meeting on [date], the CWCB determined that it is appropriate to enter this Agreement and that the best use of the acquired interest in the Shoshone Water Rights is use up to the full decreed amount of 1,408 c.f.s., for instream flow use to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach. Such use of the Shoshone Water Rights for instream flow purposes can occur within the Shoshone Reach to the extent the Shoshone Water Rights are not being exercised for hydropower generation purposes at the Shoshone Power Plant, up to the full amount of 1,408 c.f.s. of Natural Flow (hereinafter, the "ISF Rate"), subject to the limitations described in Paragraphs 7 and 9 below.

K. The CWCB, the River District, and PSCo wish to cooperate to implement such legal mechanisms and to obtain such court decree and approvals as are necessary to change the Shoshone Water Rights to include instream flow use for the purpose of preserving and improving the natural environment within the Shoshone Reach, and to protect the Natural Flow ISF Rate through the Shoshone Reach to the extent it is not being exercised for hydropower generation purposes at the Shoshone Power Plant.

AGREEMENT

NOW THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the parties agree as follows:

DEDICATION

1. The Recitals to this Agreement are incorporated by this reference and shall constitute part of this Agreement.

2. The River District hereby dedicates to the CWCB, effective as of the date of closing of the PSA, at no additional cost to the CWCB, the exclusive right to use the Shoshone Water Rights for instream flow use within the Shoshone Reach, to the extent such water rights are not being used for hydropower generation purposes at the Shoshone Power Plant pursuant to the Lease, and subject to the requirements of Paragraph 9 below. The River District shall retain title to the Shoshone Water Rights.

3. This Agreement acknowledges the CWCB's consideration of the Colorado Parks and Wildlife analysis showing a biological need to preserve and improve the natural environment of the Shoshone Reach of the Colorado River to a reasonable degree.

4. The parties intend that the Decree, as further described in Paragraphs XX and XX below, shall confirm that the water attributable to the Shoshone Water Rights up to the available ISF Rate will remain in the stream to preserve and improve the environment to a reasonable

degree within the Shoshone Reach where the CWCB does not presently have a decreed instream flow right, to the extent the Shoshone Water Rights are not being used for hydropower generation purposes.

5. The parties intend that the Decree shall confirm that the Shoshone Water Rights shall be administered by the State Engineer and the Division Engineer for Water Division No. 5 ("Engineers") based on the Natural Flow at the Dotsero Gage. Instream flow use of the Shoshone Water Rights will be administered through the Shoshone Reach where the intended instream flow use will occur with the goal of utilizing the Shoshone Water Rights up to the available ISF Rate without diversion or exchange by intervening water users. The parties intend that the Decree shall also contain an affirmative finding which confirms that the change of the Shoshone Water Rights for the additional instream flow use is administrable by the Engineers and is capable of meeting all applicable statutory requirements.

6. In the event any new infrastructure or stream gaging stations are either necessary or desirable for the implementation of this Agreement, or in the event that any new infrastructure—including measuring devices—are deemed necessary by the Engineers with respect to the Shoshone Water Rights, the parties agree to work cooperatively with each other in good faith to accommodate the installation of any such infrastructure or gaging stations, which are necessary to make water available for use under this Agreement, in an efficient and economical manner.

CONDITIONS ON THE ADMINISTRATION AND EXERCISE OF THE SHOSHONE WATER RIGHTS FOR INSTREAM FLOW USE

7. It is the intent of the parties that the Shoshone Water Rights will be protected for instream flow use to the maximum extent possible as allowed under the Water Court Decree, to the extent the Shoshone Water Rights are not being used for power generation. To implement this mutual intent, the CWCB agrees that it will request administration of the Shoshone Water Rights for instream flow use in the Shoshone Reach of the Colorado River to preserve and improve the natural environment to a reasonable degree at all times when the Natural Flow of the Colorado River as measured at the Dotsero Gage is less than 1,408 c.f.s., subject only to the limitations set forth below:

   a. Any terms, conditions, and limits set forth in the Decree;

   b. Any reduction in instream flow use made pursuant to the terms and conditions of Paragraph 9, below, due to use or planned use of the Shoshone Water Right for power generation; and

   c. During any period wherein the CWCB and the River District jointly agree in writing to reduce the flow rate requested for administration of the Shoshone Water Rights for instream flow purposes.

8. Pursuant to ISF Rule 10, 2 CCR 408-2, the parties shall cooperate in the administration and monitoring of the instream flow use of the Shoshone Water Rights dedicated to the CWCB under this Agreement so that, subject to the terms of this Agreement and the Decree, the CWCB will maximize the use of the Shoshone Water Rights for instream flow purposes to the extent the rights are not being used for hydropower generation purposes at the Shoshone Power Plant. PSCo, the CWCB and the River District shall coordinate with DWR to monitor the flow and calculate the Natural Flow of the Colorado River at the Dotsero Gage as the point of administration for the Shoshone Water Rights for hydropower generation and instream flow use.

9. The CWCB and the River District shall notify PSCo of any request for administration required by the provisions of this Agreement. PSCo shall provide advance written notice to the River District and the CWCB at least thirty (30) days prior to any scheduled operations or maintenance activities that result in a full or partial shutdown of the Shoshone Power Plant, and shall provide notice as soon as reasonably possible of any unscheduled shutdown or reduction of Shoshone Power Plant operations. During the term of the Lease, the parties will coordinate on at least an annual basis to determine how the Shoshone Water Rights will be allocated between hydropower generation and instream flow use in a manner consistent with the terms and conditions of the Decree that (1) maximizes PSCo's ability to exercise the Shoshone Water Rights for hydropower generation purposes; and (2) maximizes the ability to use the Shoshone Water Rights for instream flow purposes to the extent the water rights are not being used for hydropower generation purposes at the Shoshone Power Plant, in a manner that does not reduce the availability of the Shoshone Water Rights for subsequent hydropower use. Upon termination of the Lease, this paragraph, and any other restrictions on the Shoshone Water Rights throughout this Agreement due to hydropower use, shall no longer be in effect, and, subsequent to any permanent decommissioning of the Shoshone Power Plant, instream flow shall be the only use of the Shoshone Water Rights.

10. Each party to this Agreement shall also immediately report, in writing, to the other parties the nature of any communications with the Engineers concerning the administration of the Shoshone Water Rights as contemplated by this Agreement. Following the closing of the PSA, the parties shall identify those persons and provide such contact information (including email and telephone number) to the other parties necessary to effectuate the purposes hereof.

11. Any rights created by this Agreement are contractual rights. Use by the CWCB for instream flow purposes in accordance with this Agreement does not provide the CWCB an ownership right in the Shoshone Water Rights or in any of the River District or PSCo's facilities or water rights as they exist now or may exist in the future.

12. The CWCB's contractual rights to and interest in the Shoshone Water Rights dedicated to the CWCB for use in the Shoshone Reach under this Agreement extends to and terminates at the downstream termination point of the Shoshone Reach, which is the stream accrual point for the current Shoshone Power Plant Discharge Outlets.

NO CREATION OF RIGHT OF SUCCESSIVE USE OF THE SHOSHONE WATER RIGHTS DOWNSTREAM OF THE SHOSHONE REACH

13. This Agreement does not recognize any use or create any right of use by the River District of the Shoshone Water Rights downstream of the Shoshone Reach. Notwithstanding the foregoing, this Paragraph 13 does not prevent any use by the River District or its constituents of the natural stream flow downstream of the Shoshone Reach within the priority system and in accordance with Colorado law and the Decree.

WATER COURT PROCEEDINGS

14. The parties shall file and diligently pursue a Water Court application and any necessary appeals to obtain the Decree in a final, unappealable form confirming a change of water right for the Shoshone Water Rights to include the additional use for instream flow purposes by the CWCB and confirming that the water attributable to the Shoshone Water Rights will be used for instream flow to preserve and improve the natural environment in the Shoshone Reach of the Colorado River to a reasonable degree up to the full amount of the ISF Rate , subject to the terms and conditions of the Decree and this Agreement. In such water court application, the CWCB, the River District, and PSCo shall be co-applicants for the purpose of advancing and protecting their contractual rights under this Agreement, including adjudicating a decreed right to use of the Shoshone Water Rights by the CWCB to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach. Except as otherwise provided in the PSA, to which the CWCB is not subject, each party shall bear its own attorney fees and costs related to its participation in any water court adjudication contemplated under this Paragraph 14. Except for its own attorney fees and court filing fees, the CWCB is not responsible for paying costs of prosecuting the water court application, including the costs of hiring a consulting engineer or other witnesses in furtherance of such application, or attorney fees of any other party incurred in relation thereto.

15. The parties intend that the Decree shall confirm that to the extent the water dedicated under this Agreement is not being used for hydropower generation at the Shoshone Power Plant, such water shall be beneficially used by the CWCB for instream flow purposes to preserve and improve the natural environment of the Colorado River within the Shoshone Reach to a reasonable degree, subject to the terms and conditions of the Decree and this Agreement.

16. The parties agree that the Decree shall not confirm any new appropriation of water. N or shall any claim be included in the Water Court application except as expressly described in this Agreement. The parties further agree that, upon the successful prosecution of the Water Court application described in Paragraph 14, above, and upon the issuance of the Decree by the Water Court, no further claim for approval of any change of water right with respect to the Shoshone Water Rights shall be sought by any of the parties to this Agreement in the future without first obtaining the prior written consent of all the parties hereto. The River District agrees it will not transfer or otherwise encumber the rights to any other person or entity without the express written consent of the CWCB, with the exception of the right to enter into a promissory note and deed of trust to the benefit of

PSCo as provided by paragraph 3.1.d.2 of the PSA. The parties agree to request that the Water Court include an express statement in the Decree setting forth the limitations described in this Paragraph 16, to wit:

a. the decree does not confirm any new appropriation or change except to add instream flow;
b. no further claim for approval of any change of the Shoshone Water Rights will be sought by any of the applicants without written consent of the other applicants hereto; and
c. the River District will not transfer or otherwise encumber the Shoshone Water Rights to any other person or entity without the express written consent of the CWCB.

RECORDS AND ACCOUNTING

17. The River District shall be responsible for maintaining all records and accounting necessary for the implementation of this Agreement, using forms mutually agreeable to the parties, and all records required by the Engineers for the administration of the changed Shoshone Water Rights.

18. The River District will provide accounting related to the operation of this Agreement to the CWCB and PSCo.

MISCELLANEOUS PROVISIONS

19. The term of this Agreement is perpetual unless terminated in accordance with the terms of this Agreement.

20. This Agreement will automatically terminate and be of no further effect in the event that (i) the sale of the Shoshone Water Rights from PSCo to the River District does not close or occur, or (ii) the PSA is terminated or otherwise expires. Except as otherwise provided in the immediately preceding sentence in this Paragraph 20, this Agreement may be amended or terminated by the written agreement of the parties, and any such termination or amendment shall take effect only when signed by all of the parties to this Agreement or their successors in interest.

21. Neither the CWCB nor PSCo is responsible for construction or modification of any structures that may be necessary for use of the Shoshone Water Rights for instream flow purposes.

22. This Agreement shall not be assignable by any party without the written consent of all the parties hereto. Notwithstanding the foregoing, an assignment by PSCo of this Agreement to any successor or assign of its rights under the Lease is approved by the CWCB and River District without separate written consent, however thirty (30) days advanced written notice of the assignment to the River District and the CWCB is required, and PSCo may assign the Lease only to a successive owner or operator of the Shoshone Power Plant for power generation purposes. Notice and contact information shall be provided to all parties concurrent with any assignment. In the event of the termination of the Lease by PSCo or

its successors or assigns pursuant to Paragraph 26, below, the River District and CWCB will not be required to obtain the written consent of PSCo or its successors or assigns to assign this Agreement.

23. Pursuant to section 37-92-102(3), C.R.S., this Agreement shall be enforceable by each of the parties hereto as a water matter according to the terms and conditions of this Agreement. The parties further agree that the exclusive venue for and jurisdiction of any dispute pertaining to the interpretation or enforcement of this Agreement shall be the Water Court (as defined herein); *provided, however*, that before commencing any action for enforcement of this Agreement, the party alleging the violation shall notify the other parties in writing of the alleged violation and the parties shall make a good faith effort to resolve their differences through informal consultation.

24. The parties hereto acknowledge and agree that specific performance of this Agreement shall be the exclusive remedy for failure of any party to comply with any provision of this Agreement. The parties hereby waive any right to seek or collect damages for any breach or violation of this Agreement.

25. Enforcement of this Agreement and all rights and obligations hereunder are reserved solely to the CWCB, the River District, and PSCo, and not to any third party. Any services or benefits which third parties may receive or provide as a result of this Agreement are incidental to the Agreement and do not create any rights for such third parties.

26. The parties anticipate that at some point in the future, PSCo may permanently decommission the Shoshone Power Plant, and the Lease will terminate. In the event that the Lease terminates, then PSCo shall provide written notice to the parties of the termination of the Lease and PSCo's rights and obligations under this Agreement will also be deemed to be terminated; however, all rights and responsibilities between the CWCB and the River District will remain in effect. Upon termination of the Lease, all restrictions on the Shoshone Water Rights throughout this Agreement due to hydropower use shall no longer be in effect, and, subsequent to any permanent decommissioning of the Shoshone Power Plant, instream flow shall be the only use of the Shoshone Water Rights.

27. The provisions of §§37-92-102(3) and 305(3)(b), C.R.S. that require that all contracts or agreements for interests in water, and the water court decree implementing the contracts or agreements, to state the board or the lessor, lender, or donor may bring about beneficial use of the historical consumptive use of the leased, loaned, or donated water right downstream of the instream flow reach as fully consumable water are not relevant and do not apply to this acquisition.

28. In the event the Decree and this Agreement are inconsistent, the Decree shall control.

29. This Agreement shall be construed in accordance with the laws of the State of Colorado and shall be interpreted broadly to give effect to its purposes.

30. Any failure or delay by a party in exercising any of its rights, power, and remedies hereunder or in accordance with laws shall not lead to a waiver of such rights, and the waiver of any single or partial exercise of a party's rights shall not preclude such party from exercising such rights in any other way and exercising the remaining part of the party's rights.

31. Any notice, consent, waiver, request or other communication required or provided to be given under this Agreement shall be in writing and shall be sufficiently given and shall be deemed delivered when: (a) delivered personally; (b) transmitted by email to the then-designated address of the party, provided that a delivery receipt sent by the recipient is received by the sender, provided if the delivery receipt is sent on a non-business day, or after 5:00 p.m. local time at the physical address of the recipient, then the notice will be deemed received on the next business day; (c) two (2) business days after deposit with the United States Postal Service by certified or registered mail, return receipt requested, postage prepaid; or (d) one (1) business day following deposit with a nationally recognized overnight delivery service, in any event, addressed to the applicable party as set forth below, or at such address as either party may from time-to-time specify in writing to the other:

If to the CWCB:

Section Chief
Colorado Water Conservation Board
Stream and Lake Protection Section
1313 Sherman Street, Room 721
Denver, CO 80203
DNR_CWCBISF@state.co.us

and

Jen Mele
First Assistant Attorney General
Natural Resources and Environment Section
1300 Broadway, 7th Floor
Denver, CO 80203
jen.mele@coag.gov

If to PSCo:

Public Service Company of Colorado
Attn: Environmental Services
1800 Larimer Street, Suite 1300
Denver, CO 80202

and

Public Service Company of Colorado
Attn: Legal Dept. – Real Estate
1800 Larimer Street, Suite 1400
Denver, CO 80202

(303) 294-2222
Frances.A.Folin@xcelenergy.com

and

Welborn Sullivan Meck & Tooley, P.C.
Carolyn F. Burr, Esq.
James M. Noble, Esq.
1401 Lawrence Street, Suite 1800
Denver, CO 80202
(303) 830-2500
cburr@wsmtlaw.com
jnoble@wsmtlaw.com

If to the River District:

Colorado River Water Conservation District
General Manager
Andrew Mueller
201 Centennial St., Suite 200
Glenwood Springs, CO 81601
edinfo@crwcd.org

and

General Counsel,
Peter Fleming, Esq.
201 Centennial St., Suite 200
Glenwood Springs, CO 81601
(970) 945-8522
pfleming@crwcd.org

32. Each provision contained herein shall be severable and independent from each of the other provisions such that if at any time any one or more provisions herein are found to be invalid, illegal, or unenforceable, the validity, legality, or enforceability of the remaining provisions herein shall not be affected as a result thereof.

33. The effective date of this Agreement shall be the last date shown on the signature page or pages of this Agreement, provided however that parties' rights and obligations under this Agreement with specific regard to the exercise of the Shoshone Water Rights for instream flow purposes shall not commence until the closing date of the PSA. If the PSA is terminated according to its terms, then this Agreement shall also automatically terminate. This Agreement may be executed in two or more counterparts, each of which when so executed shall be deemed to be an original and all of which when taken together shall constitute one and the same instrument. The counterparts of this Agreement may be executed and delivered by electronic means (including portable document format) by either of the parties and the receiving party may rely on the receipt of such document so executed and delivered electronically as if the original had been received.

[remainder of page intentionally blank]

[signature page(s) follow]

IN WITNESS WHEREOF, the CWCB, the River District, and PSCo have executed this Agreement as of the last date of execution.

COLORADO WATER CONSERVATION BOARD

By: _____
Lauren Ris, Director

Date: _____

[signatures continue on next page]

[signature page to Water Right Dedication Agreement (Shoshone Water Rights)]

COLORADO RIVER WATER CONSERVATION DISTRICT

ATTEST:

By: _____
Andy Mueller, General Manager

BY: _____

Date: _____

[signatures continue on next page]

[signature page to Water Right Dedication Agreement (Shoshone Water Rights)]

PUBLIC SERVICE COMPANY OF COLORADO

By:_____
Robert Kenney, President

Date:_____

[signature page to Water Right Dedication Agreement (Shoshone Water Rights)]

Exhibit A
(Shoshone Diversion Dam and Tunnel)

Exhibit B
(Purchase and Sale Agreement)

COLORADO
Parks and Wildlife
Department of Natural Resources

Enclosure D1
Agenda Item 10.d
CWCB Board Meeting
May 21-22, 2025

May 6, 2025

Director Lauren Ris
Colorado Water Conservation Board
1313 Sherman Street, 7th Floor
Denver, CO 80203

Subject: Colorado Parks and Wildlife Recommendation on the Proposed Acquisition of an Interest in the Shoshone Hydroelectric Power Plant Water Rights

Dear Ms. Ris,

Colorado Parks and Wildlife (CPW) offers the following evaluation of the proposed instream flow (ISF) acquisition of water rights associated with the Shoshone Hydroelectric Power Plant, which are currently owned and operated by Public Service Company (PSCo), a subsidiary of Xcel Energy. The Colorado River District (CRD) is in the process of acquiring the Shoshone water rights and has proposed adding ISF as a beneficial use and making that water available to the Colorado Water Conservation Board (CWCB or Board) for the benefit of the aquatic ecosystem in the Colorado River. The CWCB will review this proposal and may accept an interest in the water rights through a two-board meeting administrative approval process, currently scheduled to commence in May. As required under CWCB's Instream Flow and Natural Lake Level Program Rules, CWCB has requested that CPW evaluate the aquatic benefits and provide recommendations on the proposed acquisition. CPW's perspective is offered under the mandate of our mission to perpetuate the wildlife resources of the state and provide enjoyable and sustainable outdoor recreation opportunities that educate and inspire current and future generations to serve as active stewards of Colorado's natural resources.

The Shoshone water rights include a 1250 cfs senior right with a 1905 priority date and a 158 cfs junior right with a 1940 priority date for a total decreed flow rate of 1408 cfs. The CRD is in the process of acquiring the Shoshone water rights from PSCo under procedures described in their Purchase and Sales Agreement executed in December 2023. If the CWCB votes to approve the acquisition by accepting an interest in the water rights, PSCo, CRD, and the CWCB will file a joint water court application to add ISF as a decreed beneficial use to the Shoshone water rights. Once a decree is obtained, the Shoshone water rights can be dedicated to CWCB to exercise ISF use

Jeff Davis, Director, Colorado Parks and Wildlife
Parks and Wildlife Commission: Dallas May, Chair · Richard Reading, Vice-Chair · Karen Bailey, Secretary · Jessica Beaulieu
Marie Haskett · Tai Jacober · Jack Murphy · Gabriel Otero · Murphy Robinson · James Jay Tutchton · Eden Vardy

when the rights are not used to generate hydropower. Furthermore, should the power plant be decommissioned, ISF use will become the sole beneficial use for the water rights. The reach defined for ISF use extends from the point of diversion for the hydroelectric plant at the Shoshone Dam approximately 2.4 miles downstream to the outfall of the power plant discharge outlets. This reach, referred to as the Shoshone Reach, will benefit from a donation of the full water right (up to 1408 cfs) when in priority and as dictated by the water court change case.

The Shoshone water rights have a significant influence on administration of the Colorado River due to their seniority, magnitude, and location. An administrative call of the Shoshone water rights has historically served as an important legal mechanism for water right curtailment on the upper Colorado River mainstem and its tributaries, with broad implications for flow management throughout the Upper Colorado River watershed. Given the age of the power plant and operational challenges, permanent preservation of the Shoshone water rights has been contemplated for decades and prioritized in numerous planning efforts. As entirely non-consumptive water rights, partnering with the CWCB to utilize the state's ISF acquisition tool and dedicating the rights to ISF use was identified as an appropriate legal mechanism to protect the rights in perpetuity.

In response to CWCB's request, CPW's offers the attached report which details our assessment, professional opinions, and recommendations on the proposal. The report includes details about several factors the Board must consider in evaluating the appropriateness of the acquisition, specifically the natural environment and whether that natural environment will be preserved and/or improved to a reasonable degree by the water available from the proposed acquisition. The Shoshone Reach of the Colorado River is a high-gradient, dangerous segment of river, so no fishery and habitat studies existed in the reach prior to 2023. CPW staff conducted fishery surveys to fill this data gap and coordinated with CRD and CWCB staff to assess flow-habitat relationships using two-dimensional hydraulic habitat modeling.

Based on these assessments, CPW concludes there is a flow-dependent natural environment that can be preserved and improved by the proposed acquisition. The water right preserves the historical flow regime in the Colorado River upstream while improving flows in the Shoshone Reach by adding additional wetted area and suitable fish habitat to a historically dewatered section of the Colorado River. The best use of this water is to preserve and improve the natural environment at any flow rate up to 1408 cfs, the amount decreed for the subject water rights. Additionally, hydraulic-habitat modeling shows that fish habitat improves in the Shoshone Reach at flows up to at least 3000 cfs. However, this upper threshold of 3000 cfs is based on the upper limit of the hydraulic-habitat model. It is also our professional opinion that flows

greater than 3000 cfs provide improvements to fish habitat, specifically by supporting important geomorphic functions and habitat maintenance. Based on professional expertise, flows greater than 3000 cfs maintain an aquatic food base, provide additional thermal refuge areas, and support fish passage. Given the anticipated biological benefits, CPW staff believes this acquisition will preserve and improve the natural environment to a reasonable degree and recommends the CWCB accept the interest in the acquired water. CPW staff will be available at the May CWCB meeting to address the benefits provided by the proposal and to answer any questions about the fishery and associated flow benefits of dedicating the Shoshone water rights to ISF use.

Sincerely,



Jeff Davis

Director of Colorado Parks and Wildlife

Biological Evaluation of the Shoshone Water Rights Instream Flow Acquisition



Colorado Parks and Wildlife

May 6, 2025

Contents

1. Introduction 3
2. Natural Environment & Biological Data 4
2.1 Natural Environment Overview 4
2.2 Colorado River Fish Community 5
2.2.1 Fish Community Overview 5
2.2.2 Fish Survey Results 6
2.2.3 Fishery Discussion & Conclusion 7
2.3 Biocriteria & the Macroinvertebrate Community 9
2.3.1 Biocriteria Overview 9
2.3.2 Macroinvertebrate Survey Results 10
2.3.3 Macroinvertebrate Community Discussion & Conclusion 11
3. Instream Flow Evaluation & Flow-Habitat Relationships 12
3.1 Instream Flow Evaluation Overview 12
3.1.1 Overview Freshwater Consulting Habitat Modeling – 2023-24 12
3.1.2 Results Freshwater Consulting Habitat Modeling – 2023-24 13
3.2 Hydraulic Habitat Model Limitations 14
3.2.1 Overview Ecosystem Sciences Habitat Modeling – 2024-25 15
3.2.2 Results Ecosystem Sciences Habitat Modeling – 2024-25 15
3.2.3 Addressing Modeling Limitations 17
3.3 Discussion and Conclusions on Flow-Habitat Relationships 18
3.3.1 Other Considerations in Assessing Flow-Habitat Relationships 19
4. Colorado River System Assessment 20
4.1 Upper Colorado River Wild and Scenic Reach 20
4.2 Temperature Exceedances 21
4.3 Anchor ice and winter temperature issues 23
4.4 Lower Glenwood Canyon Fishery Resources 23
4.5 Quality Trout and Gold Medal Fisheries 24
4.6 Maintaining and Restoring River Connectivity 24
4.7 Benefits to Existing Instream Flow Reaches 26
5. Conclusion & CPW Recommendation 27
Photos 28
..... 29
References 37

1. Introduction

Built in the early 1900s, the Shoshone Hydroelectric Power Plant sits on the north bank of the Colorado River in the middle of Glenwood Canyon. Currently owned and operated by Public Service Company (PSCo), a subsidiary of Xcel Energy, the power plant and associated direct flow water rights are used to generate hydroelectric power by diverting flow from the Colorado River through two hydropower turbines. The water rights consist of a relatively senior water right with a 1905 priority date for 1250 cfs and a junior right with a 1940 priority date for 158 cfs. The combined total of 1408 cfs is decreed for non-consumptive beneficial use of power generation.

The seniority, magnitude and decreed use of these water rights, when combined with a call on the water right(s), have historically commanded water administration on the Colorado River. When a valid call is placed and administered at the Shoshone power plant, junior appropriators upstream are directed to curtail surface diversions or provide augmentation water to replace out of priority depletions to the calling right. Additionally, a Shoshone call dictates reservoir releases that supplement baseflows in the Upper Colorado River. During periods of low flows in the river, which can extend from the conclusion of spring runoff through the winter, the diversion is legally required to sweep, or divert the entirety of the river to place a call on the hydropower right. This administrative requirement results in the river channel being significantly dewatered for 2.4-miles between the Shoshone Dam and power plant outfall. Without the Shoshone call in place, junior appropriators are entitled to exercise their water rights, depleting streamflows throughout the Upper Colorado Basin and impacting many water rights, including instream flow (ISF) water rights held by the Colorado Water Conservation Board (CWCB).

The Colorado River District (CRD) is in the process of acquiring the Shoshone water rights from PSCo. In partnership with the CWCB, the CRD has proposed adding an ISF beneficial use to the water rights by filing a joint water court change case application. Once a decree is obtained, the Shoshone water rights can be dedicated to CWCB to exercise ISF use when the rights are not used or only partially used to generate hydropower. Furthermore, should the power plant be decommissioned, ISF use will become the sole beneficial use for the water rights. The reach defined for ISF use extends from the point of diversion for the hydropower plant at Shoshone Dam approximately 2.4 miles downstream to the power plant outfall (Map 1). This reach is referred to as the Shoshone Reach and is described in detail below.

CPW supports CWCB's ISF Program by providing biological and technical expertise and assists CWCB staff in making a determination of whether the natural environment will be preserved and/or improved to a reasonable degree by the water made available under the proposed acquisition. CPW staff use professional judgement and best available data to make that determination and in some instances collect additional biological data where little exists. The

Shoshone Reach of the Colorado River is a high-gradient, dangerous segment of river, so limited biological information existed in the reach prior to 2023. CPW reviewed existing data, collected additional data, and worked with CWCB, CRD, and consultants to develop additional studies for the proposed acquisition. The following report is CPW's evaluation of the proposed acquisition and CPW's recommendations to the Board pursuant to C.R.S.37-92-102(3).

2. Natural Environment & Biological Data

2.1 Natural Environment Overview

The Shoshone Reach of the Colorado River runs through the central portion of Glenwood Canyon, a confined canyon where the river over time carved a deep gorge that runs nearly 15-miles between 2,500 feet high walls of sedimentary rock. The canyon is a heavily trafficked corridor and the river and its floodplain are confined by Interstate 70, a streamside recreational path, and railroad. The river is heavily used by whitewater enthusiasts and floatboaters. In the Shoshone Reach, steep riverbed drops create renowned rapids for expert whitewater kayakers. Downstream of the outlet of Shoshone Power Plant, the Shoshone Rapids are targeted by private and commercial whitewater boaters spring through fall as flows allow. Immediately below the rapids, year-round casual and angler floatboating occurs from Grizzly Creek to Glenwood Springs. Throughout Glenwood Canyon, there are diverse outdoor recreational opportunities beyond river whitewater and floatboating including coldwater sportfishing, hiking, rock climbing, streamside bike and pedestrian trail use, vapor caves, and hot springs. These recreational opportunities provide the foundation of the local tourism-based economy.

The infrastructure and operation of the Shoshone water rights creates significant hydrological alteration to the Colorado River. The dam was constructed to impound and divert water for hydropower generation and creates a barrier to downstream sediment transport and upstream river connectivity for aquatic organisms, especially fish. For a Shoshone call to be administered the structure much divert the called priority water. This can result in the legal diversion of the entirety of the Colorado River when flows are less than 1408 cfs, which leaves the Shoshone Reach in a dewatered state. During seasonally low flows, the Colorado River flows are comprised of seepage from the dam (Photo 1), groundwater, and tributary inputs. Under these diminished flow conditions, aquatic habitat persists mainly in deep pools and glides that are isolated by steep boulder drops or shallow riffles that present passage challenges for fish. Aquatic organisms are impacted by habitat fragmentation and limited occupiable wetted habitat. Through the reach, there are many insurmountable drops created by the river gradient and large boulder constrictions. While the Shoshone water rights call may have specific localized impacts to the Shoshone Reach, there are broad benefits provided by the call in the form of flow supplementation to the Colorado River mainstem and its tributaries.

Despite the anthropogenic alteration of the Colorado River through Glenwood Canyon, the Shoshone Reach continues to support a variety of native and sport fisheries and some limited

riparian areas. Wildlife commonly encountered include bighorn sheep, river otters, beaver, Mule Deer, elk, Peregrine Falcons, and eagles. Riparian and upland plant communities generally consist of cottonwood and alder in the riparian areas, and oak, pine, spruce, fir, and aspen trees in the uplands. The unique canyon geology includes caves, springs, and geothermal outputs. The discrete and diffuse geothermal springs occur at the eastern and western ends of Glenwood Canyon, including one of the largest hot springs in the state of Colorado, Glenwood Hot Springs and in the popular Yampah Vapor Caves. These and other extraordinary values of the Colorado River between Gore Canyon and Glenwood Canyon qualify it as eligible for a federal Wild and Scenic Rivers designation.

2.2 Colorado River Fish Community

2.2.1 Fish Community Overview

The Colorado River hosts a diversity of native river fishes and abundant coldwater sportfishes. The native fish community inhabiting the Colorado River in proximity to and through the Shoshone Reach includes multiple cold and cool water species, including small-bodied sculpin and dace, and larger-bodied Bluehead Suckers, Flannelmouth Suckers, and Roundtail Chub, which are naturally adapted to a wide range of mainstem river habitats and water quality conditions. A variety of coldwater salmonid species, both native and introduced, comprise the sportfish community, including (in order of abundance): Brown Trout, Rainbow Trout, Mountain Whitefish, and Cutthroat Trout. The coldwater sportfish thrive in colder temperatures and clearer waters than Colorado River mainstem native fish, but are able to withstand some seasonal perturbations including warmer summer water temperatures and occasional sediment flows from monsoonal rains. CPW manages the Colorado River from its headwaters downstream to Rifle for coldwater sportfish, including the Shoshone Reach. Near Rifle, warmer river temperatures develop as well as increased turbidity. Critical Habitat begins at the Highway 13 bridge in Rifle for the federally listed Threatened and Endangered river fishes, Colorado Pikeminnow and Razorback Sucker, and farther downstream near the Utah Border for Bonytail Chub and Humpback Chub. The diversity of Colorado River fishes and their life history characteristics are sustained by the variety of habitats and dramatic landscapes that characterize the river corridor in Western Colorado.

The current State Wildlife Action Plan (SWAP) identifies wildlife conservation priorities of CPW and recognizes the Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub (collectively known as the "Three Species") as Tier 1 Species of Greatest Conservation Need. In the Colorado River and its tributaries, the Three Species persist from higher elevation waters around 8,000 feet downstream to the western desert and canyon reaches where they overlap with the Colorado River Threatened and Endangered fishes. As documented in the 2019 Rangewide Three Species Conservation Agreement and Strategy ("2019 Conservation Strategy"), the Three Species have become increasingly rare with significantly reduced occupancy in less than 50 percent of their historic range. The dramatic decline of the Three Species in mainstem rivers is attributed to habitat degradation due to hydrologic alterations and reduced water availability because of water diversions, fragmentation and passage

impediments from dams and diversions, and the widespread invasion of nonnative fishes that either hybridize with (in the case of native suckers), compete with, or predate upon native fishes. The ability of the Three Species to exploit ephemeral and intermittent tributary habitats and the seasonal movements (some greater than 100 miles) performed by native suckers, allows for their long-term persistence in the Colorado River.

The Upper Colorado River is well suited to coldwater fishes in its cooler high-elevation climate sustained by winter snowpack that provides cold waters that surge seasonally as runoff or upwells through springs. The widespread introduction of several trout species, Brown Trout, Rainbow Trout, and Brook Trout, and their salmonid relative, Mountain Whitefish, began in the late 1800s in the Colorado River basin. In the 1940s, Colorado wildlife officials introduced the Mountain Whitefish, another Colorado native fish, from its indigenous waters in the Yampa River to the Roaring Fork River to increase diversity in angling opportunities. Expansion of whitefish into the Colorado River above Glenwood Canyon is limited by Shoshone Dam, as it provides a substantial barrier to upstream fish passage. Once the only trout in the Colorado River, native Colorado River Cutthroat Trout continue to use the Colorado River mainstem periodically, but primarily sustain their populations in cold tributary streams where they are better suited to high elevation and isolated habitats than the introduced trout species. Coldwater sportfish and sculpin are best suited to the coldwater reaches of the Colorado River where high seasonal flows and higher stream gradients maintain hydraulic conditions for the maintenance of preferred habitats for reproduction, growth, and forage.

Rainbow Trout and Brown Trout are the two most popular sportfish targeted by anglers in Colorado (2020 Colorado Angler Survey Summary Report). Prioritized for Wild Sportfish Management, CPW categorizes the Colorado River as “302 - Salmonid Recreation Stream” which specifies that the fishery consists of mostly wild-produced trout, with some stocking of Whirling Disease (WD) resistant Rainbow Trout fingerlings to overcome losses from the WD parasite. Increasingly successful, the current fishery management strategy allows CPW to designate the Colorado River in Glenwood Canyon as a Quality Trout Water, as it is considered a productive, quality fishery where anglers are likely to catch quality-sized trout (greater than 14 inches). Fishing the Colorado River is an enticing recreational opportunity that attracts visitors and residents to the area and generates millions of dollars for local economies annually. Small native fish (sculpin and dace) serve as a nutritious food source along with a healthy macroinvertebrate community to support the sport fishery, and the rare native fishes occasionally encountered by anglers while fishing for sportfish add unexpected and unique encounters.

2.2.2 Fish Survey Results

Recent CPW fish surveys in the Shoshone Reach of the Colorado River (November 2023 and October 2024) revealed a notably high abundance of desirable fish species. These efforts were the first documented fish surveys by CPW in this section of river. The sampling included both opportunistic capture surveys for presence detection (spot electrofishing) and a population

survey to estimate relative fish abundance and biomass. The November 2023 survey occurred during an extended period of time when the Shoshone power plant was inoperable (February 2023-August 2024), allowing more natural flow conditions. Due to flow conditions, the 2023 survey was limited to electrofishing along the banks and wadeable river margins. Spot electrofishing in 2023 detected the presence of Brown Trout and Rainbow Trout, confirming trout will migrate into and use the Shoshone Reach following a period of restored flows.

In October 2024, extensive spot surveys were conducted in the dewatered river channel after the power plant came back online. The 2024 spot electrofishing surveys demonstrated the extent of Brown Trout, Rainbow Trout, dace, sculpin, Mountain Whitefish, and Longnose Sucker (in order of relative abundance) and confirmed their presence throughout the 2.4-mile Shoshone Reach. In October 2024, CPW staff also conducted a depletion estimate to survey the population for the first time in order to assess fish abundance, biomass, and size class structure of the fishery (Photo 2). Fish captured during the survey include in descending order of abundance: dace, Brown Trout (Photo 3), Rainbow Trout (Photo 4), Mountain Whitefish, Longnose Sucker, Bluehead Sucker (Photo 5), and sculpin. Table 1 summarizes the Abundance (fish/acre), Biomass (pounds/acre), and Total Fish Length from tip of nose to tip of tail in inches calculated for each fish species encountered.

Table 1: Summary of Abundance (fish per acre), Biomass (pounds per acre), and the average and range of Fish Total Lengths (inches) for an October 23, 2024 survey in a dewatered Colorado River reach between Shoshone Dam and Shoshone Hydropower Plant near Flag Buttress.

Fish Species	**Abundance** fish/acre	**Biomass** pounds/acre	**Fish Total Length Mean (Min-Max)** inches
Brown Trout	205	205.1	11.3 (3.9 – 21.9)
Rainbow Trout	157	125.6	13.0 (8.2 – 15.6)
Mountain Whitefish	20	10.2	10.6 (5.6 – 12.3)
Sculpin *spp.*	6	--	3.4 (3.2 – 3.6)
Dace *spp*.	260	--	3.8 (1.9 – 5.2)
Bluehead Sucker	8	2.3	8.3 (7.7 – 8.9)
Longnose Sucker	14	7.1	10.7 (10.0 – 11.3)

2.2.3 Fishery Discussion & Conclusion

Low flows in October 2024 in the Shoshone Reach provided CPW an opportunity to thoroughly evaluate the fishery in the high-gradient, boulder-lined river channel that would otherwise be

inaccessible. Though significantly depleted from its natural flow condition, the residual stream was sustained by a minimal flow of water bypassing the dam, perennial tributary flow, and spring flows that maintained pools, riffles, and runs to harbor a notable abundance of fishes. The presence of sub-adult Bluehead Suckers and a variety of age-classes of trout suggests that some spawning occurs in this reach in either mainstem or proximal tributary habitats. Juvenile and adult fish are able to find refuge from aquatic and terrestrial predators in the channel's limited wetted area, specifically in small habitat features created by large boulders and in runs and pools that hold residual depth. Furthermore, the persistence of large trout supports quality angling opportunities in the canyon-bound river that benefits local communities that are sustained by tourism-based economies.

The adaptability of the Three Species to intermittent and seasonally dynamic river conditions allows for their persistence in an altered river system. CPW researchers have documented the use of small tributary habitat in the Colorado River basin (Thompson and Hooley-Underwood 2019), where naturally ephemeral and intermittent stream conditions are similar to those in the Shoshone Reach under current hydropower diversion operations. Within proximity to Glenwood Canyon, fishery monitoring reaches at Lyons Gulch (6 miles upstream), No Name (lower Glenwood Canyon), South Canyon (6 miles downstream), and New Castle (13 miles downstream) have detected the presence of at least one of the Three Species during each sampling occasion between 2008 and 2024, and CPW considers the Colorado River to be occupied Three Species habitat throughout Glenwood Canyon.

The recent population survey of the Shoshone Reach in October 2024 documented the presence of juvenile Bluehead Suckers. Bluehead Sucker are more likely to exploit the local canyon reaches, as they are more often found in higher gradient, swifter velocity habitats compared to the Flannelmouth Sucker and Roundtail Chub (Thompson and Hooley-Underwood 2019). In particular, juvenile Bluehead Sucker primarily consume macroinvertebrates as a food source (2019 Conservation Strategy), thus they are likely to exploit the Shoshone Reach year-round based on the 2024 CPW macroinvertebrate and fish surveys. Flannelmouth Sucker are confirmed to use the Shoshone Reach, as a CPW PIT-tagged fish from the Eagle River was detected by a PIT-tag antenna in Debeque Canyon approximately 90 miles downstream, requiring the fish to migrate downstream through the Shoshone Reach, including the power plant diversion infrastructure. Despite their rarity, Roundtail Chub are regularly detected in approximately 50 percent of surveys at three locations surrounding Glenwood Canyon – Lyons Gulch, South Canyon, and New Castle – all of which exhibit habitat characteristics (low gradient, more turbid water) preferable to Roundtail compared to high-gradient canyon reaches (2019 Conservation Strategy). All Three Species use Glenwood Canyon at least briefly to access or find refuge given the dynamic conditions that offer seasonally and spatially variable resources. Ensuring the permanency of historical flows available through the Shoshone water right and restoring instream flow to dewatered Shoshone Reach will support the continued persistence of the Three Species in the Upper Colorado River.

The Shoshone Reach of the Colorado River in Glenwood Canyon supports a high-quality fishery, even in its seasonally dewatered state with limited wetted habitat. During the

October 2024 survey, the Shoshone Reach had very low flow, as the majority of the natural river flow above Shoshone Dam was diverted into the hydropower plant. The reduced channel, despite appearing from a distance to be flowing at a mere trickle, provides enough holding habitat in deep pools and glides and offers large cover features to harbor both small and large river fishes produced in the full spectrum of waters and resources lower in Glenwood Canyon. As the water recedes from the Shoshone Reach with declining seasonal flows, smaller fish find habitats with favorable velocities and small pools to occupy between large boulders. Microhabitats that support small-bodied fish like dace persist between small substrates and also support macroinvertebrate and algae food sources. Large predatory trout will find desirable slower velocities in deep, boulder-lined runs and pools where they successfully use these habitats to make a living through the winter – finding cover from their predators and hunting for their own prey. As encountered in the fish survey, an abundance of small-bodied prey, including sculpin, dace, and juvenile trout and suckers will sustain larger predatory trout. Rainbow Trout can subsist on the abundance of macroinvertebrates, a preferred prey item, that concentrate into the reduced wetted channel. Few competitors will invade their occupied habitat, especially for the adult fishes, as large drops in the river channel once connected by water become insurmountable (Photo 6). The presence of a variety of age classes of fish indicate that some supplemental reproduction for Colorado River native and sportfish populations occurs in the Shoshone Reach, particularly following a period of restored flows.

2.3 Biocriteria & the Macroinvertebrate Community

2.3.1 Biocriteria Overview

Macroinvertebrate data can be used to evaluate the overall health of a waterbody and to analyze stressors to an aquatic ecosystem using "biocriteria" or aquatic life metrics. Water quality samples only represent a singular moment in time and provide limited information on the combination of pollutants and stressors affecting a biological community. In contrast, macroinvertebrates are the best single assemblage for bioassessment due to their generally short life spans of approximately a year, limited migration patterns, representation in most Colorado habitats, and ease of collection. Although the Colorado Department of Health and Environment (CDPHE) has macroinvertebrate data for the COUCUC03 segment of the Colorado River from the outlet of Lake Granby to below the confluence with the Roaring Fork River, no sampling stations exist in Glenwood Canyon. To fill this data gap and assess biocriteria for the Shoshone Reach, CPW staff collected macroinvertebrate samples in the Colorado River at a location below Devils Hole Creek (CRblwDH) on November 5, 2024. During the sampling event, flows were very low (approximately 50 cfs) as the Shoshone power plant was operating (Photo 8). LRE Water performed laboratory identification of the samples and ran a standard 300-count sub-sample of the macroinvertebrate data through Colorado's Ecological Data Application System (EDAS) program. Based on the analysis, CRblwDH meets the state thresholds for macroinvertebrate health and biodiversity.

2.3.2 Macroinvertebrate Survey Results

The summary tables below reports the macroinvertebrate community metrics that the state considers when assessing a stream's macroinvertebrate community and potential impairment. Macroinvertebrate metrics and thresholds are described in CDPHE Policy 10-1. Colorado's multi-metric index (MMI) is a combination of macroinvertebrate metrics used to score sites from 0 to 100. The MMI score for CRblwDH is 64.3 which exceeds the state's threshold (greater than 45) and meets the threshold for a "High Scoring Water" (greater than 56). The two auxiliary metrics used by CDPHE are the Hilsenhoff Biotic Index (HBI) and Shannon Diversity Index (SDI). HBI is an indicator of how many pollution-tolerant insects occupy the site where higher scores indicate a pollutant-tolerant community. The HBI score for CRblwDH, 4.44, is below the state threshold of 5.8 and considered typical. The SDI metric quantifies community biodiversity, with high scores indicating a greater variety of species present in a range from 0 to 5. The SDI score for this site is 2.17, narrowly meeting the state's threshold of greater than 2.1.

Table 2: Macroinvertebrate metrics (MMI, HBI and SDI) for CPW's macroinvertebrate survey site (CRblwDH) in the Shoshone Reach

Station ID	Waterbody Name	Location	Latitude	Longitude	Collection Date	Biotype	MMI	Hilsenhoff Biotic Index (HBI)	Shannon Diversity Index
WQCC Policy 10-1						1 (Transition)	> 45	< 5.8	> 2.1
CRblwDH	Colorado River	Below Devil's Hole	39.57608	-107.20968	05-Nov-24	1	64.3	4.44	2.17

Additional metrics analyzed by CPW staff evaluate the presence of sensitive macroinvertebrate species belonging to the mayfly (*Ephemeroptera*), stonefly (*Plecoptera*), or caddisfly (*Trichoptera*) orders, also known as "EPT" taxa. The metric "% EPT non-*Baetidae*" indicates how many insects belong to the EPT orders excluding the *Baetidae* family. *Baetidae* are mayfly species that are pollution-tolerant, so they are intentionally excluded from this metric. At the CRblwDH site, approximately 90% of the individuals collected in the sample belong to EPT orders while only 25% of those species belong to the EPT category which excludes *Baetidae*, indicating that a vast majority of EPT individuals at this site were pollution-tolerant *Baetidae* species. The "% Intolerant taxa" category assesses the percentage of the sample with pollution-intolerant species. At the CRblwDH site, despite a high presence of *Baetidae* species, there is a strong presence of pollution-intolerant taxa with 39.1% of the sample belonging to that category. This sample had 23 total taxa present, which demonstrates the macroinvertebrate community is species-rich, thus considered to have relatively high biodiversity. Of the 23 taxa present, 11 taxa were EPT species. The final metric assessed by CPW is sediment Tolerance Index Value (TIV) to characterize the sediment tolerance of the macroinvertebrate community on a ranking of 1 to 10. The sediment TIV score for this site is 5.62, meeting the threshold of less than 7.2 for this region. The relatively high abundance of sediment-sensitive macroinvertebrate species indicates that fine sediments are relatively low in the Shoshone Reach, which is expected in a high-gradient transport reach with an upstream on-channel dam.

Table 3: Additional macroinvertebrate metrics assessed for CPW's macroinvertebrate survey site (CRblwDH) in the Shoshone Reach

Station ID	Waterbody Name	Location	EPT % non Baetidae	% EPT	% Intolerant Taxa	Total Taxa	EPT Taxa	Sediment TIV
CRblwDH	Colorado River	Below Devil's Hole	24.7	90.5	39.1	23	11	5.62

2.3.3 Macroinvertebrate Community Discussion & Conclusion

All indices demonstrate Aquatic Life Use attainment at this site for the macroinvertebrate community despite dewatered conditions leading up to and during the sampling event. Approximately three months of extended dewatering occurred prior to sample collection. The sample was collected in a portion of a riffle where perennial water in a low-flow channel likely persists year-round despite the diversions into the power plant (Photo 9). Even under these low flow conditions, CRblwDH is meeting and even surpassing select thresholds for macroinvertebrate health and biodiversity in the low-flow channel. This indicates both good habitat and water quality are maintained in the consistently wetted portions of the channel. When Shoshone is operational and diverting, insects entrained in the river bed outside of the low-flow channel may perish as the channel dries. Several macroinvertebrate families within the orders of stonefly (6 families) and caddisfly (5 families) are present in the Colorado River upstream of Shoshone at a survey site sampled by Timberline Aquatics near Sweetwater, but are missing in the river below Shoshone Dam (GEI, 2025). Both stoneflies and caddisflies make limited movements and live attached to or under rocks. As the waters recede, they will become stranded. This is one explanation for the low SDI score and low percentage of EPT non-*Baetidae*. The missing families would likely occupy this segment of the Colorado River if there were consistent flow throughout the channel, and they may recolonize if consistent flows return.

With an overall diverse population of macroinvertebrates in the low-flow channel, the macroinvertebrate community in the Shoshone Reach has potential to improve. The current resident community of insects serves as a population center that would expand as the wetted channel area increases with additional flow. Particularly during the winter, additional flows will result in less anchor ice within the canyon, which will likely improve the macroinvertebrate community diversity. With fluctuating river flows, fish can move in to the Shoshone Reach when flow increases, but food may be limited in rewetted habitat if the majority of insects persist in the perennial low-flow channel. A healthy and diverse macroinvertebrate community is a crucial component of the ecosystem and indicates potential for healthy fish populations.

3. Instream Flow Evaluation & Flow-Habitat Relationships

3.1 Instream Flow Evaluation Overview

CPW supports CWCB's ISF Program by providing biological and technical expertise and assists the CWCB in making a determination of whether the natural environment will be preserved and/or improved to a reasonable degree by the water made available under the proposed acquisition. CPW staff use professional judgement and best available data to make that determination and in some instances may collect additional biological data to fill data gaps. No fishery or habitat studies existed in the Shoshone Reach prior to 2023 because its gradient and occasional high flows often make it inaccessible and dangerous. In addition to fisheries sampling conducted in 2023 and 2024, CPW staff recommended collecting data necessary for an instream flow evaluation using the Instream Flow Incremental Methodology (IFIM). IFIM is a widely accepted method used to quantify how hydraulic habitat attributes relevant to fish vary with flow over a representative reach. The two-part modeling approach uses habitat suitability criteria (HSC) indices and hydraulic modeling to evaluate habitat suitability as a function of discharge for specific aquatic species. IFIM has been widely used in Colorado for instream flow evaluations on large and complex rivers, namely the Dolores River, San Miguel River, Cache La Poudre River, Blue River, and Colorado River between Kremmling and Dotsero. The IFIM methodology uses a hydraulic model, paired with HSC for fish species and life stages of interest. Habitat suitability for hydraulic variables of depth and velocity, and sometimes substrate and cover, are combined into a composite score which can be summed over the representative study reach to calculate the area of suitable habitat, also known as weighted usable area (WUA). WUA is a measure of suitable fish habitat that varies as depth and velocity change with discharge.

3.1.1 Overview Freshwater Consulting Habitat Modeling – 2023-24

In November 2023, CRD contracted with two consulting firms, River Restoration and Freshwater Consulting, to evaluate hydraulic habitat-flow relationships in the Shoshone Reach using IFIM.

Two-dimensional (2D) hydraulic modeling was performed by River Restoration using SRH-2D on a representative reach of the Colorado River. The study reach, referred to as Site 1, measured 1850 feet long with an upper terminus approximately 0.5-mile downstream of the Shoshone Dam. Site 1 includes two large pools divided by riffle. Freshwater Consulting conducted habitat suitability analysis using a spreadsheet-based model and output from the 2D hydraulic model. Suitable habitat area was modeled for flows between 50 and 3000 cfs for four focal species in their adult life stage – Brown Trout, Rainbow Trout, Mountain Whitefish, and Flannelmouth Sucker. The seven selected flow rates modeled were 50, 250, 700, 1020, 1250, 1400, and 3000 cfs.

CPW reviewed and participated in the initial model scoping and selection of appropriate focal species and associated HSC. Site-specific HSC are derived from direct observations of actual

fish locations within river habitats. In the Shoshone Reach, deriving site-specific HSC was not possible due largely to safety concerns given dangerous river hydraulics, as well as time limitations. It is standard and accepted practice to use existing HSC from literature or comparable studies based on professional judgement when site-specific HSC is not possible. For the Shoshone Reach, HSC used previously for the Colorado River Wild and Scenic reach were adapted to include fish habitat preferences that are unique to a high-gradient, canyon study area such as the Shoshone Reach, namely deep pools. Adult life stages were selected because the characteristics of the canyon generally favor these larger-bodied, mature species.

3.1.2 Results Freshwater Consulting Habitat Modeling – 2023-24

Results summarized below are from the September 30, 2024 Freshwater Consulting Report. Results show that suitable habitat area (or WUA) increases rapidly between 50 to 700 cfs for all species. For the salmonid species (Brown Trout, Rainbow Trout, and Mountain Whitefish), WUA continues to increase precipitously up to 1020 cfs. Maximum WUA occurs at 1020 cfs for Brown Trout, 1400 cfs for Rainbow Trout, 1250 to 1400 cfs for Mountain Whitefish, and 700 cfs for Flannelmouth Sucker. Habitat suitability for Flannelmouth Sucker is lower than the other species overall and declines at flows greater than 700 cfs. This is because the preferred depth of Flannelmouth Sucker ranges between 1 to 4 feet with declining suitability at depths greater than 4 feet. Alternatively, HSC for salmonid species are high for depths 10 feet and greater. Given the abundance of deep water in the pool and run habitats that dominate Site 1, these flow-habitat relationships are explained.

Overall WUA, calculated by averaging the results of the four fish species, is maximized at 1250 cfs with modest declines at flows in the 1400 to 3000 cfs range. The decline in WUA at flows greater than 1400 cfs is driven in large part by high water velocities that are less suitable for all species. The initial results for Site 1 show the highest habitat availability for Brown Trout and Rainbow Trout, Mountain Whitefish, and Flannelmouth Sucker at flows in the range of 700 to 1400 cfs. The results show modest declines in suitable habitat between 1400 and 3000 cfs, although there is still suitable habitat available for fish species at higher flows. As incremental flows between 1400 and 3000 cfs were not assessed by Freshwater Consulting, it is difficult to directly evaluate the relationship between these higher flows and WUA.

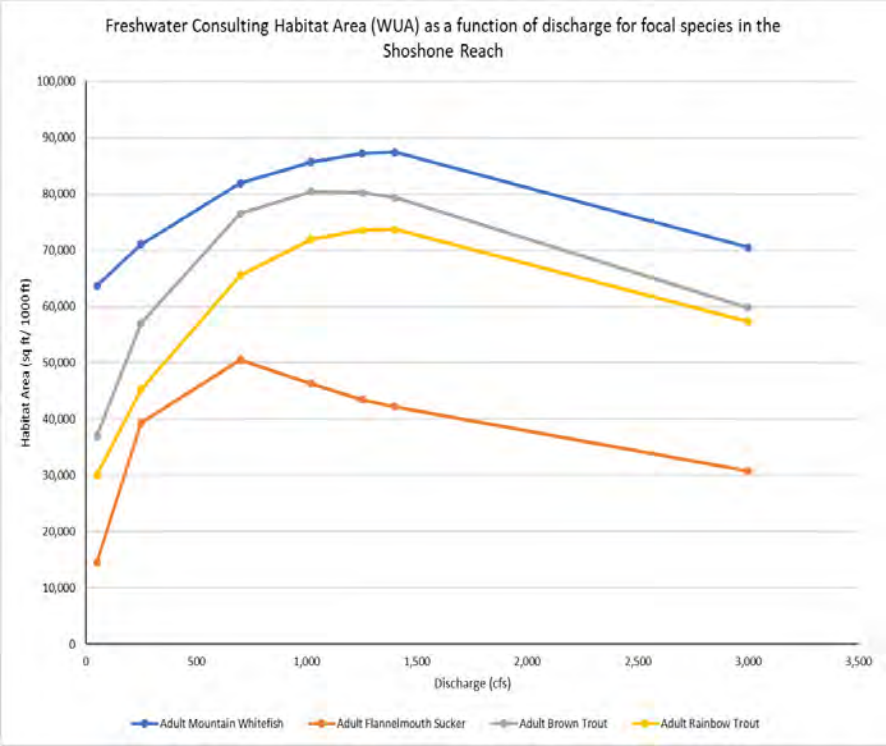


Figure 1: Freshwater Consulting assessment of Weighted Usable Area (WUA, square-feet per 1000 linear-feet of stream) across a range of river flows (cubic feet per second, CFS) for Site 1 in the Shoshone Reach of the Colorado River for four focal fish species.

3.2 Hydraulic Habitat Model Limitations

The Shoshone Reach is a high-gradient confined canyon with highly variable streambed roughness, water depths, and velocities (GEI, 2025). Within Colorado, there are multiple examples of canyon reaches like the Shoshone Reach supporting dynamic and high quality habitats for coldwater sportfish such as Brown Trout and Rainbow Trout, including the No Name Reach on the Colorado River, Gunnison Gorge on the Gunnison River, and Cheesman Canyon on the South Platte River. This is evidenced in abundance and biomass metrics documented in CPW fish surveys. Like the Shoshone Reach, many portions of these river reaches have hydraulic conditions that limit surveying efforts or make them impossible due to safety concerns. Complex hydraulics in canyon reaches like the Shoshone Reach also present nuanced fish habitat use that can be over-simplified by hydraulic habitat modeling.

The Freshwater Consulting results were developed from a single site with somewhat homogenous habitat features and a relatively coarse spatial resolution with a grid size of approximately 4 x 4 feet. While this grid size is appropriate for IFIM, it is unable to represent all microhabitat refugia used by fish. Site 1 is a pool dominated reach with two large pools divided by a boulder and cobble riffle. The reach was bound on the downstream end by a rapid created by an alluvial fan from Devils Hole Creek. This reach was selected for the survey because of surveyor safety concerns given hydraulic conditions at the time of the

survey. The limited hydraulic habitat perspective did not account for more complex habitat features present in the Shoshone Reach that are exploited by fish.

Much of the usable fish habitat in the Shoshone Reach, especially at higher flows, is in the form of velocity refuges created by variable bed substrate, large boulders, and the boundary layer of the streambed. 2D models simulate hydraulics in lateral and longitudinal directions, producing depth-average values for water velocity that moderate the variability in velocity throughout the water column. The use of depth-average velocity to calculate habitat suitability underestimates the amount of suitable habitat available in streambeds, particularly in rivers with high roughness like the Shoshone Reach of the Colorado River. Microhabitats and near-bed features used by fish are not captured with the depth-average velocities produced by the hydraulic model. Water velocities are typically lowest along the stream bed, and the variability in channels with high roughness will be even more pronounced. In channels with high roughness, actual velocities along the stream bed can be 40 to 60% lower than the depth-average velocity. Therefore, habitat suitability models which rely on depth-average velocity do not account for fish-favorable velocities in roughness features. In the Shoshone Reach, this likely resulted in an underestimate of suitable fish habitat.

3.2.1 Overview Ecosystem Sciences Habitat Modeling – 2024-25

During fall 2024, CRD contracted River Restoration and Ecosystem Sciences, an Idaho consulting firm, for additional modeling to better understand the relationship between fish habitat and flows in the Shoshone Reach. During the fall and winter of 2024-25, River Restoration and Ecosystem Sciences performed fieldwork to assess a second study site (Site 2) and address the limitations in the initial analysis. The addition of Site 2 increased the spatial coverage of the hydraulic habitat model and introduced increased channel complexity and habitat features into the model. The upper terminus of Study Site 2 is immediately downstream of Site 1 and the reach is approximately 1830 feet long. Site 2 is lower gradient and less constrained with a greater variety of habitat features, including a split-channel island, more variety in the bed composition, and complex riffle, run, and pool habitats. Adding Site 2 increased the total spatial representation of habitat evaluated to include approximately 29% of the Shoshone Reach. Lastly, five additional higher flow rates were also modeled for both sites to develop a better understanding of the habitat-flow relationships between 1500 and 3000 cfs. For the 2024-25 modeling effort, habitat suitability was evaluated at flows of 50, 250, 700, 1020, 1250, 1400, 1500, 1750, 2000, 2250, 2500, and 3000 cfs.

3.2.2 Results Ecosystem Sciences Habitat Modeling – 2024-25

Results summarized below are from the April 22, 2025 Ecosystem Sciences report. Results for Site 1 assessed by Ecosystem Sciences (Figure 2) demonstrate a similar trend to the Freshwater Consulting results (Figure 1) with steep increases in WUA for each species between 50 and 700 cfs. For Brown Trout and Rainbow Trout, WUA continues to increase sharply until 1020 cfs. Maximum WUA occurs at 2250 cfs for Brown Trout and Rainbow Trout,

2000 cfs for Mountain Whitefish, and 1500 cfs for Flannelmouth Sucker. Overall WUA is maximized at 2250 cfs. Above 2250 cfs, WUA generally plateaus and slightly declines between 2500 and 3000 cfs. This differs from the Freshwater Consulting Site 1 evaluation, but it is difficult to compare the two because incremental flows between 1400 and 3000 cfs were not evaluated by Freshwater Consulting.

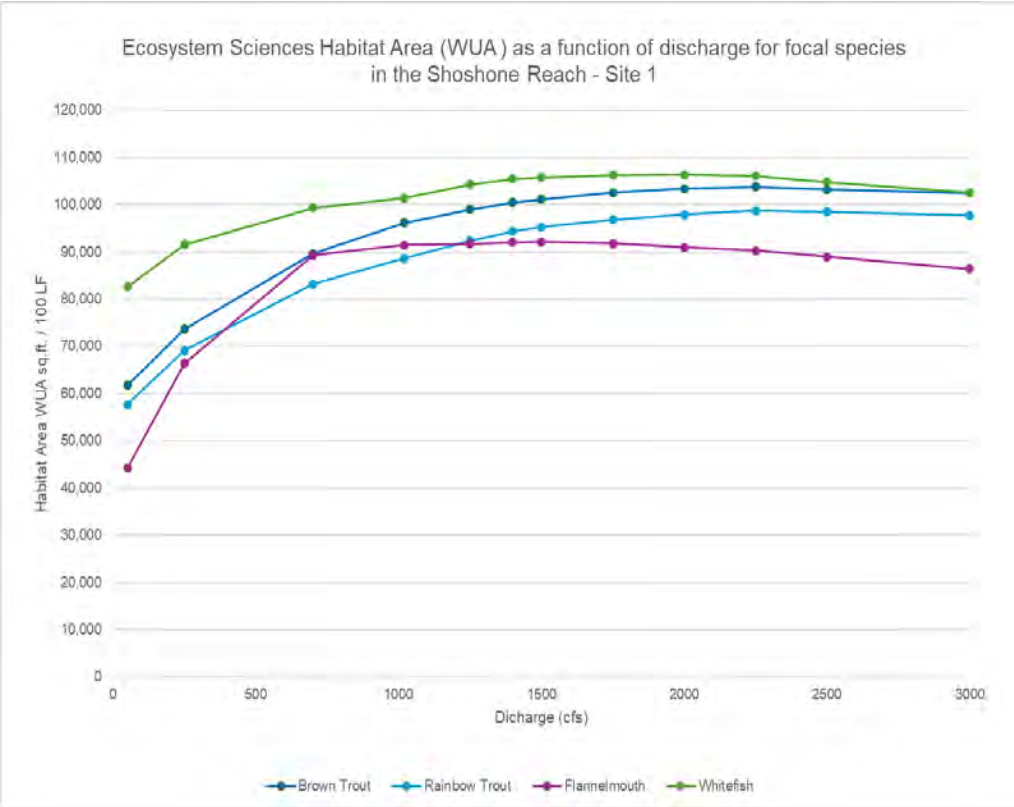


Figure 2: Ecosystem Sciences assessment of Weighted Usable Area (WUA, square-feet per 1000 linear-feet of stream), across a range of river flows (cubic feet per second, CFS) for Site 1 in the Shoshone Reach of the Colorado River for four resident fish species.

Results for Site 2 (Figure 3) demonstrate a trend of gradual and consistent increases in WUA for all four species as flows increase (as compared to the dramatic increase followed by a plateau in Site 1). Site 2 has a less constrained channel and floodplain compared to Site 1. Site 2 has more habitat complexity and depositional features that create a mid-channel island that splits the river at lower flows. Site 2 also contains deep pool and shallow riffle features similar to Site 1. For the four species evaluated, maximum WUA occurs at relatively high flows with a maximum WUA at 3000 cfs for the salmonid species and 2000 and 3000 cfs for Flannelmouth Sucker. Benefiting from the hydraulic complexity within Site 2 and supporting their lower depth and velocity preferences, WUA for Flannelmouth Sucker is greatest at Site 2. As flows increase in Site 2, portions of the islands inundate, and the split channels expand and connect, increasing the variety of depth and velocity conditions suitable for Flannelmouth Sucker. Conversely, for adult salmonids, WUA is lower at Site 2 than Site 1, though Site 2 still contains important habitats.

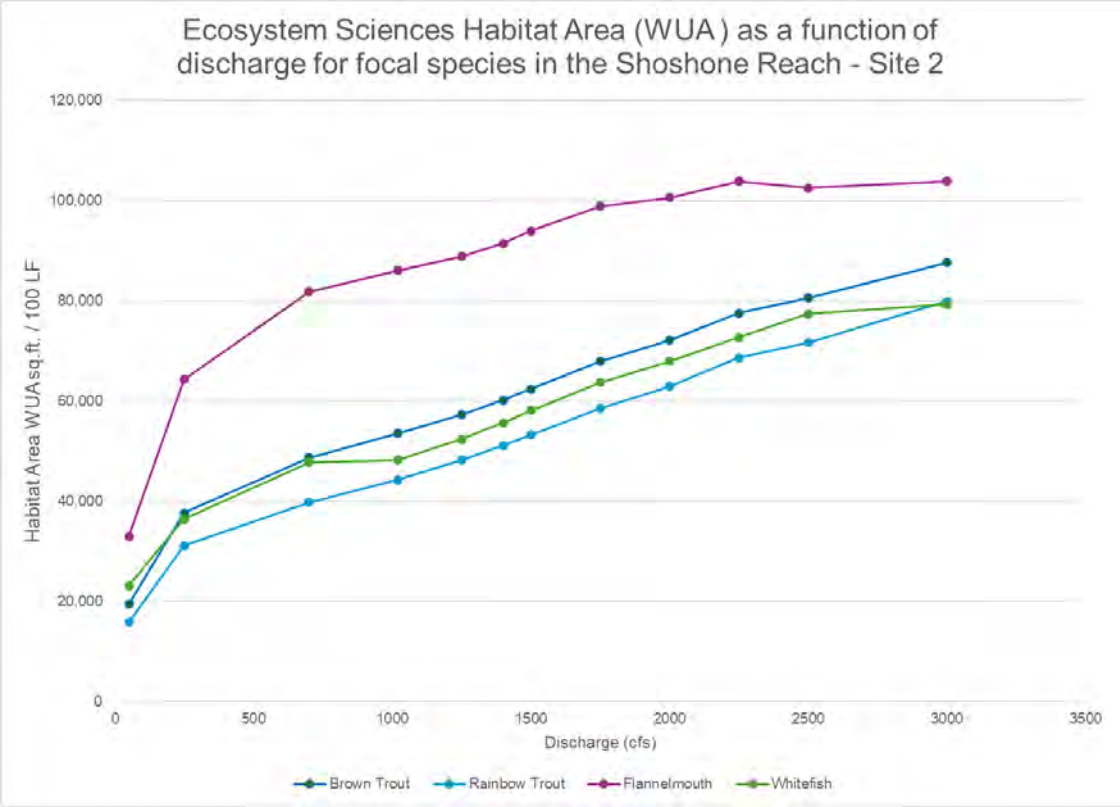


Figure 3: Ecosystem Sciences assessment of Weighted Usable Area (WUA, square-feet per 1000 linear-feet of stream), across a range of river flows (cubic feet per second, CFS) for Site 2 in the Shoshone Reach of the Colorado River in Glenwood Canyon for four resident fish species.

Adult life stage species were the focus of the habitat modeling because of complex hydraulic conditions in the Shoshone Reach. While not specifically modeled, juvenile trout will benefit from the same lower velocity, shallow habitats that benefit Flannelmouth Suckers. These conditions provide suitable rearing conditions for juvenile trout. Spawning habitat was not explicitly modeled but gravel bars provide spawning habitat for fish including Bluehead Suckers and Flannelmouth Suckers at a wide range of flows. Gravel bar deposits are present around the island features at Site 2 and is where Brown Trout redds were observed in late Fall 2024 (Photo 7).

3.2.3 Addressing Modeling Limitations

The Shoshone Reach is a high-gradient river with highly variable streambed roughness, water depths, and velocities which contributed to high velocities represented by the hydraulic model that under-represented actual suitable fish habitat availability. To address this issue, Ecosystem Sciences used an additive model to estimate the composite habitat suitability by adding depth and velocity suitability for each cell from the hydraulic model. Conversely, Freshwater Consulting used computations that multiplied depth and velocity suitability to estimate the composite habitat suitability score for each cell. The limitation of the multiplicative approach for composite suitability is that high depth-average velocities will result in low or zero habitat suitability scores for areas where suitable velocities are actually

present along the rough streambed. In Freshwater Consulting's computations, velocity suitability scores of zero will drive the overall habitat suitability to be deemed unsuitable. This misrepresents velocity refuges used by fish and underestimates suitable habitat because in reality suitable velocities exist along the streambed in roughness features. In fact, a substantial amount of these roughness features exist in the Shoshone Reach due to the highly variable substrate, velocities, and depths (GEI, 2025). Therefore, suitable habitat is under-represented by traditional IFIM modeling computations in steep canyon reaches like the Shoshone Reach. When using an additive model to estimate habitat suitability to account for a high degree of roughness in the channel, WUA results account for microhabitat features that provide important fish habitat.

3.3 Discussion and Conclusions on Flow-Habitat Relationships

Given the limitations and uncertainties discussed above, it is helpful to review the results from the Freshwater Consulting and Ecosystem Sciences reports in conjunction with one another. Freshwater Consulting used a more traditional approach for IFIM that multiplied depth and velocity suitability to estimate the composite habitat suitability and associated WUA. As previously discussed, this approach likely underestimated suitable habitat used by fish in the Shoshone Reach due to the use of depth-average velocity, particularly at higher flows. The Freshwater Consulting results indicate that overall WUA was highest between 1250 to 1400 cfs at Site 1 when averaged across the four fish species. Overall WUA increased steeply from 50 to 700 cfs before plateauing between 1020 and 1400 cfs and then declining from 1400 to 3000 cfs. As no flow values were evaluated between 1400 and 3000 cfs, it is not clear how WUA changed in between these values.

The Ecosystem Sciences report analyzed WUA at two sites within the Shoshone Reach, including the same site evaluated by Freshwater Consulting (Site 1), using an additive approach for estimating composite habitat suitability from modeled water depths and velocities. This approach was intended to address the aforementioned limitation of using depth-average velocity to calculate the composite habitat suitability. When averaged across all species, WUA peaked at 2250 cfs at Site 1. Similar to the Freshwater Consulting results, WUA increased sharply for all species between 50 and 700 cfs. WUA then increased gradually between 700 and 2000 cfs, and declined slightly between 2250 and 3000 cfs. At Site 2, there was a very steep increase in WUA between 50 and 250 cfs and a more moderated increase between 250 and 700 cfs when averaged across species. WUA then increased steadily from 1020 to 3000 cfs with no evidence of a distinct plateau.

When considered together, the habitat suitability studies by Ecosystem Sciences and Freshwater Consulting indicate that using the Shoshone water rights of 1250 and 158 cfs for a total of 1408 cfs would benefit fish habitat, as WUA consistently increased at both sites from 50 to 1400 cfs on average. However, the two reports differ in what happens to WUA above 1400 cfs. The Freshwater Consulting report indicates the WUA declines at 3000 cfs. In contrast, the Ecosystem Sciences report indicates that WUA continues to increase (Site 2) or remain relatively stable (Site 1) for flows greater than 1400 cfs. Given the limitations of

using depth-average velocity to estimate the total amount of suitable habitat in the Shoshone Reach, which provides complex and dynamic conditions that support fish, it is likely that habitat suitability does not decrease significantly as flows increase up to 3000 cfs due to the presence of lower velocities near roughness features.

3.3.1 Other Considerations in Assessing Flow-Habitat Relationships

With regard to suitable habitat, the importance of deep pools in habitat suitability models is often underestimated and modifications for the presumed importance of deep pools in the Shoshone Reach are substantiated by CPW research. Recent CPW research shows that residual pool depth is the most important physical habitat variable driving Brown Trout population biomass. Additionally, this research shows that Quality Brown Trout were only present in pools with depths of 3 feet or greater and total fish biomass increased with increasing residual pool depth (Kondratieff and Richer 2022). In addition to this research, many other studies from Colorado rivers have shown the value of deep pools in providing important habitat functions for native Cutthroat Trout and Mountain Whitefish, such as depth cover, overwinter and low-flow refugia (Harig et al. 2000, Behnke 2002, Beinstadt et al. 2004). Important pool habitat exists in the Shoshone Reach even under dewatered conditions. Additional water provided by the instream flow acquisition will support refreshening flows to maintain these pool habitats.

High flows provide important geomorphic and ecological functions related to sediment transport and habitat for benthic macroinvertebrates. Flushing fine sediment is critical to maintain habitat for fish and macroinvertebrates, especially in locations that receive episodic sediment inputs, which has been a recurring issue in Glenwood Canyon following recent wildfires. As wetted area increases with discharge, there is more habitat available for macroinvertebrates, the primary prey resource for the fishery. Higher flows may also activate new pathways through high-gradient rapids and steep drops, which could improve conditions for fish movement in some locations, providing access to a more optimal refuge habitat. The combination of increasing WUA and improved geomorphic and ecological functions indicates that using the Shoshone water rights for instream flow would be beneficial for the fishery in the study reach.

Instream flows in the Shoshone Reach will increase suitable habitat for coldwater sportfish and native species. Recent habitat suitability studies have demonstrated that when greater flows are present, the amount of usable habitat for Rainbow Trout, Brown Trout, and Mountain Whitefish increases substantially up to 1400 cfs (Freshwater Ecosystems 2024 and Ecosystem Sciences 2025) and will improve or maintain habitat to flows approaching 3000 cfs (Ecosystem Sciences 2025). Restored instream flows in the Shoshone Reach will increase wetted habitat area for fish and macroinvertebrates and will maintain pool depths that provide important cover and refugia in the Shoshone Reach, which, based on these corroborating studies, will promote increased fish abundance and enhanced angling opportunities for Quality Trout.

4. Colorado River System Assessment

In addition to benefitting the natural environment within the Shoshone Reach, the proposed acquisition will provide benefits throughout the Upper Colorado River by providing a call that maintains the historic flow regime and will continue to support the quality of fisheries. The following sections describe the benefits provided by the Shoshone water rights beyond the benefits to the Shoshone Reach.

4.1 Upper Colorado River Wild and Scenic Reach

Four segments of the Colorado River from Kremmling to No Name Creek in Glenwood Canyon (Map 2) were identified by the Bureau of Land Management (BLM) and U.S. Forest Service White River National Forest (WRNF) as eligible for inclusion in the Wild and Scenic Rivers system due to their Outstandingly Remarkable Values (ORVs). ORVs are unique or exemplary river-related values highlighted for protection for future generations. Within the Colorado River, the specific values include fishing, boating, scenic viewing, hiking, and geological features. The Wild and Scenic designation comes with protections from significant future channel and streamside development and can include federally-held water rights. Due to competing water needs and development in the Colorado River, a stakeholder group was formed to develop a plan to protect and enhance these values in lieu of a federal Wild and Scenic designation. The Upper Colorado River Wild and Scenic Stakeholder Group (SG) includes both east and west-slope water providers, local interests, environmental groups, and state agencies. The SG adopted a Wild and Scenic alternative management plan with the goal of protecting the ORV's without limitations imposed by the federal designation and water right. CPW is a cooperating agency in the SG Plan and participates in large part because the fishery in the Colorado River between Kremmling and Glenwood Springs is an important recreational asset with a high number of Quality Trout markers, high biomass, and high usage, the foundation of the Fishing ORV. CPW's fishery management goals include managing for desirable species of Brown Trout, Rainbow Trout, Mountain Whitefish, Bluehead Suckers, Flannelmouth Suckers, Roundtail Chub, sculpin, Speckled Dace, and Cutthroat Trout. Long-term fishery monitoring sites were established by CPW in 2008 throughout the Upper Colorado River Wild and Scenic reach to monitor fish population metrics and ensure that the Fishing ORV is protected (Map 3).

A key component of the SG Plan is "Long-Term Protection Measures" identified by the SG to provide for significant protection of the ORVs. The SG Plan specifically identifies the Shoshone water rights as critical to maintaining streamflows and protecting the ORVs in the Colorado River by calling water through the upstream Wild and Scenic segments to the power plant. According to the SG Plan, "this administrative call generally results in stream flow through the subject stream segments in amounts greater than would exist in the absence of the administrative call." Securing ISF water rights decreed to the CWCB was another key component to protecting ORVs on the Colorado River between Kremmling and Dotsero. In 2013, three ISF reaches were appropriated by CWCB on the Colorado River between the Blue River and the Eagle River confluence. CPW was involved in the quantification of these ISF segments and their associated flow rates. In addition to helping maintain flow-related ORVs,

the senior call by the Shoshone water rights helps to satisfy the CWCB's ISF rights, which are junior in priority. Maintaining adequate streamflows is crucial for supporting streamflow-influenced ORVs, specifically recreational fishing, floatboating, wildlife, botanical, and scenic qualities.

Table 4: Decreed ISF rights in the Wild and Scenic reach of the Colorado River

Segment	Decreed flow rates (cfs)	Priority Date
Colorado River between Blue River and Piney River	750 cfs (8/1 – 9/15) 500 cfs (9/16 – 5/14) 600 cfs (5/14 – 7/31)	07/12/2011
Colorado River between Piney River and Cabin Creek	800 cfs (8/1 – 9/15) 525 cfs (9/16 – 5/14) 650 cfs (5/15 – 7/31)	07/12/2011
Colorado River between Cabin Creek and Eagle River	900 cfs (5/15 – 6/15) 800 cfs (6/16 – 9/15) 650 cfs (9/16 – 5/14)	07/12/2011

4.2 Temperature Exceedances

Maintaining adequate seasonal streamflows is not only crucial for preserving ORVs but also plays a significant role in regulating water temperature. The Upper Colorado River's water temperature is influenced by seasonal precipitation, ambient air temperature, and flow conditions. The river flowing downstream from higher to lower elevation climates influences the natural warming trend from Kremmling to Glenwood Springs, with peak runoff periods temporarily moderating temperature differences along the stream gradient with high snowmelt flow volumes. During late summer and early fall, heat accumulation becomes more pronounced, particularly during low flow periods and when upstream reservoir releases are minimized. According to data reported annually by the SG, acute temperature standard exceedances did not occur between 2021 and 2025, as measured by the Daily Maximum (DM) temperature. However, chronic temperature standards exceedances (maximum weekly average temperature, MWAT) are a recurring issue across wet, dry, and average year-types during summer months. In 2023, an average water year, exceedances of the chronic temperature standard occurred upstream near Catamount and Red Dirt Creek beginning in early August and chronic temperature exceedances in Glenwood Canyon persisted for 3 to 4 weeks. In 2024, a wet water year, chronic temperature standard exceedances returned at Catamount and extended downstream through Glenwood Canyon from July through August, enduring for 2 to 3 weeks between Catamount and Red Dirt Creek and extending nearly 6 weeks from Dotsero to Glenwood Springs. Chronic temperature exceedances indicate repeated and extensive thermal stress is occurring in coldwater fishes during the summer months. Additional stresses such as hooking and handling stress from anglers or sediment

caused by monsoonal rain events, can create compounding impacts to fish health and mortality.

In 2010, CDPHE identified a reach of the Upper Colorado River from Kremmling to the Roaring Fork River on Colorado's Section 303(d) List of Impaired Waters due to repeated temperature exceedances that impair Aquatic Life Use (CDPHE Regulation #93). CDPHE identifies this segment at the lowest level of attainment, #5 - Impaired without a Total Maximum Daily Load (TMDL) plan, thus it has been a High Priority for TMDL development. In December 2024, CDPHE finalized Regulation #33 to create distinct water quality standards for the Upper Colorado River Basin. Regulation #33 specifies that temperature should maintain normal diurnal and seasonal fluctuations with no abrupt changes and not increase temperature at a magnitude, rate, and duration deemed deleterious to the resident aquatic life. The regulation sets temperature standards for the segment of the Colorado River between its confluence with the Blue River and the Roaring Fork River that are an amalgamation of Coldwater Stream temperature standards similar to those developed for Tier 1 species (Brook Trout & Cutthroat Trout) and Tier 2 species (other coldwater fishes) species depending on season.

Since the temperature impairment listing, stressful summer water temperatures above 70°F for coldwater sportfish in the Colorado River have become increasingly frequent. Seasonally high water temperatures resulting from low flows and hot ambient air temperatures can cause stress that impacts fish health, spawning success, and increases disease and mortality. Sediment flows from summer monsoonal rains can amplify physical stress on fish directly through tissue abrasions on skin and gills, and indirectly by enhancing solar radiation on the turbid waters. During sustained periods when daily water temperatures peak above 70°F and fish stress, disease, or mortality is observed in areas of moderate to high angling pressure, CPW implements voluntary fishing closures informing anglers not to fish in affected river reaches to protect local coldwater sportfisheries. Mountain Whitefish appear to be the most sensitive to summer stressors as mortalities with high temperatures, handling stress, and sediment events are documented more frequently than other fishes. Furthermore, their once notable spawning runs are significantly diminished in Grizzly Creek and No Name Creek in Glenwood Canyon. These same factors affect Rainbow Trout and Brown Trout where CPW has documented disease outbreaks and physiological stress from low water and high temperatures cause ubiquitous lesions and fungal infections on unusual numbers of trout and furunculosis outbreaks in the Eagle River, a tributary in close proximity to Glenwood Canyon.

Adequate and reliable river flows associated with the Shoshone call can help maintain water temperatures for popular coldwater sportfish. When ambient air temperatures are high in the late summer, additional flows can help mitigate excessive river warming. Greater flows not only moderates temperature effects directly, but it can also increase available wetted habitat, alleviate fish crowding, which reduces stress and disease transmission, and improves river connectivity to allow fish to move to more optimal habitat conditions elsewhere. In addition to Long-Term Protection Measures identified by the SG to protect the ORVs, the SG has identified Tier 2 "Cooperative Measures" which are voluntary actions to improve stream

conditions to protect the ORVs. Strategic releases from upstream reservoirs have been implemented in recent years to supplement low flows and mitigate harmful temperatures in the Colorado River.

4.3 Anchor ice and winter temperature issues

Low flows can also affect aquatic organisms in the winter. During periods of low flow, cold temperatures can impact fish in the Colorado River. When temperatures drop well below freezing, depleted baseflows can lead to the formation of anchor ice and ice dams that impound floating ice and water and deplete downstream reaches. Anchor ice can eliminate occupiable habitat for macroinvertebrates and fish. During freeze-thaw cycles, the ice dams can break, releasing a wave downstream that scours the riverbed causing localized mortality to macroinvertebrates and fish and flushes organisms downstream. The breaking of ice dams can also pose hazards for people and infrastructure near the river. In December 2010, an ice blockage on the Shoshone power plant intake prevented diversion to the penstocks and with the dam gates frozen closed, river flows were functionally shut off in the Colorado River between Shoshone Dam and Roaring Fork River from December 14 to 16, with the exception a few tributary inputs and springs. During the extensive dewatering of lower Glenwood Canyon, a fish kill occurred at the canyon mouth near hot spring inputs, leading to documented mortalities of trout and native sculpin due to high water temperatures. Additional streamflows from the proposed acquisition will mitigate incidences like this, as well as anchor ice formation. The proposed acquisition will also supplement baseflows providing additional useable overwintering habitat for fish and macroinvertebrates.

4.4 Lower Glenwood Canyon Fishery Resources

The Colorado River downstream of the Shoshone Reach supports a thriving coldwater sport fishery comprised of Brown Trout, Rainbow Trout, and Mountain Whitefish, as well as the Three Species. Return flows from the Shoshone power plant create and maintain a diversity of habitat features that support reproduction, recruitment, and seasonal needs of resident fishes. With more consistent flows below the power plant outfall, wetted habitat fluctuates more naturally with a less altered hydrograph, and habitat is maintained and connected by gradual seasonal changes in flow. CPW fish surveys from 2021, 2023, and 2024 consistently recorded high trout numbers, particularly quality-sized trout, reaffirming that lower Glenwood Canyon is a premier fishery. Traditional riverine riffle-pool sequences support a productive macroinvertebrate and fish community where sediment transport functions are maintained. These flows sustain a resilient aquatic ecosystem that is essential for both sport fishing and native fish conservation. Two large tributaries located downstream of the power plant, Grizzly Creek and No Name Creek, provide critical spawning habitat for Rainbow Trout, Brown Trout, and Mountain Whitefish. Reproductive habitat is generally limited by the fluvial geomorphology in the mainstem river in Glenwood Canyon, so connection to tributary habitats is important. These tributaries also contribute coldwater inputs as their headwaters originate at elevations well over 10,000 feet in the Flat Tops that encompass the northern portion of Glenwood Canyon. Self-sustaining trout and whitefish populations in the Colorado River are maintained by reproduction and recruitment from coldwater tributaries. Similarly, warm and

cool-water perennial, intermittent, and ephemeral tributaries play an important role in spawning for the native Three Species. Fishing regulations implemented by CPW recommend annual spawning closures for the Colorado River in and around the tributaries of Elk Creek, Canyon Creek in Garfield County, No Name Creek, and Grizzly Creek, as the aggregations of large river fish amassing in relatively small tributary streams are easy targets for anglers. Additional flows provided by the Shoshone water rights help ensure these tributary habitats are accessible, providing critical reproductive habitat and seasonally variable river resources for resident fish. Connectivity within mainstem habitats and accessibility to tributaries are both imperative to sustaining Colorado's outstanding sportfishing opportunities and long-term persistence of native fishes.

4.5 Quality Trout and Gold Medal Fisheries

CPW manages the Colorado River for Quality Trout fishing opportunities including Gold Medal Waters. A Quality Trout is defined as a trout that exceeds 14 inches in length, contributing to a high-quality fishing experience for anglers. Designated Gold Medal Trout fisheries exhibit a high density of Quality Trout (greater than 12 trout over 14 inches per acre) and high trout biomass (greater than 60 pounds per acre) that provide the highest quality fishing experiences. The fishery in the Colorado River provides increased opportunities to capture Quality Trout and reaches that meet Gold Medal criteria are designated Gold Medal Waters. The Colorado River is designated Gold Medal in two reaches upstream of the Shoshone Reach: Fraser to Troublesome Creek and Canyon Creek in Grand County to Rock Creek. Additionally, two tributaries to the Colorado River also contain Gold Metal Waters, the Blue River and Gore Creek. The historical flow regime provided by the Shoshone call and recent efforts to introduce whirling disease-resistant Rainbow Trout support fishery enhancements that strive to meet Gold Medal metrics in Glenwood Canyon. A more recent identification of the Colorado River as a Quality Trout Water from Rock Creek downstream to Rifle signals to anglers the increased opportunity and accessibility to catch large Quality Trout in the Colorado River, including through Glenwood Canyon. Maintaining the historical flow regime in the Colorado River is essential to sustaining the existing high-quality fishery and could facilitate the return of abundant wild Rainbow Trout and push the segment between Glenwood Canyon and Rifle towards a Gold Medal designation.

4.6 Maintaining and Restoring River Connectivity

The Upper Colorado River, including the Shoshone Reach, lies in an ecoregion termed the Colorado Plateau-Wyoming Basin of the Colorado Plateau and is a specified high priority habitat in the SWAP. These larger-order rivers contain habitat features that are unavailable in smaller streams, particularly deep pools and runs, and large backwaters and floodplain areas that are inundated during high flow events. As a result, they comprise the core habitat for several native big-river fish species, though these species are also occasionally found in smaller streams (e.g., the Three Species, Bluehead Sucker, Flannelmouth Sucker, Roundtail Chub, and the federally-listed river species: Colorado Pikeminnow, Razorback Sucker, Bonytail Chub, Humpback Chub). River conditions are considered moderately or highly

impacted in many river reaches due to dams and diversions that have altered the natural hydrograph to varying degrees as snowmelt-driven peak flows are greatly reduced, as are baseflows in many cases. Additionally, dams and diversion structures function as barriers preventing upstream movement of fishes that are highly migratory species which require many miles of connected habitat to move between spawning and rearing, foraging, and overwintering habitats. These hydrological alterations, combined with channelization, bank hardening, introduction of invasive species, and other anthropogenic and climatic stressors, have degraded the condition of associated in-channel and riparian habitats. Colorado's SWAP emphasizes the protection of resources, habitat, and natural processes in these rivers. Specifically, high priority conservation actions include the securing instream flow rights, restoration and maintenance of suitable hydrological regimes, and control of invasive nonnative fish.

The Shoshone Dam disrupts the hydrologic function and river connectivity of the Colorado River, significantly impacting aquatic habitat and fish populations. Immediately upstream of the dam, the river is pooled with a flat gradient and low water velocities, leading to excessive sediment deposition and the loss of essential riffle-run sequences that characterize a healthy river. This habitat degradation diminishes macroinvertebrate productivity, reduces native sculpin habitat, and eliminates crucial refugia for juvenile fish, ultimately limiting food availability and lowering fish productivity. This lentic, highly sedimented habitat favors only the invasive White Sucker that CPW actively removes in the Colorado Basin to prevent hybridization with native Flannelmouth and Bluehead Suckers. Additionally, the dam acts as a physical barrier to upstream and downstream fish movement when diversions are occurring, and an upstream velocity barrier when closed and spilling or when bottom release gates are open. Restricting the upstream movement of fish fragments their populations and reduces access to critical spawning and rearing habitats and optimal river resources that are essential to their persistence. By altering the Colorado River's flow regime and limiting sediment transport and fish passage, the Shoshone Dam severely impacts the ecological integrity of the Colorado River surrounding Glenwood Canyon.

Within the Shoshone Reach, restoring and maintaining a more natural hydrological regime will improve fish passage. With increased water volume, drop heights will be reduced at cascades and boulder drops and downstream pool depths will be increased which increases fish passage probability. Higher flows provide increased cross-sectional habitat connectivity and wetted channel complexity, which provides alternative pathways along the channel margins when velocities in the main channel are unfavorable. Reestablishing river flows will facilitate movement for resident fish species, including desirable sportfish and the Three Species. The Three Species are endemic to the Colorado River Basin and are an important assemblage of fish for the greater Colorado River ecosystem and significant to the natural heritage of the state. Trout, whitefish, and the native Three Species will make large movements to exploit seasonally variable resources and often return to the same places to spawn. Connecting long expanses of river systems allows for nutrient cycling, fish population resiliency, and preserves genetic diversity, which is especially important within declining native species populations like those of the Three Species.

Returning natural flow conditions directly upstream of the Shoshone Dam and through the Shoshone Reach would also enhance macroinvertebrate communities and strengthen the aquatic food web that supports trout and native species populations. Macroinvertebrate surveys upstream of Glenwood Canyon indicate a stable, diverse macroinvertebrate community dominated by mayflies, caddisflies, and other pollution-sensitive taxa, signaling good water quality and nutrient cycling. Perennial flows in the Shoshone Reach could sustain a similar diverse community, ensuring a steady supply of high-quality forage for sport and native fishes alike. Furthermore, with limited riparian communities that would otherwise harbor abundant terrestrial insect food inputs for fish, aquatic macroinvertebrate drift is an essential food resource from upstream (GEI, 2025). Connected river reaches and reliable baseflows would support a thriving ecosystem, promoting fish health and population stability in the Colorado River system as a whole.

4.7 Benefits to Existing Instream Flow Reaches

The continued operation of the Shoshone call results in upstream administration that helps maintain streamflows in the upper Colorado River and many of its major tributaries. When Shoshone is calling, junior water rights are curtailed and/or reservoir replacements are made resulting in increased flows to the Colorado River headwaters and major tributaries like the Fraser, Blue, and Eagle Rivers and their tributaries. Benefits are also realized to many decreed ISF reaches held by the CWCB in the upper Colorado River Basin. The CWCB holds 350 decreed instream flow water rights upstream of the Shoshone Power Plant (CRD, 2025). In their analysis of the Shoshone water rights' impact on existing ISF reaches, CRD analyzed differences in streamflow on two ISF reaches with and without the Shoshone call using the 2024 Colorado River StateMod model. Two ISF reaches were evaluated – the Colorado River between Kremmling and State Bridge and the Eagle River between Lake Creek and Brush Creek.

Based on this analysis, there is a clear trend for both ISF reaches, which experience reduced flows absent the Shoshone call, particularly during dry years and months of August through October. The analysis showed more days when the ISF was satisfied with the Shoshone call in place. Based on CRD's analysis, the Eagle River ISF, decreed for 45 cfs in the winter and 110 cfs in the summer, would see reduced flows by 5 cfs (all years) and 7 cfs (dry years) on average absent the Shoshone call. Impacts on flows in the Colorado River at Kremmling were particularly pronounced due to compounding upstream reductions. In dry years during the months of August through October, flows at Kremmling would be reduced by 80 cfs on average if the Shoshone Water Rights were not exercised and approximately 50 cfs across all years. Under current demands absent the Shoshone call, the amount of days when the ISF reach would be met is reduced by 31% in August through October for dry years and by 19% across all months in dry years. The findings of this analysis are significant, particularly as it relates to the Colorado River near Kremmling, which has been identified by CPW as a Quality Trout Water. The Eagle River has also been identified by CPW as a Quality Trout water.

5. Conclusion & CPW Recommendation

Securing the Shoshone water rights in perpetuity is a concept that has been contemplated for decades. This proposal has broad support from a wide variety of Western Slope constituents spanning irrigation, municipal, recreational, and environmental interests. Many of these interests have also contributed financially to support the project. Permanent protection of the Shoshone water rights has been identified in a number of state-funded planning documents, including the Colorado Basin Round Table's Basin Implementation Plan(s), the Upper Colorado Wild and Scenic Alternative SG Management Plan, and the Middle Colorado River Integrated Water Management Plan. The acquisition of this non-consumptive water right aligns with CPW conservation priorities as specified in the Colorado SWAP. Overall, the corroborating studies conducted within the Shoshone Reach and knowledge-based experience of CPW's aquatic experts demonstrate that the Shoshone water right supports baseflows, habitat connectivity and habitat maintenance, and attenuates seasonally stressful conditions for important sportfish and native fishes. More consistent use of the Shoshone water rights in the Shoshone Reach for ISF purposes will provide significant preservation and improvements to natural ecological processes that support fish and macroinvertebrate communities.

It is the opinion of CPW staff that the best use of this water is to preserve and improve the natural environment at any flow rate up to 1408 cfs (the amount decreed in the senior and junior water rights). Based on hydraulic-habitat modeling, fish habitat also improves in the Shoshone Reach at flows up to at least 3000 cfs. This upper threshold is based on the upper limit of modeled flows in the hydraulic-habitat model. It is our professional opinion that flows greater than 3000 cfs also provide improvements to fish habitat by supporting geomorphic functions (e.g. moving fine sediments required for clean spawning gravels and scour and maintenance of holding habitats), supporting the aquatic food web, supporting thermal refuge areas, and creating additional fish passage pathways. Because the Shoshone Reach has been historically dewatered when the plant is operating, we believe the offered water would establish flows necessary to both preserve and improve the natural environment. Furthermore, the water right preserves the historical flow regime in the Colorado River while improving flows in the Shoshone Reach by adding additional wetted area and suitable fish habitat to a historically dewatered section of the Colorado River.

Given the demonstrated biological benefits within the Shoshone Reach, to the Colorado River headwaters and tributaries, and to the mainstem Colorado River below the power plant, CPW staff believes this acquisition will preserve and improve the natural environment and recommends the CWCB accept the interest in the acquired water. CPW believes the best use of the acquired water rights is to preserve and improve the natural environment in the Shoshone Reach of the Colorado River at any rate up to full decreed amount of 1408 cfs. Fish habitat will also be improved in the Shoshone Reach at streamflows up to at least 3000 cfs.

Photos



Photo 1: Shoshone Dam leakage during November 5, 2025 macroinvertebrate sampling event by CPW staff



Photo 2: CPW fisheries crew surveys the dewatered Shoshone Reach of the Colorado in Glenwood Canyon on October 23, 2024. (Photo Credit: K. Bakich)



Photo 3: CPW aquatic staff prepares to weigh and measure a large Brown Trout captured in an October 23, 2024 fishery survey in the dewatered Shoshone Reach on the Colorado River. (Photo Credit: K. Bakich)



Photo 4: CPW aquatic staff shows off a Rainbow Trout captured during a fishery survey on October 23, 2024 in the dewatered Shoshone Reach on the Colorado River. (Photo Credit: K. Bakich)



Photo 5: Bluehead Sucker collected October 23, 2024 during a novel fishery survey in the dewatered Shoshone Reach on the Colorado River. (Photo Credit: K. Bakich)



Photo 6: Boulder constriction in the dewatered stream in the Shoshone Reach creates a >4-foot pour-over of stream water onto a flat boulder face is insurmountable to fish moving upstream. A small constricted side channel on the left of the photo has high-velocity laminar flows that also restrict upstream fish movement. (Photo Credit: K. Bakich)



Photo 7: The red arrow points to bright, clean gravels in the Shoshone Reach of the Colorado River that are indicative of a trout redd likely created by the spawning activities of local Brown Trout during a site visit in the late fall of 2024.



Photo 8: Low flow channel during November 5, 2024 macroinvertebrate sampling event. (Photo credit: M. May)



Photo 9: CPW staff collected macroinvertebrate data in the low flow channel. 11-5-2024 (Photo credit: M. May)

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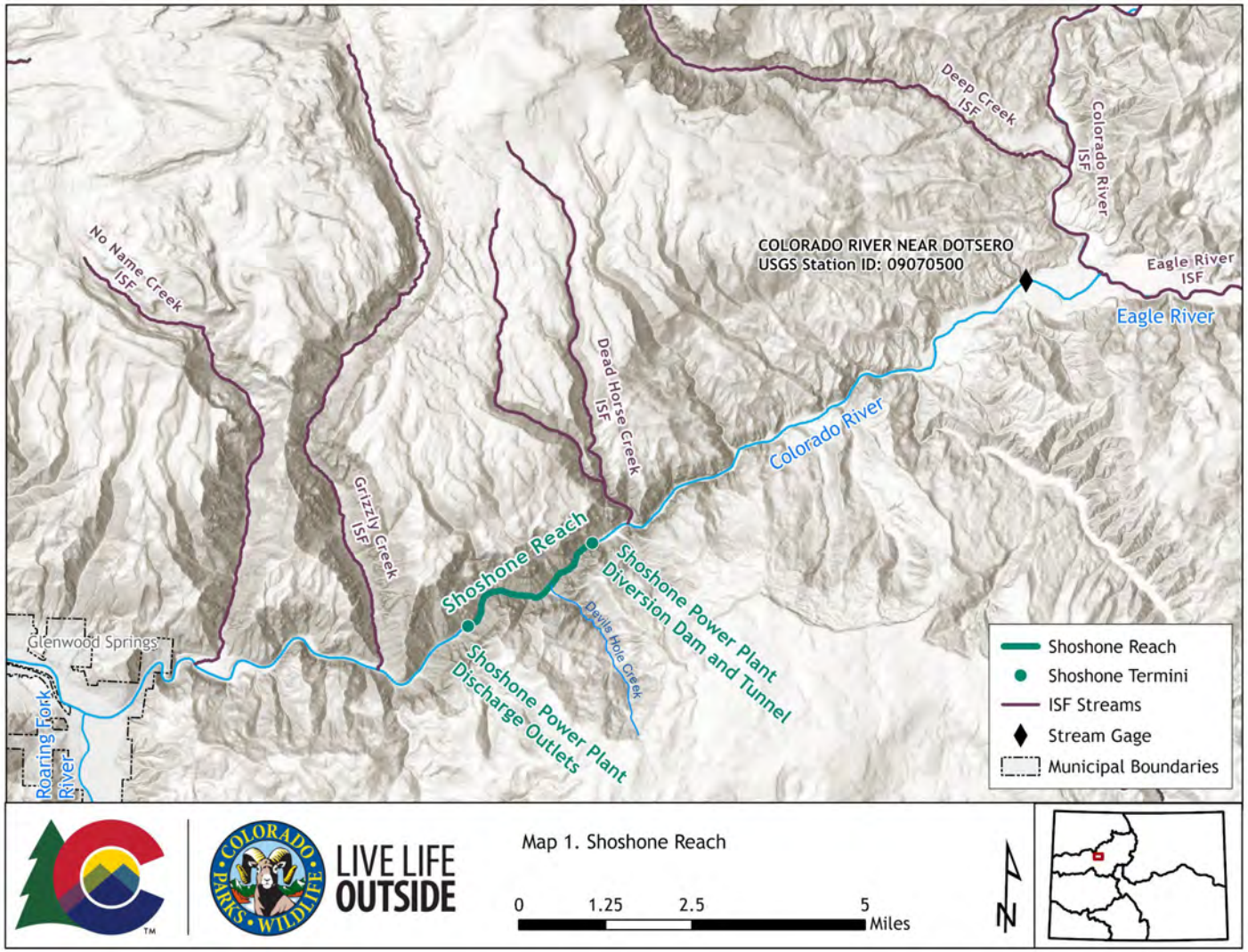
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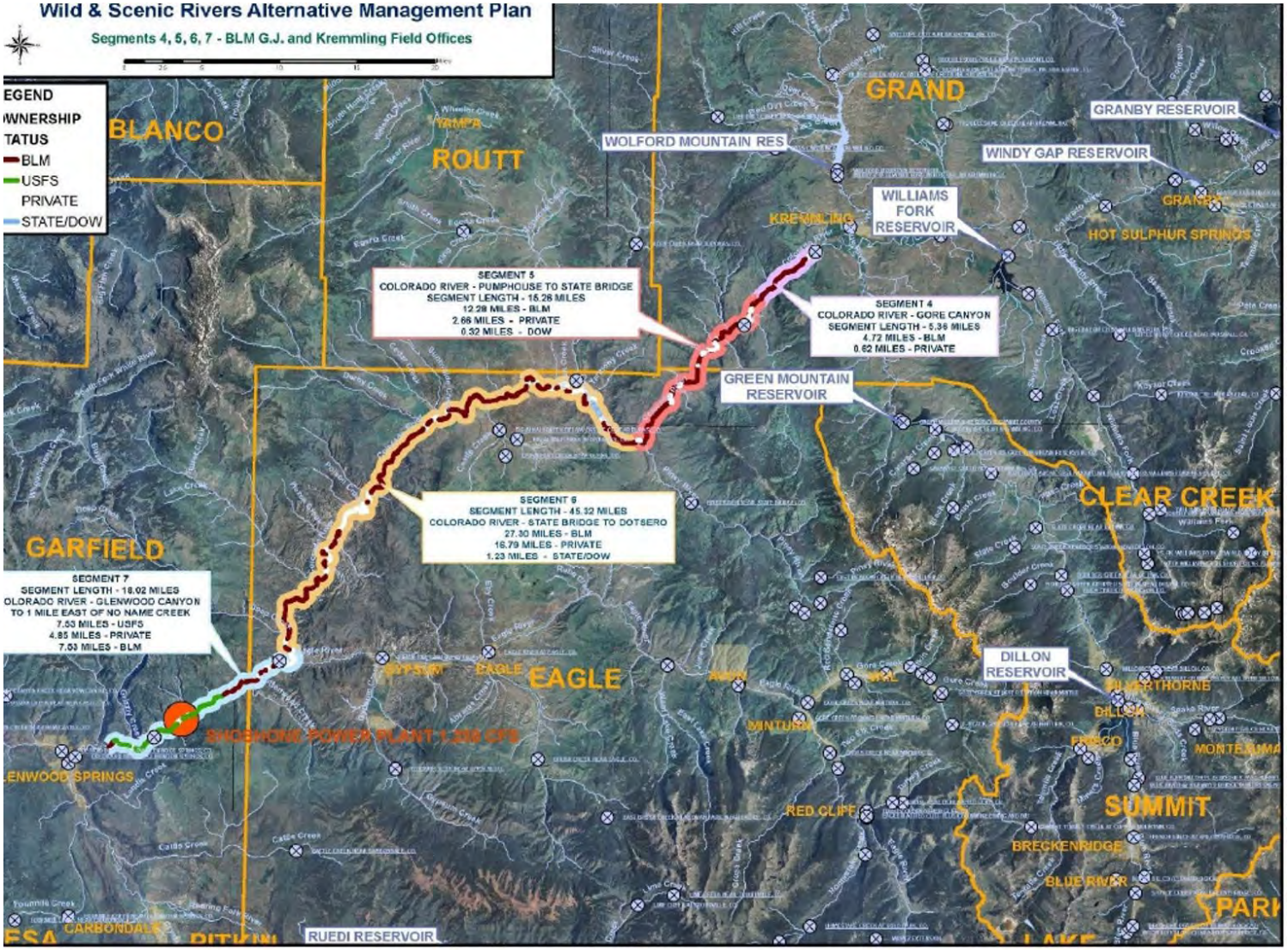
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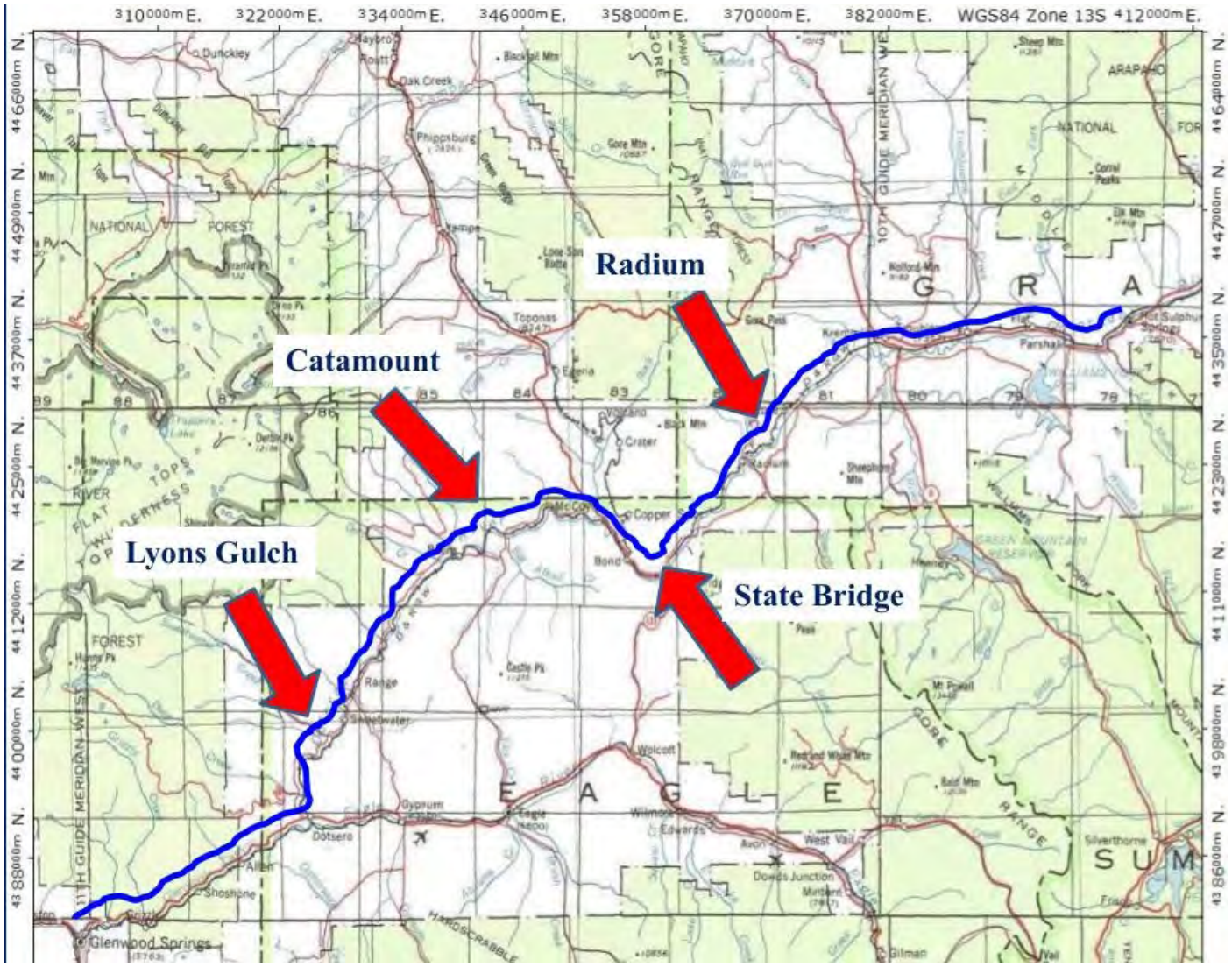
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Map 1. Proposed instream flow reach, the Shoshone Reach, where the Shoshone water rights will be dedicated for ISF use.



Map 2. Upper Colorado River Wild and Scenic Rivers segments (source: Amended and Restated Upper Colorado River Wild and Scenic Stakeholder Group Management Plan)



Map 3. CPW fishery monitoring sites in the Upper Colorado River Wild and Scenic stretch.

Enclosure E
Agenda Item 10.d
CWCB Board Meeting
May 21-22, 2025

DISTRICT COURT, WATER DIVISION 5, COLORADO Garfield County Courthouse 109 8th Street, Suite 104 Glenwood Springs, CO 81601 (970) 947-3861	
CONCERNING THE APPLICATION FOR WATER RIGHTS OF THE COLORADO WATER CONSERVATION BOARD, PUBLIC SERVICE COMPANY OF COLORADO, and THE COLORADO RIVER WATER CONSERVATION DISTRICT. In GARFIELD AND EAGLE COUNTIES, COLORADO.	▲ COURT USE ONLY ▲
Attorney for Colorado Water Conservation Board: PHILIP J. WEISER, Attorney General JENNIFER L. MELE, Reg. No. 30720* Natural Resources and Environment Section Colorado Department of Law 1300 Broadway, 10th Floor Denver, Colorado 80203 Phone: (720) 508-6282 Email: jennifer.mele@coag.gov *Attorneys for Public Service Company of Colorado:* Carolyn F. Burr, Reg. No. 25978 Jim M. Noble, Reg. No. 36716 WELBORN SULLIVAN MECK & TOOLEY, P.C. 1401 Lawrence Street, Suite 1800, Denver, Colorado 80202 Phone: (303) 830-2500 E-mail: cburr@wsmtlaw.com jnoble@wsmtlaw.com *Attorneys for Colorado River Water Conservation District*: Names: Peter C. Fleming, Reg. No. 20805 Jason V. Turner, Reg. No. 35665 Bruce C. Walters, Reg. No. 50235 Address: 201 Centennial Street, Suite 200 Glenwood Springs, CO 81601 Phone: (970) 945-8522 E-mail: pfleming@crwcd.org jturner@crwcd.org bwalters@crwcd.org	Case Number: Div.: Ctrm:
APPLICATION FOR CHANGE OF WATER RIGHTS	

PRELIMINARY DRAFT

1. Names, mailing addresses, e-mail addresses, and telephone numbers of Co-Applicants.

Colorado Water Conservation Board (the "CWCB")
Attn: Director
1313 Sherman Street, Room 721
Denver, Colorado 80203
(303) 866-3441

Public Service Company of Colorado, a Colorado Corporation ("PSCo")
Jeff West, Senior Director, Environmental Services
3500 Blake Street, CO1453-03-MCB
Denver, CO 80205
(303) 571-2762

Colorado River Water Conservation District (the "River District")
Attn: Secretary/General Manager
201 Centennial Street, Suite 200
Glenwood Springs, CO 81601
(970) 945-8522

The above-listed parties shall be collectively referred to herein as "Co-Applicants."

Please send all copies of pleadings and correspondence to:

Jennifer L. Mele, Esq.
Natural Resources and Environment Section
Colorado Department of Law
1300 Broadway, 10th Floor
Denver, Colorado 80203
(Attorney for CWCB)

Carolyn F. Burr, Esq.
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201 Centennial Street, Suite 200
Glenwood Springs, CO 81601
(Attorneys for River District)

PRELIMINARY DRAFT

1. Summary of Application.

The CWCB is an agency of the State of Colorado created to aid in the protection and development of the waters of the state for the benefit of its present and future inhabitants. Pursuant to section 37-92-102(3), C.R.S., the CWCB is authorized to acquire, by grant, purchase, donation, lease, or other contractual agreement, such water, water rights, and interests in water that are not on the abandonment list in such amount as the CWCB determines is appropriate for stream flows to preserve and/or improve the natural environment to a reasonable degree. The River District is a political subdivision of the State of Colorado charged with, among other duties, promoting the health and general welfare of the inhabitants of the River District by the conservation, use, and development of the water resources of the Colorado River and its principal tributaries. *See* §§ 37-46-101, C.R.S., *et seq*. PSCo is a Colorado corporation and is the owner and operator of the Shoshone hydroelectric power plant ("Shoshone Power Plant") located on the mainstem of the Colorado River in Glenwood Canyon, approximately six miles upstream of the City of Glenwood Springs.

The Shoshone Power Plant produces hydroelectric energy by means of PSCo's diversion of the Shoshone Water Rights, which are more particularly described in paragraph 2 below. Pursuant to the January 1, 2024 Purchase and Sale Agreement between the River District and PSCo (the "PSA"), the River District is the contract purchaser of the Shoshone Water Rights. The "PSA" (including all exhibits) is attached and incorporated hereto as **Exhibit 1.**

At its bi-monthly meeting on September ____, 2025, the CWCB determined that acquiring from the River District the exclusive right to use the Shoshone Water Rights for instream flow purposes in the reach of the Colorado River described in paragraph 3.2., below, is appropriate to preserve and improve the natural environment to a reasonable degree pursuant to section 37-92-102(3), C.R.S. Co-Applicants entered into a Water Rights Dedication and Instream Flow Agreement with the CWCB on September ____, 2025 (the "ISF Agreement," attached and incorporated hereto as **Exhibit 2**). The ISF Agreement grants to the CWCB the exclusive right to use the Shoshone Water Rights to preserve and improve the natural environment within the approximately 2.4 mile-reach of the Colorado River that extends between the Shoshone Diversion Dam and the Shoshone Power Plant's discharge outlets (the "Shoshone Reach"). The PSA provides that PSCo, or its successors and assigns is entitled to a leasehold interest in the Shoshone Water Rights for continued use of those rights for hydropower generation at the Shoshone Power Plant so long as the plant is operating.

By this Application, Co-Applicants seek to add instream flow use by the CWCB to the decreed uses of the Shoshone Water Rights. The change of water rights decree shall confirm that water attributable to the historical exercise of the Shoshone Water Rights for hydropower generation will remain in the stream to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach up to the full decreed rate of the Shoshone Water Rights of available "Natural Flow". For the purposes of this Application, the "Natural Flow" is the amount of water in the Colorado River measured at the streamflow gauge (USGS 09070500) on

PRELIMINARY DRAFT

the Colorado River near Dotsero, Colorado, located in Eagle County (the "Dotsero Gage"), including the amount of water usable by the Shoshone Water Rights when those water rights are in priority, except that the "Natural Flow" does not include any water released from storage and conducted into the Colorado River upstream of the Dotsero Gage (accounting for evaporation and transit loss), which water is intended for delivery for use downstream of the discharge outlets for the Shoshone Power Plant.

2. Decreed water rights for which change is sought and structures associated with the decreed water rights.

2.1. Glenwood Power Canal and Pipeline ("Senior Shoshone Water Right").

2.1.1. Previous Decrees. Civil Action No. 466, Eagle County District Court, decreed December 9, 1907, for a conditional water right, which was made absolute on February 27, 1911, in Civil Action No. 553.

2.1.2. Decreed Point of Diversion. The Shoshone Diversion Dam and Tunnel ("Point of Diversion") located on the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

2.1.3. Source. Colorado River.

2.1.4. Appropriation Date: January 7, 1902.

2.1.5. Decreed Uses. Power, mining, milling, manufacturing, lighting, heating, and traction purposes.

2.1.6. Amount. 1,250 cubic feet per second ("c.f.s.").

2.2. Shoshone Hydro Plant Diversion No. 2 ("Junior Shoshone Water Right").[1]

2.2.1. Previous Decrees. Civil Action No. 1123, Eagle County District Court, decreed absolute on February 7, 1956.

2.2.2. Decreed Point of Diversion. *See* ¶ 2.1.2. above.

2.2.3. Source. Colorado River.

2.2.4. Appropriation Date. May 15, 1929.

[1] The Senior Shoshone Water Right and Junior Shoshone Water Right are collectively referred to herein as the "Shoshone Water Rights" for a total combined rate of 1,408 c.f.s.

PRELIMINARY DRAFT

2.2.5. Decreed Uses. Manufacturing and generation of electrical energy.

2.2.6. Amount. 158 c.f.s.

2.3. Priorities, appropriation dates, total decreed amounts and rates of flow, and amounts Co-Applicants intend to change.

2.3.1. Co-Applicants seek to continue to use the full 1,408 c.f.s. decreed to the combined Shoshone Water Rights for the changed use for instream flow purposes, subject to terms and conditions preventing injury to other decreed water rights.

Shoshone Water Rights (all amounts are absolute and are in c.f.s.)			
Priority Date	**Appropriation Date**	**Adjudication Date**	**Total Decreed Rate of Diversion and Diversion Rate Co-Applicants Intend to Change**
December 5, 1905	January 7, 1902	December 9, 1907	1,250 c.f.s.
May 31, 1940	May 15, 1929	February 7, 1956	158 c.f.s.
TOTAL			**1,408 c.f.s.**

3. Detailed Description of Proposed Change of Water Right.

3.1. Addition of Instream Flow Use. In addition to the existing decreed hydropower generation use, Co-Applicants seek water court approval to add instream flow use of the Shoshone Water Rights exclusively by the CWCB pursuant to section 37-92-102(3), C.R.S., and the terms of the ISF Agreement (**Exhibit 2**), to preserve and improve the natural environment of the Shoshone Reach to a reasonable degree at flow rates up to 1,408 c.f.s. of Natural Flow, under their individual priorities, as measured and administered at the Dotsero Gage. Co-Applicants intend for the CWCB to use the Shoshone Water Rights for instream flow purposes to the extent that the Shoshone Water Rights are not being used by PSCo for hydropower generation at the Shoshone Power Plant. Subject to the terms and conditions of the ISF Agreement and the change of water rights decree requested herein, the CWCB shall exercise the Shoshone Water Rights for instream flow purposes to the extent that the water rights are not being exercised by PSCo for hydropower generation at the Shoshone Power Plant.

3.2. Shoshone Reach. The CWCB's instream flow use will occur in the following stream reach of the Colorado River ("the Shoshone Reach"), which is approximately 2.4 miles in length between the upstream and downstream termini. The Shoshone Reach is more particularly described below and is depicted on **Exhibit 3** attached hereto.

PRELIMINARY DRAFT

3.2.1. Upstream Terminus – Shoshone Power Plant Diversion Dam and Tunnel.

3.2.1.1. On the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

3.2.1.2. UTM Zone 13 NAD83; Easting: _____; Northing _____.

3.2.2. Downstream Terminus – Shoshone Power Plant Discharge Outlets.

3.2.2.1. On the right bank, being the northerly bank, of the Colorado River whence the Southeast corner of Section Thirty-five (35), Township Five (5) South, Range Eighty-Eight (88) West of the 6th Principal Meridian bears South 29° 24' 14" East, 1,771 feet, in Garfield County, Colorado.

3.2.2.2. UTM Zone 13 NAD83; Easting: _____; Northing _____.

3.2.3. Maximum Rate of Flow. The maximum rate of flow for the instream flow use of the Shoshone Water Rights will be their combined decreed rate of 1,408 c.f.s. of Natural Flow, under their individual priorities, for the purpose of preserving and improving the natural environment of the Shoshone Reach to a reasonable degree, subject to the terms and conditions of the change of water rights decree requested herein.

4. Quantification of Historical Exercise of the Shoshone Water Rights.

Co-Applicants will determine the historical use of the Shoshone Water Rights over a representative study period that includes wet years, dry years, and average years.

4.1. Historical Use.

4.1.1. The Shoshone Water Rights have been historically administered by the State Engineer and the Division Engineer for Water Division No. 5 (the "Engineers") at the Dotsero Gage, located approximately 8.5 miles upstream of the Shoshone Diversion Dam. The Shoshone Water Rights have historically been diverted by PSCo at the Shoshone Diversion Dam, as described in paragraph 3.2.1. above. The historical use of water attributable to the Shoshone Water Rights has been non-consumptive. The water historically diverted at the Shoshone Diversion Dam and run through the Shoshone Tunnel for delivery to the plant turbines was returned to the Colorado River at the outfall (i.e., discharge outlets) of the Shoshone Power Plant approximately 2.4 miles downstream of the Point of Diversion. *See* **Exhibit 3**. Notwithstanding the foregoing, the practice of diverting water attributable to the Shoshone Water Rights from the Colorado River and

PRELIMINARY DRAFT

into the Shoshone Tunnel for delivery to the Shoshone Power Plant means that the historical exercise of the Shoshone Water Rights has been depletive to the Shoshone Reach before the diversions are returned to the Colorado River at the Shoshone Power Plant Discharge Outlets (i.e., the Downstream Terminus described in ¶ 3.2.2. above).

4.1.2. [ ]

4.1.3. [ ]

5. Maintenance of Historical Return Flows.

5.1. Co-Applicants will maintain historical return flows by ensuring that any future use of the Shoshone Water Rights is consistent with the historical exercise of the Shoshone Water Rights, so that water will continue to be available in the stream at the same time, location, and amount at the Downstream Terminus. This maintenance of the historical return flow pattern will prevent injury to downstream water rights. Upon entry of the change of water rights decree requested herein, Co-Applicants shall maintain the return flows that historically accrued to the Colorado River at the location of the Downstream Terminus.

6. Name(s) and address(es) of owners of land on which structures are located.

6.1. _____.

WHEREFORE, the CWCB, PSCo, and the River District request the Water Court to award a change of water rights decree for the Shoshone Water Rights to confirm the addition of instream flow use by the CWCB, pursuant to section 37-92-102(3), C.R.S., to preserve and improve the natural environment to a reasonable degree in the Shoshone Reach, in the amounts and up to the full decreed 1,408 c.f.s. of Natural Flow, as set forth in this application.

Respectfully submitted this ____ day of _____, 2025.

PRELIMINARY DRAFT

COLORADO RIVER WATER CONSERVATION DISTRICT

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By: _____
Carolyn F. Burr, Reg. (#25978)
Jim M. Noble (#36716)
Attorneys for Public Service Company of Colorado

PRELIMINARY DRAFT

VERIFICATION

I, _____, state that I have read the foregoing Application for Change of Water Rights and verify its content. I declare under penalty of perjury under the laws of the State of Colorado that the foregoing is true and correct.

_____ _____

Printed Name **Signature**

PRELIMINARY DRAFT

COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

To: Colorado Water Conservation Board

From: Colorado River Water Conservation District
Public Service Company of Colorado

Subject: Technical Memorandum – Proposed Acquisition of an Interest in the Shoshone Water Rights for Instream Flow Use ("Technical Memorandum")

Date: May 6, 2025

The Colorado River Water Conservation District (the "River District") and Public Service Company of Colorado ("PSCo") provide this Technical Memorandum to assist the Colorado Water Conservation Board ("CWCB") in evaluating the proposed acquisition of an interest in the Shoshone Water Rights for instream flow use.

A. Background.

The Shoshone Power Plant is owned and operated by PSCo (an Xcel Energy company, or "Xcel"), and produces approximately 15 megawatts of electricity—enough to serve about 15,000 customers. The Shoshone Power Plant produces hydroelectric power by means of the Shoshone Water Rights, which include the 1905 senior water right in the amount of 1,250 cubic feet per second ("cfs"), and the 1940 junior water right in the amount of 158 cfs (together, the "Shoshone Water Rights"). *See* Attachment 1. The Shoshone Water Rights are fully non-consumptive, so all diverted water is promptly returned to the Colorado River.

The Shoshone Power Plant diverts water from the Colorado River via the "Shoshone Diversion Dam" which is located upstream of the Shoshone Power Plant. Once water is diverted from the river at the Shoshone Diversion Dam, it is conveyed for approximately 2.4 miles through a tunnel in the canyon walls, before dropping 167 feet through two turbines and returning to the Colorado River via discharge outlets located just below the Shoshone Power Plant. *See* Attachment 2, Map 1. Construction of the Shoshone Power Plant began in 1906, and plant operations commenced in 1909.

Figure 1: The Colorado River at the Shoshone Hydroelectric Power Plant



As is customary utility practice for the safe and prudent operation of a hydroelectric power plant, the Shoshone Power Plant was periodically taken offline, in full or in part, to conduct necessary maintenance over the course of its 115-year history. More recently, the power plant has been subject to more extended periods of outage arising from causes beyond PSCo's control. For example, in 2007, the power plant experienced a penstock blow-out resulting in significant damage to the powerhouse that required the plant to be offline for nearly a year. Then, in 2020, the Grizzly Creek Fire burned over 30,000 acres in Glenwood Canyon, destroying transmission lines and threatening the Shoshone Power Plant and its associated infrastructure. Subsequently, in 2021, Glenwood Canyon experienced repeated flooding and debris flow events carrying mud, rocks, and woody materials into the drainage basins of the canyon. These natural phenomena caused the Shoshone Power Plant to go offline for the majority of 2021. Most recently, the plant was offline for more than 15 consecutive months in 2023 and 2024 due to a combination of maintenance requirements and geologic hazard mitigation.

When offline, the Shoshone Power Plant does not generate power. Under these circumstances, or at times when the plant is operating at a reduced level due to issues related to one of the turbines, PSCo cannot *fully* exercise the Shoshone Water Rights. While PSCo has no current plans to cease operations at the Shoshone Power Plant, circumstances beyond its control have an increasing potential to lead to the reduction or abandonment of these important water rights. Unless the Shoshone Water Rights are available for instream flow use, increasingly frequent complete or partial outages of the plant due to natural hazards in Glenwood Canyon combined with the age of the plant are likely to lead to a reduction or complete abandonment of these important water rights. If the Shoshone Water Rights are no longer exercised, the result would be a significant and meaningful reduction in the historical flow regime of the Colorado River and its tributaries both upstream and downstream of the Shoshone Power Plant. The reduction in flow would be most significant during the late summer and early fall which are critical times of the year for the natural environment, fishery resources, recreational users, and water quality for municipal and irrigation

uses (significant stream reductions could also occur during the winter season and in the month of April in some years).

The risk of losing the benefits provided by Shoshone's historical flow regime remains despite the existence of the Shoshone Outage Protocol Agreement dated June 27, 2016 (the "ShOP Agreement," Attachment 3). Under the ShOP Agreement, the signatories—including the River District, Denver Water, the Colorado Division of Water Resources, the Bureau of Reclamation, and the Northern Colorado Water Conservancy District, among others—agreed to an operational approach under which some of the signatories would release or bypass water from their respective systems during certain conditions when the senior Shoshone Water Right would normally place a call for 1,250 cfs but cannot because of an outage at the Shoshone Power Plant.[1] As a term-limited contractual arrangement, the ShOP Agreement does not and cannot provide permanent protection of the historical flow regime created by the exercise of the Shoshone Water Rights. By its express terms, the ShOP Agreement is limited to the protection of a target flow of only 1,250 cfs attributable to the senior Shoshone Water Right during the irrigation season, and the protection of only 900 cfs during the non-irrigation season, which is a reduction from what the plant can and has legally diverted and used. *Id.* at p. 5, § IV.A.2.

Thus, the ShOP Agreement acts as a temporary stop-gap measure to bring some, but not all, of the flow attributable to the Shoshone Water Rights down the river when there is a plant outage. Furthermore, the ShOP Agreement has a limited term and will expire by its own terms in 2056. Importantly, ShOP cannot be made permanent without an Act of Congress. The ShOP Agreement also has numerous limitations that "excuse" water users' flow contributions during dry year conditions when flows attributable to the Shoshone Water Rights would otherwise provide the most benefit to the river. Moreover, the ShOP Agreement was not decreed by a state water court, so it is not binding on non-signatory water users and cannot bind new junior appropriations from diverting water that is contributed to the streamflow by ShOP participants. In contrast, the proposed instream flow agreement between the River District, PSCo, and the CWCB will result in a change of water rights decree, thereby maintaining the Shoshone Water Rights in perpetuity and, by doing so, ensuring the permanent protection of the historical flow regime of the Colorado River and its tributaries upstream of the Dotsero Gage.

B. Proposed Instream Flow Agreement.

The CWCB has authority, pursuant to section 37-92-102(3), C.R.S., to acquire the exclusive right to use the Shoshone Water Rights for instream flow purposes. The statute provides that the CWCB "may acquire . . . such water, water rights, or interests in water [ ] in such amounts as the board determines is appropriate for stream flows . . . to preserve or improve the natural environment to a reasonable degree." C.R.S. § 37-92-102(3). The proposed water right dedication and instream,

[1] While not parties to the ShOP Agreement, Aurora Water and Colorado Springs-Utilities also participate in a roughly identical ShOP arrangement through separate agreements with the River District and other West Slope parties.

flow agreement (the "ISF Agreement," *see* Attachment 4) is consistent with the applicable statutory framework because it will provide the CWCB with the perpetual contractual interest to use the Shoshone Water Rights for instream flow purposes as further described below.

The ISF Agreement provides that the CWCB, the River District, and PSCo will file a water court application[2] as co-applicants to change the Shoshone Water Rights to add instream flow use by the CWCB as an additional decreed beneficial use. Following the entry of the change of water rights decree, the Shoshone Water Rights will be used by the CWCB for instream flow purposes to preserve and improve the natural environment within the reach of the Colorado River in Glenwood Canyon that extends approximately 2.4 miles from the Shoshone Diversion Dam to the Shoshone Power Plant's discharge outlets (the "Shoshone Reach"). Such instream flow use by the CWCB will occur only to the extent the rights are not used for hydropower generation by PSCo at the Shoshone Power Plant and will be subject to the terms and conditions of the change of water rights decree.

C. The CWCB's Acquisition of the Exclusive Right to Use Shoshone Water Rights for Instream Flow Purposes is Appropriate for Preservation and Improvement of the Natural Environment within the Shoshone Reach.

Rule 6e. of the Rules Concerning the Colorado Instream Flow and Natural Lake Level Program, 2 CCR 408-2 (the "ISF Rule(s)") lists the factors the CWCB shall consider in determining whether to accept an interest in water for instream flow purposes. The mandatory criteria established under Rule 6.e are separately examined below in relation to the Shoshone Water Rights. Application of these criteria to the proposed ISF Agreement clearly demonstrates that there is a natural environment in the Shoshone Reach of the Colorado River, that the CWCB's acquisition of the exclusive right to use the Shoshone Water Rights for instream flow purposes in the Shoshone Reach is appropriate and will preserve and improve the natural environment, and that, in accordance with the water court change in use process, the use of the Shoshone Water Rights for instream flow purposes in the Shoshone Reach will not result in material injury to vested water rights.

1. *The natural environment to be preserved and improved by the CWCB's acquisition of the right to use the Shoshone Water Rights for instream flow purposes*.

Instream flow use of the Shoshone Water Rights will occur within the Shoshone Reach, which is an approximately 2.4-mile stretch of the Colorado River within Glenwood Canyon, extending from the Shoshone Diversion Dam to the discharge outlets of the Shoshone Power Plant. The approximate locations of the upstream and downstream points of the Shoshone Water Rights are shown in **Figure 2** and are more particularly described below:

[2] A draft water court application for the contemplated change of water rights for the Shoshone Water Rights is enclosed hereto as Attachment 14.

ISF Upstream Terminus (Shoshone Power Plant Diversion Dam and Tunnel): located on the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

ISF Downstream Terminus (Shoshone Power Plant Discharge Outlets): located on the right bank, being the northerly bank, of the Colorado River whence the Southeast corner of Section Thirty-five (35), Township Five (5) South, Range Eighty-Eight (88) West of the 6th Principal Meridian bears South 29° 24' 14" East, 1,771 feet, in Garfield County, Colorado.[3]

Figure 2: Proposed Shoshone Instream Flow Reach



The Shoshone Reach is within Glenwood Canyon and is confined on the right bank (north) by a pedestrian path and Interstate 70 ("I-70") and on the left bank (south) by the active Rio Grande Railroad. As described in an August 30, 2024, report prepared by Dr. William Miller, PhD, of Freshwater Consulting, LLC ("Dr. Miller"), the existing aquatic habitat of the Shoshone Reach consists of high-gradient riffles, pools, runs, and rapids dropping approximately 170 feet in elevation over the approximately 2.4-mile stretch. *See* "Shoshone Reach Instream Flow Habitat Data Analysis, Habitat Simulations and Habitat Evaluation of Colorado River from the Shoshone Diversion to the Shoshone Power Plant Outfall" (the "2024 Miller Report," Attachment 5). The Shoshone Reach supports multiple fish species of trout, native suckers, mountain whitefish, and sculpins as well as lower trophic level of periphyton, algae, and benthic macroinvertebrates. *Id.*

[3] The legal description set forth above for the Downstream Terminus (Shoshone Power Plant Discharge Outlets) is an approximate location developed by River District staff and may be supplemented or modified at the time a water court application is filed in Water Division No. 5.

Typical hydrology through the reach includes a high-flow runoff period with a mean peak flow of approximately 10,000 cfs in the late spring and early summer, followed by low flow conditions that can be characterized as "dewatered" during times when the Shoshone Power Plant is fully operating through the late summer and winter. During such "dewatered" periods when the plant is operating, habitat through the Shoshone Reach is connected by small inflows of groundwater and tributary streams and other sources that fill pools and flow through the large boulder and rock substrate. *See* "Shoshone Reach, Instream flow Beneficial Use and Hydraulic Habitat Suitability Assessment" (the "2025 Ecosystem Report," Attachment 6).

In addition to the benefits provided to the Shoshone Reach when the Shoshone Water Rights are not being used for hydropower generation (or are being used only at a reduced rate), the proposed instream flow use of the Shoshone Water Rights also will provide significant benefits to the greater Glenwood Canyon riverine ecosystem. In a 2024 report jointly prepared by the United States Forest Service ("USFS") and the Bureau of Land Management ("BLM") titled "Biological and Recreational Resources Dependent on Colorado River Flows Through Glenwood Canyon" (the "USFS-BLM Report," Attachment 7), the federal agencies noted, among other things, that the Shoshone Reach supports both native and sportfish species, Rocky Mountain bighorn sheep, riparian plant communities, and macroinvertebrates.

Annual fish surveys conducted by Colorado Parks and Wildlife ("CPW") demonstrate that both native and sportfish species reside within Glenwood Canyon, including within the Shoshone Reach. As observed by CPW staff, the variable riverine topography in Glenwood Canyon includes riffles and runs that provide spawning habitat, pools, and refuge from high flows for fish species. Native fish species within Glenwood Canyon include the Flannelmouth Sucker, Bluehead Sucker, Roundtail Chub, Colorado River Cutthroat Trout, Sculpin, and Dace. Sportfish species include Brown Trout, Rainbow Trout, Cutthroat Trout, Rainbow-Cutthroat hybrids, and Mountain Whitefish.

Macroinvertebrate populations play a crucial role in the food web supporting native fish species and serving as a health indicator for aquatic and riparian ecosystems. The USFS-BLM Report notes that within Glenwood Canyon, macroinvertebrate species, which include the crucially important EPT taxa (mayflies, stoneflies, and caddisflies), provide a food source for fish, bird, and bat species. *See id.* (Attachment 7).

Although the canyon walls and man-made infrastructure within Glenwood Canyon limit the extent of riparian vegetation and terrestrial habitat, such vegetation nevertheless exists within the canyon, including narrowleaf cottonwood, chokecherry, red-osier dogwood, box elder, willow, wild rose, skunkbush, riparian grasses, sedges, and rushes. The existing vegetation in Glenwood Canyon provides habitat and food sources for terrestrial and aquatic species, bank stabilization and armoring, and river cover and shading. *See id*.

When the Shoshone Power Plant is operating, water is returned at the plant's discharge outlets (*i.e.*, the Downstream Terminus of the Shoshone Reach) creating high quality and diverse habitat for aquatic species with an abundance of riffles, runs, and pools. In particular, the increased number of riffles support macroinvertebrate productivity and robust fishery. The return flows also benefit the natural environment downstream of the Shoshone Reach by contributing enough flow to the river for effective sediment transport, an important component of aquatic ecosystem functions. Trout, native Sculpin, and Mountain Whitefish are especially benefited by the conditions maintained by the return flows attributable to the Shoshone Power Plant, as these species prefer high gradient reaches with increased sediment movement. *See id.*

Finally, the majority of Glenwood Canyon is part of the White River National Forest ("WRNF") and is managed by the USFS, in partnership with the Colorado Department of Transportation ("C-DOT"). *Id.* In addition to its regionally significant natural environment, Glenwood Canyon is notable for its scenic river corridor, which supports a robust riverine ecosystem while drawing significant human visitors for recreational and other tourism purposes.

2. *The natural flow regime*.

Beginning at its headwaters in Grand County, the Colorado River flows through the State of Colorado generally in a westerly direction for approximately 300 miles, initially traveling through remote mountainous landscapes before descending into the lower elevations of Colorado's West Slope and the Colorado Plateau.

The flow of the Colorado River within Colorado is governed by seasonal snowmelt from the Rocky Mountains, which contributes to the total volume and timing of the streamflow each year. Streamflow in the mainstem of the Colorado River varies significantly on an annual and seasonal basis due to natural variations in hydrology and the impacts of water diversion and storage projects, including 100% consumptive transmountain diversions ("TMDs") from the Colorado River and its headwater tributaries. The river's flow typically peaks in the late spring and early summer months as mountain snow melts and runs off into the river system. During late summer and fall, the flow generally decreases, reflecting the reduced snowmelt and the demands from water diversion projects in the latter, drier part of the water year. Peak spring runoff flows at the Dotsero Gage range from approximately 2,000 to 22,000 cfs with winter base flows generally measured near 900 cfs. The average streamflow recorded at the USGS stream gage on the Colorado River near Dotsero, Colorado (the "Dotsero Gage," USGS 09070500) for the years 1942–2024 is approximately 2,142 cfs, although the annual average amount fluctuates significantly from year-to-year.

Several significant water systems and projects regulate and alter the flows of the mainstem of the upper Colorado River. For example, several significant diversion projects on the West Slope, including TMDs associated with the Colorado-Big Thompson Project, Moffat Tunnel, Roberts Tunnel, the Continental-Hoosier Project, and the Homestake Project, export water from the

headwaters of the Colorado River and its tributaries across the Continental Divide to Colorado's Front Range for municipal, industrial, and agricultural purposes. These TMDs generally consist of a series of tunnels, reservoirs, and pipelines that transport an average 482,200 acre-feet ("AF") of water annually from the Colorado River Basin for use on the East Slope. *See* Attachment 2, Map 2.

Streamflow for the mainstem of the upper Colorado River is measured and the Shoshone Water Rights are administered by the Colorado Division of Water Resources at the Dotsero Gage. The Dotsero Gage is located approximately 8.5 miles upstream of the upper terminus of the Shoshone Reach (*i.e.*, the Shoshone Diversion Dam).

3. *Instream flow use of the Shoshone Water Rights will not result in material injury to existing decreed water rights*.

To be used for instream flow purposes, the Shoshone Water Rights must first be changed by the Division 5 Water Court to add instream flow as an additional decreed use. The CWCB's subsequent use of the Shoshone Water Rights for instream flow purposes will not result in material injury to existing decreed water rights because the change of water rights decree will ensure that instream flow use will only be exercised consistent with historical practice and will include terms and conditions that prevent any injury to other water rights.

The purpose of a change of water rights proceeding is to ensure that use of the water right for the changed purpose does not result in injury to other vested water rights—both upstream and downstream of the subject water right. *See* C.R.S. § 37-92-305(3)(b). When a water right is changed to allow a different or alternate type of use, the water right retains its original priority date. *Colo. Water Cons. Bd. v. City of Central*, 125 P.3d 424, 437 (Colo. 2005). However, the "holders of vested water rights are entitled to the continuation of stream conditions as they existed at the time they first made their appropriation." *Orr v. Arapahoe Water & Sanitation Dist.*, 753 P.2d 1217, 1223 (Colo. 1988).

Under Colorado law, with respect to the determination of historical use of a water right in a change of use case, section 37-92-305(3)(d), C.R.S., provides that:

> Quantification of the historical consumptive use of a water right must be based on an analysis of the actual historical use of the water right for its decreed purposes during a representative study period that includes wet years, dry years, and average years. The representative study period:
>
> (I) Must not include undecreed use of the subject water right; and
>
> (II) Need not include every year of the entire history of the subject water right.

Importantly, the determination of injury in a change of water rights proceeding rests within the exclusive jurisdiction of the water court. *See* § 37-92-203(1), C.R.S.; *see also* § 37-92-305(3), the Division 5 Water Court will determine the historical beneficial use of the Shoshone Water Rights under their original appropriations and limit the amount of water that can be changed based on the amount of water actually and lawfully used over a representative historical period of time. Terms and conditions will be included in the change of water rights decree to ensure that no vested water rights will be injured.

4. *The historical use and historical return flows of the Shoshone Water Rights that may be available for instream flow use.*

To examine the historical use of the Shoshone Water Rights, the River District retained the services of Bishop Brogden Associates ("BBA") to prepare an assessment of the historical use of the Shoshone Water Rights for hydropower production over a defined period of study. A copy of BBA's Draft Preliminary Historical Use Assessment ("HU Assessment") is attached to this technical memorandum as Attachment 8. It is important to note that the HU Assessment is, as the title implies, a preliminary draft assessment of the historical yield of the Shoshone Water Rights. The yield estimates set forth in the HU Assessment may be supplemented or changed in the future as more information and data become available. That said, the estimated yield of the Shoshone Water Rights as described in the HU Assessment is reasonable and well-supported across a sufficiently representative study period.

As discussed above, the quantification of the historical use of the Shoshone Water Rights is a "water matter" that is within the exclusive jurisdiction of the Division 5 Water Court. Therefore, the water court will determine the historical use as an integral part of the change of use case. However, the ISF Rule 6.e provides that the CWCB should consider the "historical consumptive use and historical return flows" of the water rights to be changed to add instream flow use.

The use of water at the Shoshone Power Plant is non-consumptive, which means that all of the water diverted at the Shoshone Diversion Dam and runs through the turbines to generate power is returned to the Colorado River at the outfall of the Shoshone Power Plant, approximately 2.4 miles downstream of the dam. However, the historical exercise of the Shoshone Water Rights with respect to the 2.4-mile Shoshone Reach is almost entirely depletive (there are some losses and sluicing operations associated with the historical exercise that return to the Colorado River within the Shoshone Reach) before essentially 100% of the diversions are returned to the river at the Shoshone Power Plant outfall. Although this situation is different from circumstances where a partially consumptive water right, such as an irrigation water right, is changed to a different type of use, the underlying legal principle is the same—an analysis is conducted to determine the "measure" of the water right to be changed and to make sure that other water users are not injured, including downstream junior users that have come to rely upon the return flow pattern from the historical exercise of the changed water right.

5. *Instream flow use of the Shoshone Water Rights will preserve and improve the natural environment to a reasonable degree.*

Protecting the Shoshone Water Rights by adding an additional beneficial use for instream flow purposes to the decreed uses will preserve and improve the natural environment of the Shoshone Reach to a reasonable degree. The River District engaged Dr. Miller, and Ecosystem Sciences, Inc. ("Ecosystem Sciences") to evaluate the habitat within the Shoshone Reach. The respective conclusions reached by Dr. Miller and Ecosystem Sciences are set forth in the 2024 Miller Report (Appendix 5) and the 2025 Ecosystem Report (Appendix 6). The key findings of both reports are summarized below.

a. 2024 Miller Report.

Using the Instream Flow Incremental Methodology ("IFIM") on a study area within the Shoshone Reach and habitat criteria for one native fish species and three sport fish species, Dr. Miller found that flows between 700 cfs and 3,000 cfs provide a benefit to the aquatic habitat for identified fish species within the Shoshone Reach. *See* Attachment 5. Dr. Miller's analysis of a range of flow that is bounded at 3,000 cfs on the upper end is due to the fact that the Shoshone Water Rights can call for natural flow up to 1,408 cfs to satisfy the plant's demands. However, during naturally low flow periods additional water that is released from reservoirs located upstream of the Shoshone Power Plant may be commingled with the water needed to satisfy the power plant's call on the river, resulting in total flows, as measured at the Dotsero Gage, in excess of the 1,408 cfs that may be diverted at the Shoshone Diversion Dam. *Id.* at pp. 9-10.

As set forth in the 2024 Miller Report, Dr. Miller concluded that future instream flow use of the Shoshone Water Rights will result in more stable baseflows and more consistent wetted area in all year types (*i.e.*, wet, dry, and average years), which would not only improve habitat availability in the Shoshone Reach, but would also support conditions for algae and macroinvertebrate growth, which are critical food sources for fish species, including the four fish species examined by Dr. Miller. *See id.* at pp. 33-34. Dr. Miller noted that the contemplated future instream flow scenario "would provide a substantial increase in habitat and benefit aquatic biota during summer, fall, winter, and early spring as compared to the existing conditions." *Id.*

Notably, the proposed ISF Agreement provides that PSCo would be permitted to continue using the Shoshone Water Rights for hydropower purposes until such time that PSCo determines to cease generating power or the plant is permanently decommissioned. *See* Appendix 5. PSCo's continued hydropower use will mirror or continue the historical reduction of flow within the Shoshone Reach. However, Dr. Miller nevertheless concludes that the new instream flow use of the Shoshone Water Rights would still provide significant benefits to habitat within the Shoshone Reach at all times when the Shoshone Power Plant is not operating due to normal maintenance or unplanned outages up to the evaluated flow of 3,000 cfs measured at Dotsero. *See* Appendix 5 at p. 33; *see also* 2025

Ecosystem Report, Appendix 6, at p. 33 (Dr. Miller's conclusion here is supported by Ecosystem Sciences, which studied a different stream segment and different streamflow regimes.)

In sum, the 2024 Miller Report concludes that future instream flow use of the Shoshone Water Rights would preserve and improve the natural environment in the Shoshone Reach for the following reasons:

- The instream flow use would result in stable base flow conditions with no zero-flow days.
- The instream flow use would produce stable wetted area within the Shoshone Reach during late summer, fall, winter, and spring, creating better conditions for macroinvertebrates and algae, which are important food sources for fish species.
- Average year hydraulic-habitat conditions in summer and winter would experience improved base flows that provide between 81% to 99% of the potential maximum hydraulic habitat in the Shoshone Reach.
- The instream flow use would continue a long-list of indirect benefits upstream and downstream of the Shoshone Power Plant due to water "called-down" to the Shoshone Reach to satisfy the instream flow use of the Shoshone Water Rights.
- Flows transported through the Shoshone Reach as a result of the instream flow use of the Shoshone Water Rights would preserve stream conditions within the reach while simultaneously improving the aquatic habitat.

See generally Appendix 5 at pp. viii, 33.

b. 2025 Ecosystem Report.

The 2025 Ecosystem Report (Attachment 6) builds on and supports the conclusions in the 2024 Miller Report. However, in contrast to Dr. Miller's approach which relied on a comparison between the existing flow regime and a future flow regime created by the additional instream flow use of the Shoshone Water Rights, Ecosystem Sciences utilized the 2024 Upper Colorado River Basin Model ("UCRM") in StateMod to evaluate and compare a range of current and future scenarios. The future scenarios utilized by Ecosystem Sciences accounted for additional Colorado River demands intended to reflect future development on the Colorado River. Ecosystem Sciences used an additive method (as opposed to Dr. Miller's multiplied method) to determine Hydraulic Habitat Suitability from the modeled velocity and depth variables across each site. Despite the different methods used to assess stream habitat, both reports arrived at the same conclusion—instream flow use of the Shoshone Water Rights will preserve and improve the natural environment within the Shoshone Reach at measured flow rates up to 3,000 cfs.

It is worth noting that the 2024 UCRM upon which Ecosystem Sciences' analysis relies also yielded important information regarding the influence that the Shoshone Water Rights have on the Colorado River mainstem. In fact, outputs from the State of Colorado's 2024 UCRM clearly demonstrate that, if the Shoshone Water Rights are not exercised, approximately 31,900 AF to

35,500 AF less water would flow through the Shoshone Reach (under average existing and future dry-year conditions, respectively) than occurs when compared to the StateMod's "baseline" condition (which includes exercise of the Shoshone Water Rights).[4]

Ecosystem Sciences studied two sites—one of which was studied in the 2024 Miller Report—within the Shoshone Reach, which together cover approximately 29% of the reach. *See* Attachment 6 at p. 1. Through its investigation of these two study areas, Ecosystem Sciences concluded that the hydraulic habitat suitability for the same native and sport fish species examined in the 2024 Miller Report would be higher more frequently under a future scenario where the Shoshone Water Rights are permanently protected as compared to a current baseline scenario and a future scenario where the Shoshone Water Rights are not permanently protected by the addition of instream flow use. *See id.* at p. 33. This is particularly true during late summer and early fall seasons. *Id.* The protection of the Shoshone Water Rights through instream flow use also would provide significant help to address high temperatures and other stressors experienced in the Shoshone Reach and upstream reaches. In these respects, Ecosystem Sciences' analysis confirmed Dr. Miller's earlier findings and similarly found that instream flow use of the Shoshone Water Rights will preserve and improve the natural environment of the Shoshone Reach to a reasonable degree at measured flow of up to the evaluated 3,000 cfs at the Dotsero Gage. *See id.* at p. 34.

Another important series of findings in the 2025 Ecosystem Report deals with the reality that flows within the Shoshone Reach are highly variable throughout the year. *Id.* at p. xx. For instance, on days when the Shoshone Power Plant is operational, water is diverted at the Shoshone Diversion Dam (*i.e.*, the ISF Upstream Terminus) for hydropower production and the same diverted water is later returned to the river at the outfall of the power plant (*i.e.*, the ISF Downstream Terminus). During periods when the Shoshone Water Rights are placing an administrative call against upstream junior water rights (*i.e.*, when the natural flow at the Dotsero Gage is less than 1,408 cfs), river flow within the Shoshone Reach will be less than 1,408 cfs and may, at times, have virtually zero flow. Despite these conditions—which result in a partially "dewatered" Shoshone Reach during plant operations—Ecosystem Sciences arrived at the same conclusion as did Dr. Miller:

> During seasonal low flow periods the reach is dewatered when the plant is operating, though habitat in the Shoshone Reach is connected by small inflows of groundwater and tributary streams that fill pools and flow through the large boulder and rock substrate [ ] Habitat persists even during low flow periods, though wetted area in the stream channel is substantially reduced; however, habitat becomes fragmented for upstream fish movement at low flows.
>
> *See id.* at p. 4.

[4] These outputs derive from the State of Colorado's 2024 UCRM baseline model, which is accessible at https://cdss.colorado.gov/modeling-data/surface-water-statemod.

The key conclusions of the 2025 Ecosystem Report indicate that instream flow use of the Shoshone Water Rights will preserve and improve the natural environment in the Shoshone Reach by: (1) sustaining aquatic habitat; (2) fostering stream connectivity; (3) supporting primary and secondary production; (4) regulating stream temperatures; (5) maintaining habitat complexity; and (6) improving the availability of critical refuges for fish species, particularly during seasonal low-flow periods. *Id.* at p. 33. In addition to the specific preservation and improvement benefits observed within the Shoshone Reach, Ecosystem Sciences also concludes that instream flow use of the Shoshone Water Rights "play a significant, though indirect, role in maintaining the health and function of the ecosystems along the Colorado River" by preserving "flows necessary to support upstream and downstream ecosystems". *Id.* at pp. 10, 34. Please refer to the below discussion in Section 12.b. for a summary of these ancillary benefits.

In summary, the 2024 Miller Report and 2025 Ecosystem Report conclude that protecting the historical flow regime by adding instream flow use to the Shoshone Water Rights will preserve and improve the natural environment of the Shoshone Reach to a reasonable degree.

6. *The location of other water rights on the subject stream*.

There are no decreed diversionary or instream flow water rights located within the Shoshone Reach between the Shoshone Diversion Dam and the outfall of the Shoshone Power Plant. However, there are several decreed appropriative rights of exchange that can exchange against the natural flow measured at the Dotsero Gage except at times that the Shoshone Water Rights are calling pursuant to their respective administrative priorities. In addition, there are, of course, thousands of individual water rights located on the Colorado River mainstem and its tributaries upstream and downstream of the Shoshone Reach.

7. *The effect of the acquisition on any relevant interstate compact issue*.

The 1922 Colorado River Compact and the 1948 Upper Colorado River Compact allocate the beneficial consumptive use of water amongst the applicable basins (with respect to the 1922 Compact) and the states (with respect to the 1948 Compact). The proposed instream flow use of the Shoshone Water Rights will replicate the historical use of the water rights for non-consumptive hydropower generation that has existed for more than 100 years. Thus, the use of the Shoshone Water Rights for instream flow purposes will not result in delivering more water than required under compact obligations because there will be no change from the historical exercise of the Shoshone Water Rights for non-consumptive beneficial use. And consequently, maintaining the Shoshone Water Rights as proposed in the ISF Agreement will not impact the State of Colorado's remaining compact entitlement.[5]

[5] As part of the River District's decades-long effort to protect the historical Shoshone flow regime, the River District and other West Slope entities have negotiated comprehensive settlement agreements with Aurora Water and Colorado Springs Utilities (together, the "Cities"). Those agreements provide, in part, that the Cities will not oppose the instream

8. *Instream flow use of the Shoshone Water Rights will support the maximum utilization of the waters of the State of Colorado*.

The use of the Shoshone Water Rights for instream flow purposes will promote the maximum utilization of the waters of the state. Preservation and improvement of the natural environment to a reasonable degree are beneficial uses of water recognized under Colorado law. *See* C.R.S. § 37-92-102(3). Ensuring the future exercise of the Shoshone Water Rights through a change of water rights proceeding to add an alternate use for instream flow purposes will protect the historical flow regime on the mainstem of the Colorado River, upon which many critical water uses and environmental benefits depend. For instance, meeting the demands of the Shoshone Water Rights by administering a call for 1,408 cfs, consistent with historical practice, facilitates efficient water delivery operations in the Grand Valley during low flow periods, while simultaneously ensuring that aquatic habitats and ecosystems are protected.

The instream flow use of the Shoshone Water Rights will provide the continued use of a 115-year-old water right. The non-consumptive nature of the historical use and the proposed instream flow use means that the water used by the Shoshone Water Rights will continue to be made available for appropriation for consumptive purposes after it has been put to beneficial use for instream flow use, thus promoting multiple uses and maximum utilization of the state's water resources.

In addition, the continued exercise of the Shoshone Water Rights supports the ongoing viability of the 15-Mile Reach Programmatic Biological Opinion ("PBO") and the broader Upper Colorado

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flow use of the senior Shoshone Water Right, provided the ISF Agreement with the CWCB and the change of water right decree approved by the water court include language, requested by the Cities, that confirms the instream flow use of the senior Shoshone Water Right will be exercised in compliance with any potential rules on compact administration issued by the State Engineer that may be in effect. Notably, the CWCB has stipulated to similar language in previous water court decrees, including cases in which the CWCB was the applicant.

Inclusion of the following language in the ISF Agreement and in the eventual change of water right decree would effectuate the agreements with the Cities:

> In the event of a curtailment of Colorado water rights, or an imminent threat or expectation thereof, resulting from the State of Colorado's obligations under the Colorado River Compact and/or the Upper Colorado River Basin Compact, the CWCB's exercise of the Shoshone Water Rights for instream flow purposes will be consistent with any duly adopted final rules or regulations of the State Engineer adopted for purposes of fulfillment of Colorado's commitments under either or both compacts, and that are in force, any pending appeal notwithstanding.

The River District believes that including the above language would foster and maintain comprehensive settlements between the West Slope and Front Range transmountain water users. The River District pledges to work in good faith with the State Engineer, CWCB staff, and the Attorney General's Office, as well as with the Cities, to develop language agreeable to all parties prior to the CWCB's formal decision on whether to approve the proposed ISF Agreement.

River Endangered Fish Species Recovery Program (the "Recovery Program"). By way of example (and not limitation), the continued exercise of the Shoshone Water Rights in a manner consistent with historical practice is one of three conditions expressly set forth in the in the 1996 stipulation and agreement entered between the Orchard Mesa Irrigation District ("OMID"), the Grand Valley Water Users Association ("GVWUA"), and the United States Bureau of Reclamation ("Reclamation") and other parties involved in Case No. 91CW247, District Court, Water Division No. 5 (the "Check Case").

Pursuant to the Check Case stipulation and agreement (the "Stipulation"), assuming these three critical conditions are met, surplus water from Green Mountain Reservoir's Historic Users Pool ("HUP") may be quantified and delivered to the critical habitat existing within the 15-Mile Reach of the Colorado River in the Grand Valley. Notably, however, if the Shoshone Water Rights were to cease operating in a manner consistent with historical practice as described in the Stipulation, the failure to meet this condition could trigger a potential loss of the benefits that the HUP surplus water provides to all Colorado River water users within the State of Colorado. The HUP surplus deliveries have averaged approximately 32,000 AF per year, with most deliveries occurring in the critical flow months of August through October. In other words, the continued viability of the Recovery Program is necessary to provide Endangered Species Act ("ESA") coverage for all Colorado River water users in Colorado (both in-basin and transmountain uses). Thus, the use of the Shoshone Water Rights will contribute to the maximum utilization of the state's water resources by helping to ensure existing and future water use can occur with ESA coverage provided by the Recovery Program. The attached memorandum ("Check Case Memo") prepared by respective counsel for the River District, OMID, and GVWUA provides a more in-depth overview of the Check Case and the criticality of preserving the Shoshone Water Rights to the Stipulation and the Recovery Program. A copy of the Check Case Memo, initially prepared as part of the River's District's federal funding application, is attached hereto as Attachment 9.

9. *Whether the water will be available for subsequent use or reuse downstream of the Shoshone Reach*.

The provisions of §§ 37-92-102(3) and 305(3)(b), C.R.S., that require all contracts or agreements for interests in water, and the water court decree implementing the contracts or agreements, to state the CWCB or the lessor, lender, or donor may bring about beneficial use of the historical consumptive use of the leased, loaned, or donated water right downstream of the instream flow reach as fully consumable water are not relevant and do not apply to this acquisition. With respect to the Shoshone Water Rights, the historical exercise of such rights has been entirely non-consumptive, and because the instream flow will mimic the historical non-consumptive operation of the plant there is no associated impact to consumptive use or reuse claims downstream.

10. *The cost to complete the acquisition of the Shoshone Water Rights for instream flow purposes*.

In December 2023, the River District signed a Purchase and Sale Agreement (the "PSA," Attachment 10) with PSCo to acquire and permanently protect the Shoshone Water Rights for $99 million. The fundamental purpose of the PSA is to establish the CWCB's legal ability to use the Shoshone Water Rights for ISF use in a manner that mimics the historical use of the water rights for hydropower generation to protect the historical flow regime while preserving and improving the natural environment. Contemporaneous with the signing of the PSA, the River District's Board of Directors committed $20 million towards the total purchase price. Then, on January 29, 2024, the CWCB voted unanimously to recommend a $20 million investment, subject to specified pre-conditions, to help finance the acquisition. Colorado's General Assembly subsequently approved the CWCB's contribution through the 2024 Water Projects Bill (HB24-1435) with broad bipartisan support. As of the date of this memorandum, 30 water entities, local governments, and regional partners have formally committed over $17 million to finance the acquisition of the Shoshone Water Rights per the PSA. Additional funding contributions are expected based on conversations with other supporters. **Table 1** below includes local funding commitments to date:

Table 1: Local Funding Commitments (as of 05/05/2025)	
Garfield County	$3 million
Eagle County	$2 million
City of Glenwood Springs	$2 million
Ute Water Conservancy District	$2 million
Eagle River Water and Sanitation District and Upper Eagle Regional Water Authority	$1 million
Grand County	$1 million
City of Grand Junction	$1 million
Mesa County	$1 million
Summit County	$1 million
Pitkin County	$1 million
Colorado Mesa University	$500,000
Clifton Water District	$250,000
Grand Valley Irrigation Company	$250,000
Basalt Water Conservancy District	$100,000
Grand Valley Power	$100,000
Grand Valley Water Users Association	$100,000
Middle Park Water Conservancy District	$100,000
Town of New Castle	$100,000
Orchard Mesa Irrigation District	$100,000
City of Rifle	$100,000
Snowmass Water & Sanitation District	$100,000
Town of Silverthorne	$100,000
Mesa County Irrigation District	$50,000
Palisade Irrigation District	$50,000
West Divide Water Conservancy District	$50,000
Kobe Water Authority	$25,000
Town of Parachute	$25,000
De Beque Plateau Valley Soil Conservation District	$5,000
Town of De Beque	$5,000
Total:	$17.11 million

In November 2024, the River District submitted a request for funding under the Inflation Reduction Act's Upper Basin Environmental Drought Mitigation, Bucket 2 Ecosystem ("B2E") Financial Assistance Program to the U.S. Bureau of Reclamation ("Reclamation"), requesting $40 million to be committed towards the $99 million purchase price. Notably, the State of Colorado's state and federal elected officials provided overwhelming support for the River District's B2E application. The River District's B2E application and an index of 58 unique letters of support that articulate the benefits of the Shoshone Water Rights to their communities and interests across the state can be accessed at this link.

On January 17, 2025, Reclamation announced an award of approximately $40 million, allowing the River District's B2E application to proceed towards negotiation of terms and conditions for a secured funding agreement. That award, like many others, is currently under review by the new administration in Washington, D.C. The River District remains optimistic that it will secure funding from the federal government and/or if necessary, through an alternate funding strategy before the end of the change of water rights case, which is the funding deadline in the PSA between the River District and PSCo.

11. *Instream flow use of the Shoshone Water Rights to preserve and improve the natural environment will be administrable by the Division Engineer*.

Following the entry of a change of water rights decree, including any necessary terms and conditions that the Water Court deems necessary, for the Shoshone Water Rights, the Division Engineer for Water Division No. 5 will be able to administer the water rights for instream flow purposes in the manner proposed by the River District, PSCo, and the CWCB. *See* C.R.S. § 37-92-301(3) (providing that the State and Division Engineers administer waters of the state in accordance with decrees adjudicated by state water courts).

12. *Additional benefits associated with the proposed acquisition*.

The exercise of the Shoshone Water Rights protects Colorado's namesake river for the benefit of numerous and diverse water users, recreation interests, and the abundant natural habitats and ecosystems that rely on the Colorado River for survival. *See* Attachment 2, Map 4. And while the anticipated benefits to the natural environment of the Shoshone Reach are a necessary feature of the CWCB's evaluation of the proposed acquisition, the CWCB has the authority to consider other factors in accordance with Rule 6e. of the ISF Rules. We provide the following additional benefits of the acquisition for the CWCB's consideration.

With the assistance of Hydros Consulting, Inc. ("Hydros"), the River District and PSCo have undertaken a comprehensive investigation of the numerous ecosystem, habitat, and environmental benefits of the Shoshone Water Rights, both within and outside of the designated Shoshone Reach. Hydros' analysis is contained in two technical reports: (1) the Shoshone Power Plant Water Rights Yield Assessment, dated September 11, 2024 (the "Yield Assessment," Attachment 11), and (2)

the Addendum to September 11, 2024, Shoshone Power Plant Water Rights Yield Assessment, dated November 7, 2024 (the "Yield Addendum," Attachment 12).

Drawing support from the technical work performed by Hydros, some of the additional benefits afforded by the permanent protection of the Shoshone Water Rights are summarized below:

a. Benefits to Existing Instream Flow Water Rights and Tributaries Upstream of Shoshone Power Plant.

The State of Colorado has recognized the importance of the headwaters region of the Colorado River and currently holds 350 decreed ISF water rights on the Colorado River upstream of the Shoshone Power Plant, and over 120 ISF water rights located downstream of the Shoshone Power Plant, including those on downstream tributaries to the Colorado River. *See* Attachment 13, the "ISF Benefits Memorandum," Figure 1. The numerous ISF water rights located in the upper Colorado River watershed on the mainstem and its tributaries upstream of the Shoshone Power Plant benefit from the seniority of the Shoshone Water Rights and their ability to command flows down the Colorado River on a year-round basis. *See* Attachment 2, Map 3. If the flows attributable to the Shoshone Water Rights were absent from the upper Colorado River mainstem, river levels would be significantly lower (especially in drought years and late in the irrigation season), resulting in a negative impact on the riverine ecosystems that are already stressed by prolonged drought and aridification.

Figure 3: Major Tributaries Upstream of the Shoshone Power Plant



The attached memorandum titled "Shoshone Water Rights Analysis on Decreed Instream Flow Reaches in the Colorado River Watershed" (the "ISF Benefits Memorandum," Attachment 13) provides a more detailed analysis of how protecting the historical exercise and administration of the Shoshone Water Rights will benefit existing decreed ISF reaches in the Upper Colorado River Watershed. As described in the ISF Benefits Memorandum, the reduction in flow that would occur in the absence of the administration of the Shoshone Water Rights would lead to more strain on the upstream and downstream ISFs examined in the memorandum, thereby translating to fewer days when the ISFs would be satisfied. *See id*. The ISFs studied in the ISF Benefits Memorandum include tributaries as well as the Colorado River mainstem and are representative of the Shoshone Water Rights' range of influence across the basin. *Id.* The primary conclusion of the ISF Benefits Memorandum is that the exercise of the Shoshone Water Rights supports ISF reaches upstream of the Shoshone Power Plant in meeting target flows (especially in dry years and in critical months of the later irrigation season) while having a negligible impact on tributaries downstream of the power plant, including on the Roaring Fork River. *Id.* at pp. 1-2.

b. Maintaining Streamflow through Upper Colorado River Wild and Scenic Alternative Management Plan River Sections.

The Upper Colorado Wild and Scenic Stakeholder Group ("Stakeholder Group") was formed in 2007 following a report by BLM on the eligibility of rivers in the Upper Colorado River Basin for Wild and Scenic River designation. The BLM report identified 84 miles of the upper Colorado River from the Town of Kremmling to No Name Creek in Glenwood Canyon as having Outstanding Remarkable Values ("ORVs") eligible for federal designation as a Wild and Scenic River. The Stakeholder Group, which includes over 20 entities (including the River District and the State of Colorado), developed an alternative plan to a federal Wild and Scenic designation with an intention to balance permanent protection of the ORVs, provide certainty for the Stakeholder Group, ensure water project yield, and provide flexibility for water users along the upper Colorado River. The Stakeholder Group's "Alternative Management Plan" lists the continued exercise of the Shoshone Water Rights as one of four identified long-term protection measures for streamflow-influenced ORVs on the Colorado River from Kremmling to No Name Creek.[6] The Shoshone Water Rights provide base flows through the subject river segments that support aquatic habitat, lower water temperatures, and maintain minimum boatable flows.

The USFS-BLM Report confirms the importance of the Shoshone Water Rights to the federal wild and scenic designated reaches given that flows necessary to satisfy the Shoshone Call also support fisheries for native species, sport species, and aquatic invertebrates. *See* Attachment 7, pp. 16–17. The USFS-BLM Report also identifies the foundational need for the Shoshone Water Rights to maintain wild and scenic suitability for recreation through a reach that saw approximately 150,000 boater "visitor" days in 2022. *Id.* at pp. 14, 16. The USFS-BLM Report concludes by stating

[6] *See* Amended and Restated Upper Colorado River Wild and Scenic Stakeholder Group Management Plan (last revised July 2024), p. 63.

"[o]peration of the [Shoshone Water Rights] supports [ORVs] in three reaches of [the] Colorado River that have been determined to be eligible for designation into the National Wild and Scenic Rivers System." *Id.* at p. 17.

c. Recreational Benefits.

Colorado's robust recreational economy relies heavily on the Colorado River mainstem, with flows provided by the Shoshone Water Rights strengthening the state's iconic river recreation industry throughout Grand, Summit, Eagle, Garfield, and Mesa Counties. River recreation in Colorado is estimated to contribute $18.8 billion annually to the state's gross domestic product, with approximately $4 billion coming directly from the Colorado River Basin on the West Slope. *See* Attachment 2, Map 5.[7] As temperatures rise and streams diminish, the exercise of the Shoshone Water Rights provides security for this industry, protecting the recreational fishing and boating that sustain local businesses and attract water-based tourism.

The USFS-BLM Report estimated that in 2022 approximately 150,000 commercial and private boat recreationalists used the Colorado River between Kremmling and into Glenwood Canyon during the summer months with interest in river recreation growing each year. *See* Attachment 7, pp. 14, 16. The USFS-BLM Report goes even further to report on how flows impact recreational experiences, which shows the importance of protecting the Shoshone Water Rights that ensure higher flows are available for recreationalists above and below the Shoshone Reach:

> These flow-dependent activities rely heavily on the amount of water in this stretch of the river. Based on input from the outfitters and experience, these commercial operations typically cease when river flows drop below 1,200 cfs. The floating visitor experience diminishes drastically once flows drop below this level.
>
> *Id.* at p. 16.

The USFS-BLM Report also reported that outdoor recreation on BLM-administered lands in the Kremmling Field Office and Colorado River Valley Field Office contributes $145.7 million and over 1,100 jobs annually. *Id.* at p. 14.

d. Water Quality Improvements.

Communities that rely on the mainstem of the Colorado River for their drinking water supplies benefit from the enhanced water quality provided by the exercise of the Shoshone Water Rights because the flows attributable to the Shoshone Water Rights dilute salinity and sediment. These communities can experience high treatment costs during low flow conditions when concentrations of Total Dissolved Solids ("TDS") become elevated. Taste, odor, and color are affected when

[7] *See* Business for Water Stewardship, *Economic Contributions of Water-related Outdoor Recreation in Colorado*, https://businessforwater.org/wp-content/uploads/2020/05/SA_BWS_FactSheet_Digital_CO_1PG.pdf.

flows decrease due to the potential loss of the Shoshone Call. Without the higher flows of clean and cold headwater-sourced supplies provided by the Shoshone Call, a higher concentration of salinity and other water quality constituents creates increased costs for municipal drinking and wastewater treatment.

Clifton, the City of Rifle, and the Towns of DeBeque, Silt, Parachute, and Battlement Mesa are all West Slope communities which draw and treat water directly from the Colorado River as their primary domestic water supply. Securing the permanent exercise of the Shoshone Water Rights by including an alternate instream flow use will sustain critical flows and water levels in the Colorado River on a year-round basis, especially in dry years, thereby maintaining water quality through the dilution of pollutants and sediment naturally present in the river. The presence of sediment is of particular concern for a stretch of 103 river miles from the Colorado River's confluence with the Roaring Fork River to the confluence with the Gunnison River on the "Monitoring & Evaluation List" within Colorado's Section 303(d) List of Water-Quality-Limited Segments Requiring Total Maximum Daily Loads. While this reach is not listed for impairment, the "Monitoring & Evaluation" classification signifies there is "reason to suspect water quality problems".

e. Agricultural Benefits.

As discussed in Section C.8. above, all agricultural use (and all other consumptive uses) of Colorado River basin water within Colorado depends very significantly on the continued success of the Recovery Program. The Shoshone Water Rights are a critical piece to this puzzle because the exercise of the Shoshone Water Rights is one of the three express conditions in the important Check Case Settlement that allows a Green Mountain Reservoir Historic Users Pool surplus to be declared, released from storage, and delivered for the benefit of the endangered fish species. In many years, the HUP Surplus water is by far the single largest source of water delivered to benefit the endangered fish species—thus making it a very important component of the Recovery Program.

Additionally, the historical exercise and administration of the Shoshone Water Rights helps to support Colorado's robust agricultural economy, which is responsible for generating approximately $47 billion annually in economic activity in Colorado.[8] By way of example, the historical flow regime created by the Shoshone Water Rights protects and improves water quality especially in low flow periods for water users up and down the Colorado River mainstem. Agricultural producers benefit significantly from improved water quality, bringing greater agricultural production to the West Slope. High salinity levels in the Colorado River, which are expressed by the concentration of TDS, can negatively impact water use and crop yields, especially

[8] *See* Legislative Council Staff, *A Snapshot of Colorado Agriculture*, Issue Brief (March 2024), https://leg.colorado.gov/sites/default/files/r23-286_agricultural_economy_in_colorado_0.pdf; *see also* Colorado Department of Agriculture, *The Economic Contribution of Agriculture to Colorado's Economy*, (February 14, 2020), https://drive.google.com/file/d/1ZJm_G8ng_1csUQvZw_iiMsn6DYSDjm_X/edit.

for salt-sensitive cash crops, such as stone fruits, grapes, vegetables and seed crop production by up to 25%.[9]

f. Upper Colorado River Endangered Fish Recovery Program.

All Colorado River water users in the State of Colorado, whether located on the eastern or western side of the Continental Divide, rely upon the continued success of the Recovery Program and continued ESA compliance for streamlined permitting processes for over 1,250 water projects located in Colorado since 1988.[10] As explained in Section C.8., above, one of the ways in which the continued exercise of the Shoshone Water Rights benefits water users is by ensuring that Green Mountain Reservoir's HUP "Surplus" can continue to provide water for delivery to the 15-Mile Reach as provided by the terms of the Check Case Stipulation. *See* Attachment 9.

[9] *See* Colorado State University Extension, Master Gardener, *CMG Garden Notes #224 Saline Soils* (revised October 2015), https://cmg.extension.colostate.edu/Gardennotes/224.pdfm, p. 224-1; *see also* United States Geological Survey, *State News Release: New study demonstrates how climate and irrigation influence salinity of waters in the Upper Colorado River Basin* (February 8, 2024).
[10] *Id.* (detailing 1,272 projects in Colorado that have benefited from ESA Section 7 Consultations from 1988-2023).

Index of Attachments:

Attachment 1: Shoshone Water Rights Decrees
Attachment 2: Maps
Attachment 3: 2016 Shoshone Outage Protocol Agreement
Attachment 4: Draft Instream Flow Agreement
Attachment 5: 2024 Miller Report
Attachment 6: 2025 Ecosystem Report
Attachment 7: USFS-BLM Report
Attachment 8: HU Assessment
Attachment 9: Check Case Memo
Attachment 10: Purchase and Sale Agreement
Attachment 11: Hydros Yield Assessment
Attachment 12: Hydros Yield Addendum
Attachment 13: ISF Benefits Memorandum
Attachment 14: Draft Water Court Application

Attachment 1a

Decreed 6/11/1956

SHOSHONE HYDRO PLANT DIVERSION - NO. 2

That under former decree of the Court said ditch was numbered 2 and awarded a priority for 1,250.0 cubic feet of water per second of time under and by virtue of the original construction; that said ditch under this decree is entitled to Priority No. 328 for 158.0 cubic feet of water per second of time under and by virtue of the first enlargement; that the date of initiation of said appropriation was the 15th day of May, 1929; that the name and post office address of the claimant is Public Service Company of Colorado, a Colorado corporation, 900 15th Street, Denver, Colorado; that said diversion system is used in the manufacturing and generation of electrical energy and the source of supply is the Colorado River;

That the method of diversion consists of a diversion dam, tunnel and penstocks utilized by said claimant for the generation of electricity and the diversion dam is located on the Colorado River in Garfield County, State of Colorado, in Section 30 of Township 5 South, Range 87 West of the 6th Principal Meridian. The adit or headgate of the tunnel (formerly DeRemer Canal and Pipeline) is located on the right bank, being the northerly bank, of the Colorado River in the County of Garfield, State of Colorado, whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-seven (87) West of the 6th Principal Meridian bears North 23°48'20" East 2,414.64 feet, more or less;

That there be allowed to flow into said ditch and diversion system from said Colorado River for the use aforesaid and for the benefit of the party entitled thereto under and by virtue of the first enlargement, Priority No. 328 for 158.0 cubic feet of water per second of time relating back to and dating from the 15th day of May, 1929;

That said Priority No. 328 hereby awarded, to the extent of 158.0 cubic feet of water per second of time, is hereby made absolute and unconditional.

1250.0
158.0
Total - 1408.0 Cu. Ft.

Attachment 1b

STATE OF COLORADO)
)ss
COUNTY OF EAGLE)

IN THE DISTRICT COURT.

In the matter of the application of the Glenwood Light and Water Company a Corporation, for the adjudication of its priority of right to the use of water for domestic and other purposes from Grizzly Creek in Water District No. 53, Garfield County, Colorado;
and
In the matter of the adjudication of priorities of water rights in Water District No.53, in the State of Colorado, for beneficial purposes other than Irrigation.

No. 583
FINDINGS AND DECREE.

Now on this 27th day of February A.D.1911, this matter coming on for hearing and adjudication before the Court upon the petition of the Central Colorado Power Company, one of the claimants herein, to make final and absolute its decree heretofore rendered concerning the Glenwood Power Canal and Pipe Line and upon the Supplemental Statement of Claim of said Company asto said Glenwood Power Canal and Pipe Line, pursuant to an order made by this Court entered on the 14th day of November A.D.1910, said The Central Colorado Power Company appearing by J.T.Adams and C.T.Taylor, its Council Frank W.Allen and John Thomas appearing by C.S.Rowe, their Council and the Town of Glenwood Springs appearing by E.J.De Lac, Esq., Its Council and to the claims of the Central Colorado Power Company having been duly considered and dismissed by the Court and there being no objections or exceptions to the hearing of the evidence concerning said Glenwood Power Canal and Pipe Line or to the entry of the findings and decree concerning the same hereinafter refered to; said hearing having been commenced on Monday the 27th day of February A.D.1911 at 10 o'clock A.M. at the Court House at Red Cliff, Eagle County, Colorado, pursuant to said order of this Court, dated November 14th 1910, and

It further appearing to the Court and the Court doth find that notice thereof was given in manner and form and within the time as re provided in said order by the Clerk of this Court by publishing said notice in not less than one public newspaper in each of the counties

This is just a readjudication of part of 466

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into which Water District No.53, State of Colorado, extends, namely; the counties of Eagle, Grand, Routt, and Garfield; that said notice contained a copy of said order of November 14th 1910 and was published in such papers not less than once each week, until four successive weekly publications had been made; the last of which was made and published in each case upon a day previous to the day fixed for the commencement of said hearing; that the said notice so published in Eagle County was published in the Eagle County Blade; that the said notice so published in Grand County was published in the Kremling News and Middle Park times; that said notice so published in Routt County was Published in the Steamboat Pilot; that said notice so published in Garfield County was in the Glenwood Post; that each and all of said newspapers are published ~~in~~ within the State of Colorado, having been published continuously and uninterruptedly in each of said counties during a period of more than twenty-six consecutive weeks prior to the first publicationof each of said notices and were and are newspapers within the meaning and requirements of the laws of the State of Colorado; and

It further appearing to the Court and the Court doth find that said notice was also served upon all such parties to this action who have filed statements of claim or claims in this proceeding, claiming priority or priorities of right to the use of water for beneficial purposes in said Water District No.53 at least ten days prior to the time of said hearing; that the only party or parties who have filed any statement or statements of claim or claims in this proceedings and who thereby entitled to notice other than posting or publication were and are The Glenwood Light and Water Company and the Town of Glenwood Springs and D. Broughton; that said parties and each thereof were duly served with said notice within the time and in accordance with the provisions of said order; and

It further appearing to the Court and the Court doth find that ten printed copies of said notice were posted in ten public places in said water district not less than twenty days from the day so appointed which copies were posted or caused to be posted by said The Central Colorado Power Company; and

It further appearing to the Court and the Court doth find that each and all of said notices as given, published, posted and served were in all things given, published, posted and served within the time and in the manner provided by said order of November 14th 1910, and that all persons and associations and corporations entitled to notice of this proceeding were duly and regularly notified thereof in the manner provided by law and in accordance with the orders of this Court; and the Court having heard the evidence adduced as well as having considered the evidence heretofore taken in the matter and being fully advised in the premises, as to

THE GLENWOOD POWER CANAL AND PIPE LINE,

the Court doth find:

That heretofore and on to-wit: the 4th day of August A.D. 1903, a decree of this Court was duly made and entered of record in a certain proceeding then pending in said Court, entitled: "In the matter of the application for the adjudication of priority of right to the use of water for the Bellamer Canal and Pipe Line and its extention from the Grand River, for power and manufacturing purposes in Water District No. [illegible]", that in said proceeding there was duly adjudicated and decreed to the said canal and pipe line for the use and benefit of the owners thereof, their heirs and assigns for said purposes, 3500 cubic feet of water per second of time of the waters of the Grand River, with priority dating from January 7,1903,to be diverted into said canal and pipe line through the headgate thereof, conditioned however, that the final completion of said canal and pipe line, and auxiliary works in connection therewith, and the application of the waters aforesaid to said beneficial purposes, should be completed and consumated with all due diligence, and within a reasonable time.

That thereafter, and on to-wit: the 9th day of December A.D. 1907,a decree of this Court was duly made and entered of record in this proceeding, among other things awarding to the Glenwood Power Canal and Pipe Line, for the use and benefit of the owners thereof, 1250 cubic feet of water per second of time with priority No.2 dating from the 7th

day of January, 1902, for power, mining, milling, manufacturing, lighting, heating and traction purposes, conditioned, however, that the work of construction thereon should be diligently and continuously prosecuted and the waters of said Grand River to be diverted by means of said canal and pipe line, should be applied to the beneficial uses aforesaid within a reasonable time; that part of the waters decreed as aforesaid to The DeRemer Canal and Pipe Line, was and is used at the Glenwood Power Canal and Pipe Line, the headgate of which pipe lines are substantially at the same point, as will more fully appear from said proceedings.

That it was provided in the decree of the Glenwood Power Canal and Pipe Line, that it should not be taken to operate as a denial or dismissal of the rights theretofore adjudicated to The DeRemer Canal and Pipe Line,

That the work of construction upon said canal and pipe lines and each thereof was at all times diligently and continuously prosecuted until the completion thereof; that 1200 cubic feet of water per second of time has been diverted and used in the County of Garfield and State of Colorado by means of said Glenwood Power Canal and Pipe Line, (formally a part of the DeRemer Canal and Pipe Line) and applied to the beneficial purposes aforesaid, within the State of Colorado, with all due diligence and within a reasonable time, by reason whereof said claimant is entitled to a final order and decree of this Court, making absolute the decrees of heretofore rendered, the said decree to be for 1200 cubic feet of water per second of time of the waters of the Grand River and its Tributaries to be diverted by means of said Glenwood Power Canal and Pipe Line for power, for mining, milling, and manufacturing, lighting, heating and traction purposes, with priority No.2 dating from the 7th day of January, 1902, in said Water District No. 56.

That said Glenwood Power Canal and Pipe Line, as constructed and completed is as follows:

The name of said canal and pipe line is the Glenwood Power Canal and Pipe Line.

The name of the owner thereof is the said Central Colorado Power Company, a Colorado corporation.

The Postoffice address of said company is Denver, Colorado.

The headgate of said Glenwood Power Canal and Pipe Line is located at a point on the right bank being the northerly bank of the Grand River in the county of Garfield, State of Colorado, from which stream the said canal and pipe line derives its supply of water, at a point whence the north quarter corner of Section Thirty (30),Township Five (5) South, Range Eighty-seven (87) West 6th P.M. bears north 830 45' 30" East 2414,04 feet.

The general course thereof is westerly from said headgate.

That said canal and pipe line consists of a diverting dam located upon the Grand River at the headgate thereof; a gravity line; a pressure pipe line consisting of two pipes running from the gravity line to the power house at the lower end of said pipe line where electrical power is generated by means of water passing through said Glenwood Power Canal and Pipe Line, All in Garfield County, Colorado, and thence transmitted and used by means of transmission and distribution lines and other electrial appliances to various parts of the State.

The length of said gravity line is 12,483 feet and consists of a tunnel with concrete walls and floor 10 feet 8 inches in width and 12 feet high,inside measurement; the grade thereof is five-tenths (5) feet per Thousand (1000) feet.

The length of said pressure line as constructed is 937 feet and the grade thereof is a fall of 165 feet in said Distance; each section of said line as constructed consists of a pipe 108 inches in interior diameter.

The purposes for which the water is used and to be used is for power , mining, milling, manufacturing, lighting, heating and traction purposes.

The carrying capacity of said canal and pipe line is 1300 cubic feet of water per second of continuous flow.

The date of the appropriation of water by origional construcyion of said canal and pipe line is the 7th day of January A.D.1902 and the amount of water appropriated by and under said construction is 1250 cubic feet of water per second of time.

The work of construction upon said Glenwood Power Canal and Pipe Line was commenced under the name of the DeRemer Canal and Pipe Line on the 6th day of Januagy 1902, by J.R. DeRemer and others, the grantors by

mense conveyances of said claimant The Central Colorado Power Company.

On the 10th day of April A.D. 1902 The Grand River Power and Transmission Company duly located The Grand River Power and Transmission Company's Canal and Pipe Line appropriating 300 cubic feet of water per second of time. The Central Colorado Power Company is grantee and present owner thereof.

The said DeRemer Canal and Pipe Line and the Grand River Power and Transmission Company's pipe line and other projects and the rights of way and water rights for said canals and pipe lines and projects have been acquired and are now owned by said The Colorado Power Company and are now a part of said Glenwood Power Canal and Pipe Line.

The said Glenwood Power Canal and Pipe Line has its headgate substantially at the same point and the lines thereof substantially along the line of the said DeRemer Canal and Pipe Line, for which a right of way was granted by the United States to J.R.DeRemer and others under Section 3 of the Act of Congress of July 26, 1866 (U.S.R.S) Section 2339) and the laws, rules and regulations supplementary thereto and passed in furtherance of the purposes of said Act; which right of way was on the 30th day of August, 1905, approved by the Secretary of the Department of the Interior of the United States and was thereafter granted to and acquired by said The Central Colorado Power Company with the approval of the Secretary of the Interior and is now owned by said The Central Colorado Power Company.

The said Glenwood Power Canal and Pipe Line also has its headgate substantially at the same point and the lines thereof substantially along the line of said The Grand River Power and Transmission Company's Canal and Pipe Line, for which a right of way was granted by the United States to said company under Section 3 of the Act of Congress of July 26, 1866 (U.S.R.S. Section 2339) and laws, rules and regulations supplementary thereto and passed in furtherance of the purposes of said Act; which right of way was on the 15th day of November, 1905, approved by the Secretary of the Department of the Interior of the United States and was thereafter granted to and acquired by said The Central Colorado Power Company with the approval of the Secretary of the Interior and is now owned by said The Central Colorado Power Company.

the work of construction upon said Glenwood Power Canal and Pipe Line was continuously and diligently prosecuted at a great cost and difficulty and was completed on or about May 24th, 1909, and water diverted through said canal and pipe line and used for beneficial purposes aforesaid and ever since said time the water from the Grand River has been and is now being used by means of said canal and pipe line for such beneficial purposes tothe extent of 1250 cubic feet of water per second of time and by reason whereof the decrees concerning said canal and pipe line are hereby ratified confirmed and [illegible] approved to the extent of 1250 cubic feet of water per second of time of the Grand River with priority No. 2 dating from January 7th 1902.

The work necessary for the construction of said canal and pipe line has been of great difficulty and performed at an outlay of great cost and expense and among other things has consisted of expensive surveys and re-surveys for the purposes of determining the most feasible and practical rout and location thereof; as well as the building of tunnels and costly engineering construction; that the Grand River at and near the point of diversion thereof is walled in by masses of almost purpendicular solid rock and the route of said canal and pipe line passes through precipitous cliffs and solid walls of granite rock all of which it was necessary to overcome in the construction of said canal and pipe line, and that all of the work thereon was necessary as a part and in furtherance of the completion of said canal and pipe line.

Therefore, as to the Glenwood Power Canal and Pipe Line itiis hereby ORDERED,ADJUDGED AND DECREED, that said Glenwood Power Canal and Pipe Line is entitled to priority No. 2. It is claimed and owned by The Central Colorado Power Company, organized and existing under the laws of the State of Colorado, and is a part of said company's water power system. The water to be diverted by means thereof is used and to be used for power, mining, milling, manufacturing, lighting, heatingand traction purposes to the extent of 1250 cubic feet of water per second of time, continuous flow through said canal and pipe line for said purposes, to be taken from the Grand River through said canal and pipe line from its headgate located on the right bank, being the northerly bank, of the Grand River, from which it derives its supply of water, at a point whence the north Quarter Corner

of Section 30, Township 6 South, Range 87 West, 6th P. M. bears north 38° 48' 26" East 2414.64 feet, running thence in a generally westerly direction from said headgate and the decrees heretofore entered concerning said Glenwood Power Canal and Pipe Line are hereby ratified, confirmed and approved to the extent of 1250 cubic feet of water per second of time of the Grand River with priority No.2 dating from January77, 1902.

And it is hereby,

FURTHER ORDERED, ADJUDGED AND DECREED, that there be allowed to flo into said canal and pipe line from said Grand River for the beneficial uses and purposes aforesaid and foe the use and benefit of the patty or parties lawfully entitled thereto and under by virtue of the appropriatin by origional construction at any and all times, during any and all season 1250 cubic feet of water per second of time, the appropriation of which water took effect on and said priority No.2 dates from the 7,of january 1902.

Provided However, that after the waters of the Grand River shall have been used for the beneficial purposes aforesaid by means of said canal and pipe line,the said waters shall be returned to the stream not less than two miles above the Town of Glenwood Springs, in Garfield County, Colorado.

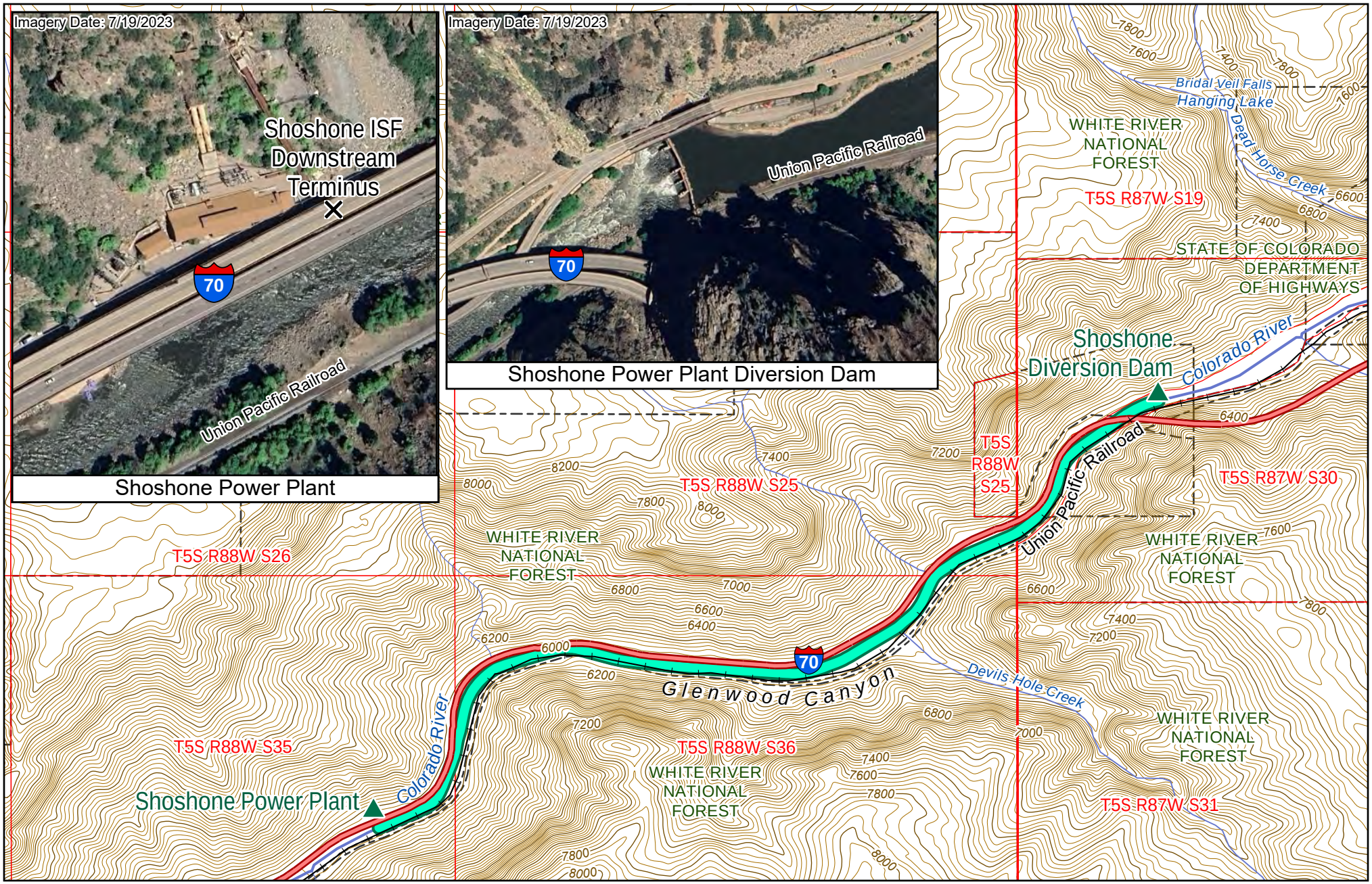
IT IS FURTHER ORDERED by the Court that each and every person interested in or claiming any ditch, canal or reservoir in this proceeding whether as to the decrees heretofore rendered or as to this supplementary decree shall receive from the Clerk of this Court, on the payment of the sum of $2.50 for each certificate and a further sum of 20¢ per folio for the matters contained therein a certificate under the Seal of the Court showing the date or dates and the amount or amounts of the appropriation adjudged in favor of such ditch, canal, flume, pipe line or reservoir under and by virtue of the construction, extension and enlargments thereof severally; also specifying the number of said ditch, canal,flume or pipe line and of each priority to which the same may be entitled by reason of such construction, extention and enlargment, if any.

Done in open Court at Red Cliff, Eagle County, Colorado, this 27th day of February A. D. 1911.

By the Court,

Chas. Cavender,
Judge.

Attachment 2



Map 1: Shoshone Instream Flow Reach Project Map

State: Colorado

County: Garfield

Created Tuesday, March 4, 2025

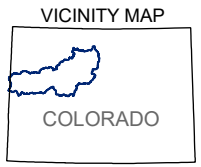
0 ¼ ½ 1 Miles

Scale: 1:24,000

Proposed Shoshone ISF Reach Project Boundary

TRUE-NORTH MAGNETIC-NORTH

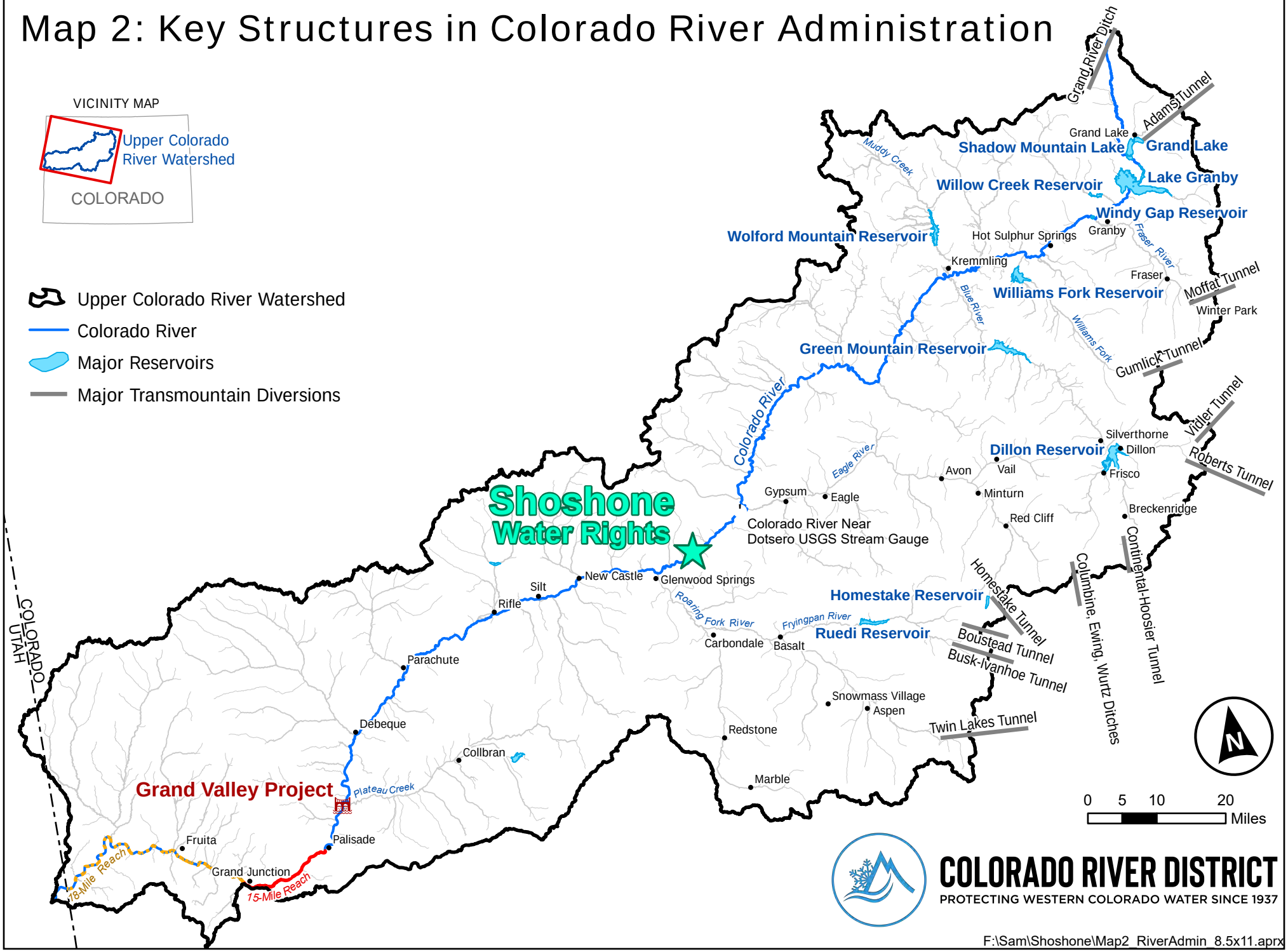




COLORADO RIVER DISTRICT

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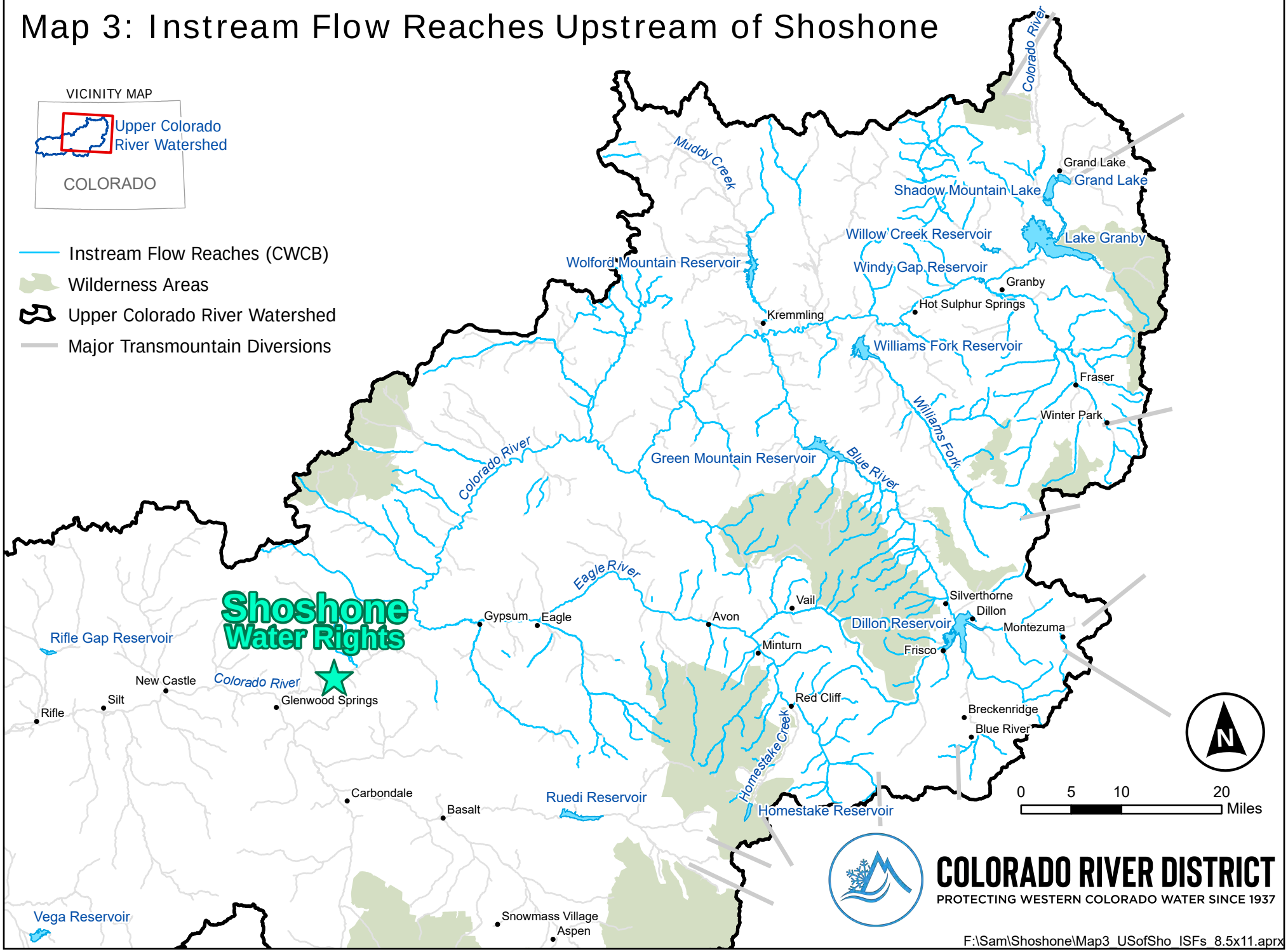
Map 2: Key Structures in Colorado River Administration



COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

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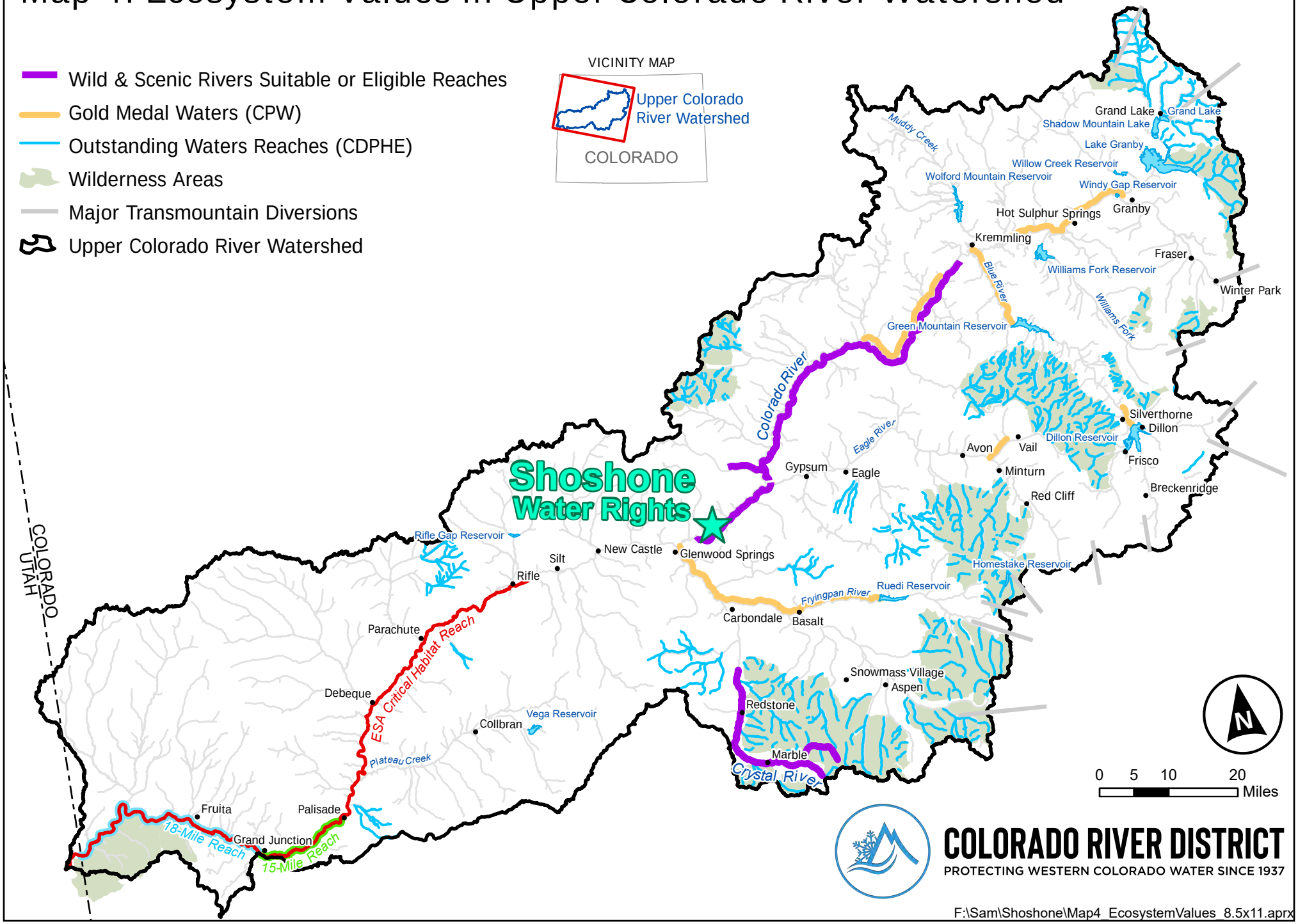
Map 3: Instream Flow Reaches Upstream of Shoshone



COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

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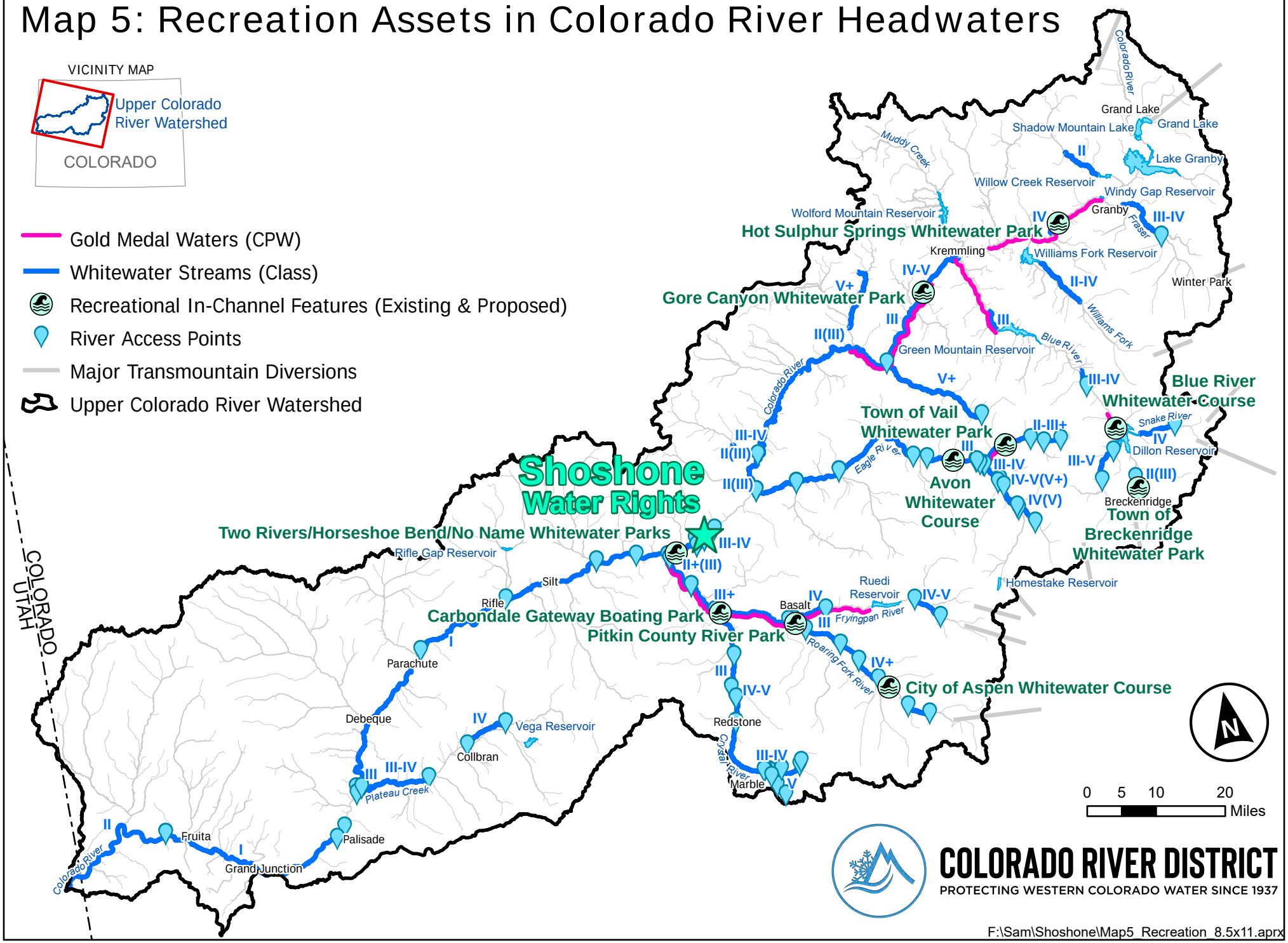
Map 4: Ecosystem Values in Upper Colorado River Watershed



COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

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Map 5: Recreation Assets in Colorado River Headwaters



COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

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SHOSHONE OUTAGE PROTOCOL
AGREEMENT NUMBER 13XX6C0129
INCLUDING THE
UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, THE STATE OF COLORADO, DIVISION OF WATER RESOURCES, THE CITY AND COUNTY OF DENVER, ACTING BY AND THROUGH ITS BOARD OF WATER COMMISSIONERS, THE COLORADO RIVER WATER CONSERVATION DISTRICT, THE MIDDLE PARK WATER CONSERVANCY DISTRICT, THE NORTHERN COLORADO WATER CONSERVANCY DISTRICT, THE MUNICIPAL SUBDISTRICT, NORTHERN COLORADO WATER CONSERVANCY DISTRICT, THE GRAND VALLEY WATER USERS ASSOCIATION, THE ORCHARD MESA IRRIGATION DISTRICT, AND THE GRAND VALLEY IRRIGATION COMPANY

THIS AGREEMENT is made this 27th day of June, 2016, and includes the **UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION** (Reclamation), the **STATE OF COLORADO DIVISION OF WATER RESOURCES** (DWR), **THE CITY AND COUNTY OF DENVER acting by and through its BOARD OF WATER COMMISSIONERS** (Denver Water), the **COLORADO RIVER WATER CONSERVATION DISTRICT** (River District), the **MIDDLE PARK WATER CONSERVANCY DISTRICT** (Middle Park), the **NORTHERN COLORADO WATER CONSERVANCY DISTRICT** (Northern Water), the **MUNICIPAL SUBDISTRICT, NORTHERN COLORADO WATER CONSERVANCY DISTRICT** (Subdistrict), the **GRAND VALLEY WATER USERS ASSOCIATION,** the **ORCHARD MESA IRRIGATION DISTRICT**, and the **GRAND VALLEY IRRIGATION COMPANY**, hereinafter collectively referred to as the "Parties".

I. EXPLANATORY RECITALS

The following statements are made in explanation:

A. When the Shoshone Power Plant is operating, the Shoshone Call can command the flow in the Colorado River and its tributaries in certain stream conditions by exercising the Shoshone Water Rights against upstream junior water rights. When the Shoshone Call is being administered, junior water rights cannot store or divert water without providing replacement water to offset their depletions to the river system as necessary to prevent injury.

B. Whenever the Shoshone Power Plant is subject to a shutdown for repair, maintenance, or other reasons, the Shoshone Call cannot be exercised, and river flows may drop.

C. Certain Parties desire to keep the flow regime of the Colorado River as it has been historically influenced by the Senior Shoshone Call.

D. The Parties agree to implement the operational procedures described in this agreement during a Shoshone Outage.

E. This Agreement will provide greater certainty for the administration of water rights.

F. As is explicitly provided for in this Agreement, certain Parties to this Agreement are only agreeing to be bound by specifically identified sections of this Agreement.

NOW, THEREFORE, in consideration of the foregoing recitals and mutual covenants hereinafter set forth, the Parties hereto agree as follows:

II. DEFINITIONS

Where used herein, unless specifically expressed otherwise or obviously inconsistent with the intent herein, the following definitions apply to this Agreement. Nothing in these definitions alters or amends any existing or future agreement between all or various Parties to this Agreement:

A. "15-Mile Reach" is the reach of the Colorado River which extends from the point at which the tailrace common to the Grand Valley Power Plant and the Orchard Mesa Irrigation District pumping plant returns to the Colorado River below the Grand Valley Irrigation Company diversion dam, downstream to the confluence of the Colorado River and Gunnison River (definition verbatim from the Stipulation and Agreement incorporated into the decree entered in Case No. 91CW247, Colorado Water Division 5).

B. "2007 Shoshone Agreement" is an agreement between Denver Water and Public Service Company of Colorado d/b/a Xcel Energy, effective January 1, 2007, concerning reduction of the Shoshone Call.

C. "Dotsero Gauge" is Gauge Number 09070500 on the Colorado River, near Dotsero, Colorado, which is operated by the United States Geological Survey, Colorado Water Science Center.

D. "End of Fill Season" is the end of the Green Mountain Reservoir fill season as defined in the Green Mountain Reservoir Administrative Protocol.

E. "Grand Valley Entities" are the Grand Valley Water Users Association, the Orchard Mesa Irrigation District, and the Grand Valley Irrigation Company.

F. "Green Mountain Reservoir 1935 First Fill Storage Right" is the storage right for Green Mountain Reservoir with a priority date of August 1, 1935, from the Blue River and its tributaries in the amount of 154,645 acre-feet (AF).

G. "Green Mountain Reservoir 1935 Senior Refill Storage Right" is the storage refill right for Green Mountain Reservoir with a priority date of August 1, 1935, from the Blue River and its tributaries in the amount of 6,316 AF.

H. "Green Mountain Reservoir 1935 Direct Flow Hydropower Right" is the direct-flow right with a priority date of August 1, 1935, from the Blue River and its tributaries in the amount of 1,726 cubic feet per second (cfs) for the generation of electrical power at the Green Mountain Power Plant.

I. "Green Mountain Reservoir Administrative Protocol" is the protocol for administration of Green Mountain Reservoir that will result from the procedures that will be specified in the Green Mountain Reservoir Protocol Agreement by and among Reclamation, Denver Water, Northern Water, the Subdistrict, the City of Colorado Springs acting through its Utilities Department, River District, Middle Park, Grand Valley Water Users Association, Orchard Mesa Irrigation District, Grand Valley Irrigation Company, Palisade Irrigation District, Climax Molybdenum Company, Ute Water Conservancy District, and the State Engineer and Division Engineer for Water Division 5, Colorado Division of Water Resources.

J. Green Mountain Reservoir Historic User Pool Operating Criteria is the operating criteria set forth in Exhibit D of the Orchard Mesa Check Case Stipulation and Agreement.

K. "Green Mountain Reservoir Marketing Allocation" is a 20,000 AF marketable yield available for contracting from the Power Pool.

L. "Green Mountain Reservoir Operating Policy" is the Operating Policy for Green Mountain Reservoir, Colorado-Big Thompson Project, Colorado (Volume 48, No. 247 Federal Register December 22, 1983; as amended in Volume 52, No. 176 Federal Register September 11, 1987).

M. "Historic Users' Pool" ("HUP") is water to be released from the Green Mountain Reservoir Power Pool as described in paragraphs 2 and 3 of the Green Mountain Reservoir Operating Policy.

N. "Non-Winter Season" is the period of any year from March 25 through November 10 of any year.

O. "Orchard Mesa Check Case Stipulation and Agreement" is the September 4, 1996, agreement incorporated into the decree entered October 1, 1996 in Case No. 91CW247, District Court, Colorado, Water Division 5.

P. "Power Pool" is 100,000 AF of water stored primarily for power purposes in Green Mountain Reservoir and available for such other uses in western Colorado as provided in Senate Document 80.

Q. "Senate Document 80" is the "Manner of Operation of Project Facilities and Auxiliary Features" section of the Synopsis of Report document referenced in the Act of August 9, 1937, 50 Stat 564, 75 Congress, 1st Session, which authorized the Colorado-Big Thompson Project.

R. "Senior Shoshone Call" is a request to the state water officials to curtail diversions of junior water rights to produce a flow at the Dotsero Gauge sufficient for diversion at the Shoshone Dam of 1,250 cfs for power purposes at the Shoshone Power Plant.

S. "Shepherded Streamflow Reservoir Releases" are those reservoir releases in rate and volume made for the reservoir owners' purposes of increasing stream flows either at the Shoshone Power Plant, in the 15-Mile Reach, or at other stream locations at rates and volumes in excess of the stream flows that would exist at these locations in the absence of such reservoir releases (including streamflows that may exist as a result of releases, power diversions, or bypasses made pursuant to this Agreement), provided such releases are made for decreed beneficial uses for instream or in-channel purposes at any such locations including, but not limited to, endangered fish species purposes within the 15-Mile Reach.

T. "Shoshone Call" is a request to the state water officials to curtail diversions of junior water rights to produce a flow for beneficial use at the Shoshone Power Plant pursuant to the Shoshone Senior Right or the Shoshone Junior Right.

U. "Shoshone Junior Right" is the water right decreed for and associated with the Shoshone Power Plant adjudicated for 158 cfs on February 7, 1956, with an appropriation date of May 15, 1929.

V. "Shoshone Outage" is whenever the Senior Shoshone Call cannot be fully exercised because the Shoshone Power Plant is subject to a shutdown for repair, maintenance, or other reasons. For the purposes of this Agreement, a Shoshone Outage does not include a cumulative total of 17 days during January and February of each Winter Season, when the Shoshone Senior Right is not calling for water due to regularly scheduled maintenance at the Shoshone Power Plant.

W. "Shoshone Outage Protocol" is a combination of the respective described actions to be taken by each of the Parties.

X. "Shoshone Power Plant" is owned and operated by Public Service Company of Colorado, d/b/a/ Xcel Energy ("Xcel"), and is located on the mainstem of the Colorado River in Glenwood Canyon. The Shoshone Power Plant produces hydroelectric energy by means of the Shoshone Water Rights.

Y. "Shoshone Senior Right" is the water right decreed for and associated with the Shoshone Power Plant adjudicated for 1,250 cfs on December 9, 1907, with an appropriation date of January 7, 1902.

Z. "Shoshone Water Rights" are both the Shoshone Senior Right and the Shoshone Junior Right.

AA. "Start of Fill Date" is the date between April 1 and May 15 fixed annually by the Secretary of the Interior as the start of fill of Green Mountain Reservoir.

BB. "Windy Gap Project" and "Windy Gap Firming Project" shall have the meanings defined in the Windy Gap Firming Project Intergovernmental Agreement ("WGFP IGA").

CC. "Winter Season" is the period from November 11 of any calendar year through March 24 of the next calendar year.

III. TERM OF AGREEMENT

A. This Agreement will remain in effect for 40 years unless terminated sooner pursuant to paragraph III.B, below. Any of the Parties have the right to request renewal of this agreement for an additional 40-year term upon written request to all other Parties on or before two years prior to the expiration of this agreement. The Parties agree to negotiate any requests for renewal in good faith.

B. This Agreement may be terminated upon written mutual agreement of all Parties.

C. This Agreement may be amended at any time by written consent of all Parties hereto.

D. Notwithstanding paragraph III.B, Reclamation may, at any time, terminate its participation in this Agreement for just cause upon providing written notice to all other Parties.

IV. DESCRIPTION OF SHOSHONE OUTAGE PROTOCOL ACTION BY PARTIES

A. Actions by the River District, Middle Park and Denver Water.

1. This Section IV.A is an Agreement between the River District, Middle Park and Denver Water. Other parties are not bound by this Section IV.A.

2. Outage During the Non-Winter Season. If a Shoshone Outage occurs during the Non-Winter Season and results in a flow of the Colorado River at the Dotsero Gauge below 1,250 cfs (not including Shepherded Streamflow Reservoir Releases), then the River District, Middle Park and Denver Water agree that they will operate their water resources as if the Senior Shoshone Call was being administered in order to result in a flow of not more than 1,250 cfs at the Dotsero Gauge (not including Shepherded Streamflow Reservoir Releases).

3. Denver Water, the River District, and Middle Park will not participate in the Shoshone Outage Protocol during periods of certain very dry Non-Winter Seasons that meet the definition of a Water Shortage in accordance with this paragraph IV.A.3. For the purposes of this paragraph IV.A, a Water Shortage exists when the following two conditions exist:

a. Using the procedures described in Exhibit A of the 2007 Shoshone Agreement (copy attached hereto for reference) and based on the "normal" scenario, Denver Water predicts that reservoir storage in its system on July 1 will be at or below 80% full; and

b. The "most probable" forecast of streamflow prepared by the Natural Resources Conservation Service (NRCS) or jointly by NRCS and the Colorado Basin River Forecast Center (or such other forecast that the River District, Denver Water and Middle Park agree to use) indicates that the April – July undepleted flow of the Colorado River at the Kremmling gage will be less than or equal to 85% of average. If no forecast for the Kremmling gage is available, then the Dotsero gage will be used.

4. Denver Water will make projections prior to March 25th, and again in early May and late June to determine whether a Water Shortage exists.

a. If a projection made under paragraph IV.A.3 above meets the conditions for a Water Shortage, then the Shoshone Outage Protocol will not apply during the period from that projection to the next projection. If a projection does not meet the conditions for a Water Shortage, then the Shoshone Outage Protocol will apply during the period from that projection to the next projection; provided, however, that the Shoshone Outage Protocol will not apply during any period when the Shoshone Call is relaxed under the 2007 Shoshone Agreement.

b. If the projection made in June under paragraph IV.A.3 above meets the conditions for a Water Shortage, then the Shoshone Outage Protocol will not apply during the remainder of the Non-Winter Season that year. If the projection made in June does not meet the conditions for a Water Shortage, then the Shoshone Outage Protocol will apply during the remainder of the Non-Winter Season that year.

5. Outage During Winter Season. If a Shoshone Outage occurs during the Winter Season and flows at the Dotsero Gauge are at or below 900 cfs, the River District, Denver Water, and Middle Park agree that they will operate their water resources as if the Senior Shoshone Call were on the Colorado River in the amount of 900 cfs, subject to the following:

The Shoshone Outage Protocol will not apply fully to Shoshone Outages that occur during certain very dry Winter Seasons, when the overall storage in Denver Water's system is less than 79% of capacity on November 1. For purposes of this Agreement, the reservoirs that will be considered in determining overall storage for Denver Water are those reservoirs listed in Exhibit A to the 2007 Shoshone Agreement (Antero, Eleven Mile, Cheesman, Marston, Chatfield, Gross, Ralston,

Dillon, Williams Fork, and Wolford Mountain), but excluding any reservoirs under storage restrictions due to maintenance, repairs or orders from the Colorado State Engineer.

a. If the storage is less than 79%, but more than 63% of capacity, then the Shoshone Outage Protocol will be applied at half the normal effect during that Winter Season. For example, if Denver Water would be required to bypass or replace 60 cfs under the full operation of the Shoshone Outage Protocol, Denver Water would be required to bypass or replace 30 cfs if the Shoshone Outage Protocol is applied at half the normal effect.

b. If the storage is equal to or less than 63%, but more than 49% of capacity, then the Shoshone Outage Protocol will be applied at one-fourth the normal effect during that Winter Season.

c. If the storage is equal to or less than 49% of capacity, then the Shoshone Outage Protocol will not be applied during that Winter Season.

6. As between the River District, Denver Water, and Middle Park, releases from Wolford Mountain Reservoir shall be accounted to the various accounts at Wolford Mountain Reservoir in the same manner that would have occurred if the Shoshone Senior Right had been exercised.

7. Prior to any final decree that is entered to amend the Windy Gap Project water rights to implement the Windy Gap Firming Project, Middle Park's water resources in this Shoshone Outage Protocol will be limited to water released on Middle Park's behalf from Wolford Mountain Reservoir. Subsequent to any final decree that is entered to amend the Windy Gap Project water rights to implement the Windy Gap Firming Project, Middle Park's water resources in this Shoshone Outage Protocol may include water released on its behalf from Wolford Mountain Reservoir, and Windy Gap Project water released from Granby Reservoir. Any such release of Middle Park's Windy Gap Project water resources will be consistent with the water court decrees for such resources and with any final Windy Gap Firming Project Intergovernmental Agreement by and between the Municipal Subdistrict, its Windy Gap Firming Project Water Activity Enterprise, Board of County Commissioners of Grand County, Middle Park, River District, and Northwest Colorado Council of Governments.

B. Actions by the Subdistrict.

1. The Municipal Subdistrict agrees to the operation by Reclamation of Green Mountain Reservoir as contemplated by this Agreement and will not object to the operation of Green Mountain Reservoir in the manner described in this Agreement, unless any person or entity (other than the Municipal Subdistrict or Northern Water):

a. Objects, in any judicial or administrative forum, to the operation of the Windy Gap Project or Windy Gap Firming Project in the manner described in this Agreement;

b. Asserts, in any judicial or administrative forum, that an historic or a future operation of the Windy Gap Project or Windy Gap Firming Project including, without limitation, the performance of this Shoshone Outage Protocol in accordance with this Agreement, is in violation of Senate Document No. 80, the Blue River Decree, or the decrees for the Windy Gap Project or Windy Gap Firming Project; or

c. Asserts, in any judicial or administrative forum, that bypasses of water otherwise divertible by the Windy Gap Project count toward Windy Gap Project diversions.

2. Operation of Windy Gap Project.

a. Nothing in this Agreement shall alter or amend the Intergovernmental Agreement between the Subdistrict, Grand County, Middle Park, the Northwest Colorado Council of Governments (NWCCOG) and the River District fully executed in 2016 ("WGFP IGA"), including, without limitation, Paragraph IV.K. of the WGFP IGA, which remains in full force and effect and provides, with respect to the subject of the Shoshone Outage Protocol, that [abbreviations and short-forms in the quoted text below rely on definitions set forth in the WGFP IGA]:

K. Shoshone Outage Protocol.

1) For purposes of this WGFP IGA, the Shoshone Outage Protocol means that the Windy Gap Project and WGFP will operate as described in this paragraph IV.K.1), IV.K.2), and IV.K.3) during periods when the Shoshone Power Plant is shutdown or otherwise not able to divert the full amount of its 1,250 cfs senior water right due to repair, maintenance, or other reasons ("Shoshone Outage"). When the Windy Gap Project's participation in the Shoshone Outage Protocol is in effect pursuant to this WGFP IGA, the Windy Gap Project and WGFP will bypass the amount of water that the Windy Gap Project and WGFP would have been required to bypass if the Senior Shoshone Call had been in effect in order to result in a flow of not more than 1,250 cfs at the Dotsero gage on the Colorado River (not including any water released for endangered fish species purposes). For purposes of this WGFP IGA, a Shoshone Outage does not include a shutdown of the Shoshone Power Plant for regularly scheduled maintenance for a cumulative period of 17-days during the period of November 1 through March 15.

2) The Windy Gap Project and WGFP will operate in accordance with the Shoshone Outage Protocol from July 16-April 14 of each year. Prior to WGFP Completion, the Windy Gap Project and WGFP may operate in accordance with the Shoshone Outage Protocol during the period of April 15-July 15 on a voluntary cooperative basis. Following WGFP Completion, the Windy Gap Project and WGFP will operate in accordance with the Shoshone Outage Protocol during the period April 15 – July 15 at any time during this period when the combined amount of Windy Gap Project Water stored in Chimney Hollow Reservoir and Windy Gap Project Water stored on behalf of WGFP Participants in Granby Reservoir is greater than 50% of the Active Capacity of Chimney Hollow Reservoir.

3) Participation in the Shoshone Outage Protocol by the Windy Gap Project and WGFP during the period of April 15-July 15 will be limited to a total maximum volume of foregone pumping equal to 10,000 acre feet (30 days with one pump running) in one year, a total of 20,000 acre feet (60 days with one pump running) in any 3 consecutive year period, and a total of 30,000 acre feet (90 days with one pump running) in any 5 consecutive year period.

4) The Subdistrict agrees that it will participate in good faith in negotiations to achieve permanent management of the flow of the Colorado River to address certain flow changes that result during a Shoshone Outage.

3. Nothing in this Agreement shall create, modify, alter or amend the contractual relationships between Reclamation and the Municipal Subdistrict.

4. No Waiver.

a. Except as expressly provided herein, this Agreement shall never give rise to any claim, defense, or theory of acquiescence, bar, merger, issue or claim preclusion, promissory estoppel, equitable estoppel, waiver, laches, unclean hands or any other similar position or defense concerning any factual or legal position regarding the parties respective positions regarding the operation of the Windy Gap Project and Windy Gap Firming Project. This Agreement shall not have the effect of precedent or preclusion on any factual or legal issue in any other matter. The Subdistrict expressly reserves its rights to assert any legal or factual position or challenge the legal or factual position taken by any other party on any other matter

C. Actions by Northern Water.

1. Northern Water agrees to the operation by Reclamation of Green Mountain Reservoir, as contemplated by this Agreement and will not object to the operation of Green Mountain Reservoir in the manner described in this Agreement, unless any person or entity (other than the Municipal Subdistrict or Northern Water):

    a. Objects, in any judicial or administrative forum, to the operation of Green Mountain Reservoir in the manner described in the Shoshone Protocol Agreement; or

    b. Asserts, in any judicial or administrative forum, that an historic or a future operation of Green Mountain Reservoir or the Colorado-Big Thompson Project including, without limitation, the performance of this Shoshone Outage Protocol in accordance with this Agreement, is in violation of Senate Document No. 80 or the Blue River Decree.

2. This Agreement meets the requirements of the first sentence of Paragraph 3 of the Intergovernmental Agreement between Northern Water, Grand County, Middle Park, and the River District fully executed in 2016.

3. Nothing in this Agreement shall create, modify, alter or amend the contractual relationships between Reclamation and Northern Water.

D. Actions by Reclamation.

1. Subject to the provisions of paragraph IV.G.4 of this Agreement, Reclamation will participate in the Shoshone Outage Protocol when either of the following conditions are met:

    a. The Shoshone Outage occurs between the Start of Fill Date and the End of Fill Season and Reclamation projects with 90% probability that a total of 154,645 AF will be accounted toward the volumes of water calculated in accordance with paragraphs II.A.3.b.i through II.A.3.b.v of the Green Mountain Reservoir Administrative Protocol prior to the Green Mountain Reservoir End of Fill Season, and that Reclamation projects with a 90% probability that after the End of Fill Season any volume of Bypassed Storage Water Owed To Green Mountain Reservoir by the Cities will be available to Reclamation pursuant to the Green Mountain Reservoir Administrative Protocol.

or;

    b. The Shoshone Outage occurs after the End of Fill Season and a total of 154,645 acre feet have been accounted toward the volumes of water identified in paragraphs II.A.3.b.i through II.A.3.b.v of the Green Mountain Reservoir Administrative Protocol and that any Bypassed Storage Water

Owed to Green Mountain Reservoir by the Cities will be available to Reclamation.

c. Capitalized terms in paragraphs IV.D.1.a and b have the same meaning as set forth in the Green Mountain Reservoir Administrative Protocol.

2. Green Mountain Releases Under Shoshone Outage Protocol: Reclamation will bypass storable inflow, exercise the Green Mountain Reservoir 1935 Direct Flow Hydropower Right, and/or make releases from previously stored water in its Power Pool as follows:

a. The daily total reservoir release will be equivalent to the amount that would have been required had the Senior Shoshone Call been in place on that day in the amount of 1,250 cfs during the Non-Winter Season and 900 cfs during the Winter Season, subject to the following conditions:

i. The daily total release will not exceed the release that would have been made had the Senior Shoshone Call been in place on that day and all junior water rights had been curtailed or the appropriate amount of replacement or augmentation water made available.

ii. In order to prevent any unintended impact to the HUP by this Agreement, during a Shoshone Outage, the Grand Valley Entities will not request any direct delivery of HUP water without first placing a call with the Division 5 Engineer's Office, unless Reclamation and the Grand Valley Entities agree that such a call is not necessary to prevent impacts to the HUP.

b. Except as provided in paragraph IV.D.2.c, below, the total volume of storage water released from the Power Pool for Shoshone Outage Protocol purposes from the Start of Fill Date will not exceed the sum of the following:

i. 2,000 AF

plus;

ii. The amount of uncontracted water in the Green Mountain Reservoir Marketing Allocation.

plus;

iii. The amount of water that would have been released for HUP beneficiary purposes had the Senior Shoshone Call been in place during the Shoshone Outage period.

c. Reclamation may, at its own discretion, bypass storable inflow, exercise the Green Mountain Reservoir 1935 Direct Flow Power Right, or release additional water from the Power Pool to assist in meeting the purposes of Shoshone Outage Protocol if it deems that conditions make additional water available.

3. Accounting: The Green Mountain Reservoir releases, bypasses, and power diversions shall be accounted for as follows:

a. Bypass of Inflow and Power Diversions: Reclamation will bypass storable inflow or exercise the Green Mountain Reservoir 1935 Direct Flow Hydropower Right to the extent that a bypass of inflow would have been required by a Senior Shoshone Call. The accounting of discretionary power releases and bypassed storable inflow will be consistent with the Green Mountain Reservoir Administrative Protocol.

b. Release of Stored Water: All releases of stored water shall be charged to the aggregate Power Pool rather than individual allocations in the Power Pool. However, the HUP allocation will be reduced by the amount of water that was released from Green Mountain Reservoir in accordance with paragraph IV.D.2.b.iii, above.

E. Actions by the Grand Valley Entities and Reclamation.

1. This Section IV.E is an Agreement between the Grand Valley Entities and Reclamation. Other parties are not bound by this Section IV.E.

2. Subject to the provisions of Paragraph IV.E.3, below, the Grand Valley Entities and Reclamation agree, solely for purposes of paragraph 3.b.(3) of the Orchard Mesa Check Case Stipulation and Agreement, that the Shoshone Water Rights continue to be exercised in a manner substantially consistent with their historical operation for hydropower production at their currently decreed point of diversion.

3. Paragraph IV.E.2, above, shall not be effective:

a. During any period of time in which any Party is not in compliance with their obligations described in this Agreement; or

b. During any period of time in which storage releases or bypasses of water made pursuant to this Agreement are being diverted or exchanged in a manner that results in flow at the Dotsero Gauge that is materially lower than the flow that otherwise would have been produced by the Shoshone Senior Call; or

c. If the United States terminates its participation in this Agreement pursuant to Paragraph III.D., above.

F. Actions by DWR.

The DWR shall administer water released, bypassed, or diverted for power purposes pursuant to this Agreement as follows:

1. Reservoir releases from Wolford Mountain Reservoir shall be administered as Shepherded Streamflow Reservoir Releases for in-channel recreation and fishery purposes and, as directed by the River District for subsequent consumptive uses, within the boundaries of the River District pursuant to the decree entered in Case No. 87CW283, Water Division 5. The River District will provide information to the Division Engineer for Water Division 5 to support the intended in-channel recreation and fishery purposes. Bypasses of storable inflow at Wolford Mountain Reservoir will be accounted toward the fill of the Wolford Mountain Reservoir storage decree for the then-current storage season on an instantaneous store and release accounting basis. Any bypasses made pursuant to this Agreement shall not be accounted toward the next fill season's storage volume for Wolford Mountain Reservoir. If a hydroelectric power facility is constructed to use inflow to Wolford Mountain Reservoir, then any diversions used to generate power may be accounted toward the exercise of the direct flow power right decreed in Case No. 87CW283 and will not count toward the fill of the then-current fill season's storage account for Wolford Mountain Reservoir provided the direct flow power right is operated and administered under the same priority as the storage right.

2. Reservoir releases and direct diversions at Williams Fork Reservoir to generate power will be accounted as releases or diversions made for power purposes and will not be accounted toward the decreed storage volume for Williams Fork Reservoir. Bypasses of storable inflow at Williams Fork Reservoir that are not used to generate power will be accounted toward the fill of the Williams Fork Reservoir storage decree for the then-current storage season on an instantaneous store and release accounting basis. Any such bypasses made pursuant to this Agreement shall not be accounted toward the next fill season's storage volume for Williams Fork Reservoir.

3. Reservoir releases, diversions for power purposes, and the bypass of storable inflow from Green Mountain Reservoir without power generation will be accounted for in accordance with the Green Mountain Reservoir Administration Protocol. Releases and the bypass of storable inflow shall be administered as Shepherded Streamflow Reservoir Releases to the Shoshone Power Plant or to and through the 15-Mile Reach as directed by Reclamation.

4. Bypasses of water otherwise divertible by the Windy Gap Project will not count toward the diversion amount for the Windy Gap Project. Releases of Windy Gap Project water from storage will be accounted in accordance with the then current

Windy Gap Project water right decrees, and subject to paragraph IV.A.7 of this Agreement.

Shepherded Streamflow Reservoir Releases shall be shepherded and protected by DWR under C.R.S. §§ 37-87-102(4) and 37-87-103 or as otherwise provided by law to accomplish the reservoir owners' purposes for making such releases as is consistent with the reservoir owners' legal use of such stored or storable waters. The intent is to continue the historical practice of administering such releases to produce increased flows in the 15-Mile Reach above the flows that would otherwise occur in the 15-Mile Reach, and to accommodate any new releases to be made for such or similar purposes.

G. Notice and Cooperation.

1. Notification to DWR. The Parties will work cooperatively to timely notify DWR, through the Division Engineer for Water Division 5, of operations pursuant to the Shoshone Outage Protocol.

2. The Parties will not divert or exchange any of the water released, diverted for power purposes, or bypassed by any of the Parties pursuant to this Agreement at any location upstream of the current location of the Shoshone Power Plant, or otherwise operate their systems or water rights in a manner that will diminish the benefit to the stream system at any location upstream of the current location of the Shoshone Power Plant of the releases, diversions for power purposes, and bypasses of water made pursuant to this Agreement.

3. Subject to the express conditions and limitations of this Agreement, the Parties will cooperate in good faith to achieve the goals of this Agreement of managing the flow of the Colorado River to maintain the historical flow regime of the Colorado River influenced by the exercise of the Shoshone Senior Right and to mitigate the impacts of any Shoshone Outage. If any party believes that the goals of this Agreement are not being met, including but limited to circumstances where water released or bypassed pursuant to this Agreement during a Shoshone Outage is diverted or exchanged by persons or entities who are not parties to this Agreement at locations upstream of the Dotsero Gauge, then any Party may, in its discretion and in good faith, issue a written notice to the other Parties of such circumstances. Upon such notice, the Parties will meet promptly and work together in good faith to identify such actions as may be necessary to alleviate the conditions that led to the written notice and to implement such actions to which the Parties may agree or any such actions that can be implemented by a subset of the Parties to which that subset may agree.

4. Notwithstanding any provision in this Agreement to the contrary, none of the Parties are obligated by this Agreement to participate in the Shoshone Outage Protocol

during such periods that a Shoshone call reduction is in effect pursuant to the terms of the 2007 Shoshone Agreement (copy attached for reference).

V. SEVERABILITY AND REFORM

Wherever possible each provision of this Agreement shall be interpreted and implemented in such manner as to be effective and valid under applicable law. If any provision or portion of this Agreement is determined to be invalid or unenforceable, the remaining provisions shall remain in full force and effect unless the remaining provision's effectiveness is explicitly dependent upon the invalid or unenforceable provision. The Parties agree to reform this Agreement to replace any such invalid or unenforceable provision with a valid and enforceable provision that comes as close as possible to the intention of the stricken provision. The provisions of this Agreement shall be reasonably and liberally construed to achieve the intent of the Parties.

VI. COMPENSATION

Consideration for the actions pursuant to this Agreement is in providing greater certainty in the administration of water rights, and in the resolution among some of the Parties of certain unresolved issues. There will be no charge for water released under this agreement.

VII. GREEN MOUNTAIN RESERVOIR

Subject only to the express exceptions provided herein, the Parties agree not to challenge Reclamation's operation of Green Mountain Reservoir under this Agreement as inconsistent with Senate Document 80 or the Green Mountain Reservoir Operating Policy. The Parties will work in good faith to address any conflicts that may arise between the operations contemplated by this Agreement and the Green Mountain Reservoir Administrative Protocol. Any conflict that may arise shall be resolved in a manner that is consistent with Senate Document 80, the Blue River Decree, the Green Mountain Reservoir Operating Policy, and the Green Mountain Reservoir Administrative Protocol.

VIII. COLORADO RIVER COOPERATIVE AGREEMENT

Nothing in this Agreement shall be interpreted to constitute compliance with, or satisfaction of, the obligations of Article VI.C of the Colorado River Cooperative Agreement between Denver Water and seventeen West Slope entities.

IX. NO WAIVER

The Parties agree that nothing contained in this Agreement including, but not limited to, any Party's forbearance in the exercise of any Party's right to divert, store, and beneficially use water pursuant to its decrees, is intended nor shall it be construed to give rise to any claim, defense, or theory of acquiescence, bar, merger, issue or claim preclusion, promissory estoppel, equitable estoppel, waiver, laches, unclean hands or any other similar position or defense concerning the operation of such Parties' water rights.

The Parties agree that except as expressly provided herein, this Agreement shall never give rise to any claim, defense, or theory of acquiescence, bar, merger, issue or claim preclusion, promissory estoppel, equitable estoppel, waiver, laches, unclean hands or nay other similar position or defense concerning any factual or legal position regarding the Parties respective positions regarding the operation of the Colorado-Big Thompson Project. The Parties further agree that they do not intend this Agreement to have the effect of precedent or preclusion on any factual or legal issue in any other matter. The Parties expressly reserve their rights to assert any legal or factual position or challenge the legal or factual position taken by any other Party or third-party on any other matter.

X. REGULATION AND DISTRIBUTION OF WATER

Nothing in this Agreement abridges the obligations of the DWR established by Section 37-92-304(8), Colorado Revised Statutes (2011), or other applicable law.

XI. PRIOR VERSIONS.

This Agreement replaces and supersedes the 2013 Shoshone Outage Protocol Agreement that was executed by some, but not all, of the Parties to this Agreement.

XII. SIGNATURES of PARTIES

UNITED STATES DEPARTMENT OF THE INTERIOR

By: _____

Michael J. Ryan, Regional Director
Great Plains Regional Office
Bureau of Reclamation
P.O. Box 36900
Billings, MT 59107-6900
(406) 247-7600

STATE OF COLORADO, DIVISION OF WATER RESOURCES

By: Dick Wolfe 7-12-16

Dick Wolfe, State Engineer
1313 Sherman Street, Suite 821
Denver, CO 80203
(303) 866-3581

DocuSign Envelope ID: 3BA65EFC-2942-4AA6-9753-BCCC13CC953E

AGREEMENT NUMBER 13XX6C0129

DENVER WATER

By: _____

James S. Lochhead, CEO/Manager
1600 W. 12th Avenue
Denver, CO 80204-3412
(303) 628-6000

REGISTERED AND COUNTERSIGNED:
CITY AND COUNTY OF DENVER

By: _____

Timothy M. O'Brien, CPA
Auditor

APPROVED AS TO FORM

_____
LEGAL DIVISION

COLORADO RIVER WATER CONSERVATION DISTRICT

By: _____

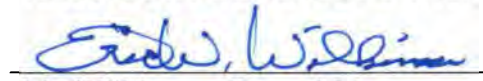
Eric Kuhn, General Manager
P.O. Box 1120
Glenwood Springs, CO 81602
(970) 945-8522

MIDDLE PARK WATER CONSERVANCY DISTRICT

By: Duane Scholl

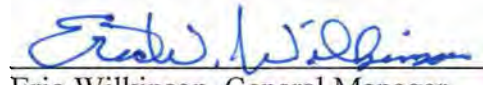
Duane Scholl, President
P.O. Box 145
Granby, CO 80446
(970) 887-3376

NORTHERN COLORADO WATER CONSERVANCY DISTRICT

By: 

Eric Wilkinson, General Manager
220 Water Avenue
Berthoud, CO 80513
(800) 369-7246

MUNICIPAL SUBDISTRICT,
NORTHERN COLORADO WATER CONSERVANCY DISTRICT

By: 

Eric Wilkinson, General Manager
220 Water Avenue
Berthoud, CO 80513
(800) 369-7246

GRAND VALLEY WATER USERS ASSOCIATION

By: Mark Harris

Mark Harris, Manager
1147 24 Road
Grand Junction, CO 81505-9639
(970) 242-5065

ORCHARD MESA IRRIGATION DISTRICT

By: _____

Max Schmidt, Manager
668 38 Road
Palisade, CO 81526
(970) 464-7885

GRAND VALLEY IRRIGATION COMPANY

By: Phil Bertrand

Phil Bertrand, Superintendent
668 26 Road
Grand Junction, CO 81506
(970) 242-2762

2007 SHOSHONE AGREEMENT
(as referenced in
Agreement Number 13XX6C0129)

Please reference the following number on all billings or payments.
Contract # 10766A

AGREEMENT CONCERNING
REDUCTION OF SHOSHONE CALL

This Agreement is between the City and County of Denver, acting by and through its Board of Water Commissioners (Board), and Public Service Company of Colorado d/b/a Xcel Energy (Company).

Recital

The Board's ability to store water in its reservoirs for beneficial use by its customers is adversely impacted, especially in dry years, by the Company's Shoshone Call. Following the drought year of 2002, a brief relaxation of the Shoshone Call during the spring of 2003 provided some benefit to storage reservoirs operated by both west slope and east slope entities, including the Board. Although a more comprehensive and long-term agreement on relaxation achieved through multi-party negotiations may be desirable, the Company and the Board agree to a relaxation of the Call under the provisions in this Agreement. The Company agrees to participate in developing a long-term program of relaxation, including a relaxation of the junior Shoshone Call, with the Board, other water users on the Colorado River and appropriate west slope entities.

Agreement

1. Agreement to Relax Call. When a water shortage occurs, as defined in Paragraph 2, the Company agrees to reduce the Shoshone Call to a one-turbine call of 704 cfs. If the Call is relaxed and the flow of the Colorado River at the Shoshone Power Plant, together with flows contributed by intervening tributaries, is not sufficient to meet the then-current demand of the major Grand Valley water rights, up to 1950 cfs (commonly referred to as the "Cameo Call"), then the level of the Shoshone Call will be adjusted to an amount greater than 704 cfs so as to avoid the initiation of a Cameo Call.

2. Water Shortage Defined. For purposes of this Agreement, a water shortage occurs when the following two conditions are met:

a. Using its regular methodology and based on the "normal" scenario, the Board predicts that reservoir storage in its system on July 1 will be at or below 80% full; and

b. The Most Probable forecast of streamflow prepared by the Natural Resources Conservation Service (NCRS) or jointly by NCRS and the Colorado Basin River Forecast Center indicates that the April – July flow of the Colorado River at the Kremmling gage will be less than or equal to 85% of average. If no forecast for the Kremmling gage is available, then the Dotsero gage will be used.

3. Timing of Relaxation of Call. If the two forecasts described in paragraph 2 occur in March, then the call will be relaxed beginning March 14 until May 20, inclusive, in accordance with this Agreement. If the two conditions described in paragraph 2 occur in April or May forecasts, then the Call will be relaxed in accordance with this Agreement until May 20, inclusive. The methodology that the Board uses to predict system storage shall be substantially the same as that described in the attached Exhibit A.

4. Power Interference. The Board agrees to pay power interference to compensate the Company for its incremental cost of replacement power and energy as a result of relaxing the Shoshone Call, regardless of which entity ultimately stores the water not called. The procedure for determining power interference is shown in Exhibit B.

5. Potential for Longer Call Relaxation. The Company agrees to consider a longer period of relaxation when water supplies are more severely impacted than described in paragraph 1, if such longer period is defined cooperatively between the Board, the Company and appropriate west slope entities.

6. Water for the Company's Facilities. The Board agrees to deliver water as described in this paragraph to the Company's Cherokee, Arapahoe, or Zuni Power Plants or a future Company power plant located within the Board's Combined Service Area. The Company will select the plant or plants to which the water will be delivered. Deliveries to the Arapahoe, Zuni or a future plant will be made to the South Platte River. Deliveries to the Cherokee plant will be made, at the Board's choice, to the South Platte River or through the Board's Recycled Water Plant. The Board may choose in its discretion the type of water delivered to these facilities, so long as the water is suitable for their use. The Board will not deliver water under this paragraph to the South Platte River downstream of the Cherokee plant's diversion structures. Any water delivered by the Board to the Company under this paragraph shall be used by the Company only at the plants listed in this paragraph 6 and only for purposes for which the Board's water rights have been decreed.

6.1 Amount of Water. The Board shall deliver under this paragraph 6 an amount of water equivalent to 15% of the "net water" it is able to store or divert as a direct result of the reduction of the Shoshone Call. "Net water" is defined as the total amount of water the Board is able to store or divert as a direct result of the reduction of the Shoshone Call at the following facilities, less any deductions described below:

a. Water stored or diverted at the Board's Dillon Reservoir, less any water spilled from Dillon after filling and any water bypassed from Dillon for flood management purposes; and

b. Water stored or diverted at the Board's Williams Fork Reservoir, less any water spilled from Williams Fork after filling and any water bypassed from Williams Fork for flood management purposes; and

c. Water stored in the Board's account in Wolford Reservoir, less any water spilled from the Board's account after filling; and

d. Water diverted through the Board's Moffat Tunnel, less any water spilled from the Fraser Collection System in excess of the Forest Service minimum bypass flow requirements; and

e. Water stored or diverted at any western slope reservoir or storage account acquired or constructed by the Board after the date of this agreement, less any water spilled after filling and any water bypassed for flood management purposes.

6.2 Schedule for 15% Water Delivery. The Board shall make deliveries under this paragraph 6 between June 1 in the same calendar year as the Shoshone Call is reduced and March 31 of the following calendar year. The delivery schedule will be subject to approval by the Company.

6.3 Cost of Water Delivered. For each acre foot of water delivered to the Company under this paragraph 6, the Company shall reimburse the Board for the Board's power interference payments at the same rate per acre foot as the Board paid to the Company under paragraph 4.

7. Water for West Slope Entities. The Board agrees to make available to entities on the west slope, at no charge to the recipients, an amount of water equivalent to 10% of the "net water" it is able to store or divert as a direct result of the reduction of the Shoshone Call. "Net water" is defined in paragraph 6.1. The Board may choose in its discretion the method of delivery that is consistent with its water right decrees, so long as the delivery method is suitable for each recipient's desired use. The Board shall deliver the water in the same calendar year as the Shoshone Call is reduced. The Board agrees to cooperate with the Colorado River Water Conservation District to determine the particular west slope entities and the proportionate share of the water to be made available to each entity.

8. Additional East Slope Participants. The Board and the Company agree to make a good faith effort to secure commitments from the Municipal Subdistrict of the Northern Colorado Water Conservancy District, the City of Aurora and Colorado Springs Utilities to deliver to the Company, at no charge, 15% of their additional water diversions that result from a relaxation of the Shoshone Call, in accordance with paragraph 6, and to deliver 10% of the water diverted or stored to west slope entities in accordance with paragraph 7.

9. Priority System. Water made available by the relaxation of the Shoshone Call will be allocated in accordance with the priority system.

10. No Warranties. The Company is not warranting or representing that the diversion and use by the Board of additional water as a result of the relaxation of the Shoshone Call is administrable or lawful. To the extent that the State Engineer or a court with jurisdiction determines that the diversion and use by the Board of additional water as a result of the relaxation of the Shoshone Call is not administrable or lawful, the Company can continue to place the Shoshone Call notwithstanding this Agreement.

11. Increased Call for Company Operations. If the Company in its sole discretion determines that additional river flow is required for safe operation of the Shoshone Hydroelectric Station or the Company's electrical system, then the Company may increase the Call, notwithstanding this Agreement.

12. Operational Meeting. The Company agrees to meet with the Board each October to discuss operation of the Shoshone Call and any planned outages of the Shoshone Plant for repair or maintenance during the following twelve months so that the parties may better coordinate their activities.

13. Sale of Shoshone Water Rights. In the event the Company should determine that it is in its best interest to sell the Shoshone water rights, it agrees to do so only on an open bidding basis in which the Board shall have an equal opportunity to purchase the water rights as all others. If the Company sells the Shoshone water rights to an entity other than the Board, the new owner shall have the right to terminate this Agreement two years after closing of the sale.

14. Term. This Agreement shall be effective as of January 1, 2007 and will terminate on February 28, 2032.

15. Prior Agreement. The previous Letter Agreement between the Company and the Board dated April 14, 1986, is hereby terminated in its entirety.

IN WITNESS WHEREOF, the Board and the Company have executed this Agreement.

ATTEST:

PUBLIC SERVICE COMPANY OF COLORADO d/b/a XCEL ENERGY

Asst. Secretary — Carol J. Peterson

By: _____
President and CEO
Public Service Company of Colorado

Reviewed
Legal
3/31/06

CITY AND COUNTY OF DENVER,
acting by and through its
BOARD OF WATER COMMISSIONERS

ATTEST:

Secretary

President

APPROVED:

Director of Planning

Director of Finance

APPROVED AS TO FORM:

Legal Division

REGISTERED AND COUNTERSIGNED
Dennis J. Gallagher, Auditor

By:

Title:
Deputy Auditor

Exhibit A

DESCRIPTION OF PROCEDURES USED BY THE BOARD
FOR RESERVOIR PROJECTIONS

Denver Water projects future reservoir levels monthly in the springtime and less frequently throughout the rest of the year. Active storage levels (excluding the dead storage pools) for the10 largest reservoirs in Denver's system (Antero, Eleven Mile, Cheesman, Marston, Chatfield, Gross, Ralston, Dillon, Williams Fork, and Wolford Mountain) are forecasted. Calculations of gross and net aggregate reservoir contents are made. The calculation of net reservoir contents excludes any water in Denver's system owed to others (primarily Green Mountain Reservoir). The net active storage of the 10 reservoirs will be used in the forecast for the Shoshone call reduction.

The reservoir projections are based on natural streamflow forecasts produced primarily by the Natural Resources Conservation Service (NRCS). However, streamflow forecasts produced by other organizations including the Colorado Basin River Forecast Center, the Bureau of Reclamation, the Northern Colorado Water Conservancy District and Denver Water are also used.

The reservoir projections utilize correlations between natural streamflow and divertible streamflow to estimate how much of the natural streamflow can be diverted under Denver's water rights. Other factors incorporated in the reservoir projections include projections of treated water use, raw water deliveries, evaporation (based on rates approved by the State Engineer's Office), minimum bypass and release requirements, carriage losses assessed by the State Engineer's Office, existing capacities of diversion and conveyance facilities, system outages and river calls. The assumed treated water use considers any water use restrictions approved by the Denver Water Board at the time of the forecast.

Usually, three levels of reservoir projections are produced. These projections are based on three scenarios after the forecast date: "dry", "normal" and "wet" conditions. The "dry" scenario is based on the "reasonable minimum" streamflow forecasts, which have a 90% chance of being exceeded. The "normal" scenario is based on the "most probable" streamflow forecasts, which have a 50% chance of being exceeded. The "wet" scenario is based on the "reasonable maximum" streamflow forecasts, which have a 10% chance of being exceeded. The "normal" scenario will be used for the Shoshone call reduction.

Exhibit B

COMPENSATION FOR POWER INTERFERENCE

The Board agrees to pay power interference to compensate the Company for its incremental cost of replacement power and energy as a result of relaxing the Shoshone Call. The procedure for determining power interference is shown below.

Depletions to Shoshone Power Plant

The Board will compensate the Company for each acre-foot of net turbine flow depletion caused to the Shoshone Power Plant through the relaxation of the Shoshone Call. Net depletions are defined as gross depletions caused by the Board and all other water users upstream of the Shoshone power plant, less any water subsequently released from Green Mountain and Wolford Reservoirs utilized to generate power at the Shoshone plant. Some of the water stored in Green Mountain and Wolford as a result of relaxation of the Call will later be released, run through the Shoshone Plant for power generation, and delivered for use below the plant; such amounts of water do not constitute a net depletion for purposes of calculating power interference. Similarly, amounts of water spilled from Dillon Reservoir, Williams Fork Reservoir, the Board's account in Wolford Reservoir, or a new west slope reservoir or storage account described in Paragraph 6.1(e), and run through the Shoshone Plant for power generation, do not constitute a net depletion for purposes of calculating power interference. Depletions will be calculated at the Shoshone plant and will be adjusted for stream carriage losses assessed by the State Engineer in water rights administration.

Reimbursement to Xcel

The Board will reimburse the Company for power interference at the rate of at least $5.00 per acre-foot of the net depletion described above. The $5.00 per acre-foot minimum will be adjusted on a monthly basis (but not below $5.00 per acre-foot) by the change in the Price of Spot Gas Delivered to Pipelines for Colorado Interstate Gas, Rocky Mountain (Index) as published in "Platts Inside FERC Gas Market Report," compared to a baseline representing the average Index for the first three months of 2006.

Accounting and Payment.

After the Call relaxation has ended, the Board will prepare an accounting of the power interference and provide it to the Company for review. Once final accounting as been determined, the Board will make payment to the Company within 60 days. Upon mutual agreement and the development of mutually agreeable terms, the Board may substitute a delivery of energy to the Company for the payment of power interference.

DRAFT

SHOSHONE WATER RIGHTS DEDICATION AND ISF AGREEMENT

(Shoshone Water Rights)

This WATER RIGHT DEDICATION and ISF AGREEMENT ("Agreement"), is made as of this ____ day of _____, 2025, by and between the Colorado Water Conservation Board ("CWCB"), an agency of the State of Colorado, the Colorado River Water Conservation District ("River District"), a political subdivision of the State of Colorado, and Public Service Company of Colorado, a Colorado corporation ("PSCo"). The CWCB, the River District, and PSCo may be hereinafter referred to individually as a "party," and together as the "parties."

RECITALS

A. The CWCB is an agency of the State of Colorado created to aid in the protection and development of the waters of the state for the benefit of its present and future inhabitants. In 1973, the General Assembly vested the CWCB with the exclusive authority to appropriate waters of the natural stream for minimum stream flows between specific points on a stream to preserve the natural environment to a reasonable degree.

B. Pursuant to section 37-92-102(3), C.R.S., the General Assembly has also vested the CWCB with the ability to acquire, by grant, purchase, donation, lease, or other contractual agreement, such water, water rights, and interests in water that are not on the division engineer's abandonment list in such amount as the CWCB determines is appropriate for stream flows to preserve and/or improve the natural environment to a reasonable degree.

C. The River District was created by the provisions of sections 37-46-101, C.R.S., *et seq*., to promote the health and general welfare of the State of Colorado by the conservation, use, and development of the water resources of the Colorado River and its principal tributaries. The River District constituents include West Slope governmental entities and water interests that desire to maintain in perpetuity the flow regime within Water Division 5 created by the historical exercise of the water rights that are the subject of this Agreement.

D. PSCo is a Colorado corporation and is the owner and operator of the hydroelectric power plant (the "Shoshone Power Plant") located on the mainstem of the Colorado River in Glenwood Canyon, approximately six miles upstream of Glenwood Springs, Colorado. The Shoshone Power Plant produces hydroelectric energy by means of PSCo's diversion of the following water rights:

   (i) The Glenwood Power Canal and Pipeline water right, decreed on December 9, 1907, in Civil Action No. 466, Eagle County District Court, in the amount of 1,250 cubic feet per second of time ("c.f.s.") with an appropriation date

of January 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as decreed absolute by the Eagle County District Court on February 27, 1911, in Civil Action No. 553 (the "Senior Shoshone Water Right"); and

(ii) The Shoshone Hydro Plant Diversion No. 2 water right, decreed absolute on February 7, 1956, in Civil Action No. 1123, Eagle County District Court, in the amount of 158 c.f.s. with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy (the "Junior Shoshone Water Right").

Together, these two water rights are referred-to as the "Shoshone Water Rights".

E. The Senior Shoshone Water Right is one of the most senior water rights on the Colorado River. During significant periods of the year, there is not sufficient water to satisfy all water rights decreed on the Colorado River and its tributaries within the State of Colorado. At such times, when the measurable Natural Flow of the Colorado River drops below 1,408 c.f.s. (the sum of 1,250 c.f.s. attributable to the Senior Shoshone Water Right and 158 c.f.s. attributable to the Junior Shoshone Water Right) at the streamflow gauge (USGS 09070500) located on the Colorado River near Dotsero, Colorado ("Dotsero Gage"), the Colorado Division of Water Resources ("DWR") administers a call for the Shoshone Water Rights which results in the curtailment of junior water rights upstream of the Shoshone Power Plant. The Dotsero Gage is the location where the administration and measurement of the Shoshone Water Rights has historically occurred. The "Natural Flow" is the amount of water in the Colorado River measured at the Dotsero Gage, including the amount of water usable by the Shoshone Water Rights when those water rights are in priority, except that the "Natural Flow" does not include any water released from storage and conducted into the Colorado River upstream of the Dotsero Gage (accounting for evaporation and transit loss), which water is intended for delivery for use downstream of the discharge outlets for the Shoshone Power Plant.

F. The Shoshone Water Rights are decreed for non-consumptive hydropower generation use at the Shoshone Power Plant. All of the water diverted by PSCo for hydropower generation use is returned to the Colorado River after such water is conveyed through the Shoshone Power Plant's penstocks and turbines, to a point of return at the plant's discharge outlets that is approximately 2.4 miles downstream of the point of diversion at the Shoshone Diversion Dam and Tunnel, as depicted on the map attached as **Exhibit A**. The approximate locations of the "Shoshone Diversion Dam and Tunnel" and the outfall for the "Shoshone Power Plant Discharge Outlets" are as follows:

i. **Shoshone Power Plant Diversion Dam and Tunnel:** on the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

ii. **Shoshone Power Plant Discharge Outlets:** on the right bank, being the northerly bank, of the Colorado River whence the Southeast corner of Section Thirty-five (35), Township Five (5) South, Range Eighty-Eight (88) West of the 6th Principal Meridian bears South 29° 24' 14" East, 1,771 feet, in Garfield County, Colorado.[1]

The reach of stream between the Shoshone Power Diversion Dam and Tunnel and the Shoshone Power Plant Discharge Outlets is referred to herein as the "Shoshone Reach." Through this Agreement, the parties seek to preserve and improve the natural environment of the Colorado River within the Shoshone Reach to a reasonable degree.

G. Pursuant to the Purchase and Sale Agreement between the River District and PSCo, with an effective date of January 1, 2024 (the "PSA"), the River District is the contract purchaser of the Shoshone Water Rights. The PSA provides that PSCo, and its successors and assigns, is entitled to a perpetual leasehold interest in the Shoshone Water Rights for continued use of the Shoshone Water Rights for hydropower generation at the Shoshone Power Plant (the "Lease," the form of which is attached to the PSA as "Exhibit D"). The PSA (including all its Exhibits and Attachments) is attached and incorporated hereto as **Exhibit B**.

H. PSCo's historical exercise of the Shoshone Water Rights has resulted in a streamflow regime that has benefitted the natural environment of the Colorado River basin both upstream and downstream of the Shoshone Power Plant. In addition, the historical exercise of the Shoshone Water Rights has provided benefits to water users throughout the Colorado River basin by providing a relatively predictable water rights administration regime both upstream and downstream of the Shoshone Power Plant.

I. The parties wish to continue the general historical call operations and maintain the flow regime of the Colorado River, both upstream and downstream of the Shoshone Power Plant. In furtherance of that effort, and subject to the terms of this Agreement, the River District wishes to dedicate to the CWCB, at no additional cost to the CWCB, the exclusive right to use the Shoshone Water Rights for instream flow purposes within the proposed Shoshone Reach to the extent the water rights are not being used for hydropower generation purposes at the Shoshone Power Plant, subject to the requirements of this Agreement. To that end, and subject to the terms set forth herein, the River District, PSCo, and the CWCB agree to jointly file an application to adjudicate a change of the Shoshone Water Rights in Garfield County District Court, Water Division No. 5, (the "Water Court") to add instream flow use to preserve and improve the natural environment of the Shoshone Reach of the Colorado River to a reasonable degree as an additional beneficial use of the Shoshone Water Rights. Use of the Shoshone Water Rights for instream flow and hydropower purposes shall be subject to any terms and conditions imposed by the change of water right decree to be entered by the Water Court, further described in Paragraphs XX and XX below (the "Decree").

[1] The legal description set forth above for the Downstream Terminus (Shoshone Power Plant Discharge Outlets) is an approximate location developed by River District staff and may be supplemented or modified at the time a water court application is filed in Water Division No. 5.

J. At two regularly scheduled public meetings of the CWCB held on [date], and [date], the CWCB considered the River District's proposed dedication of the exclusive right to use the Shoshone Water Rights for instream flow purposes to the CWCB in accordance with section 37-92-102(3), C.R.S., and the Rules Concerning the Colorado Instream Flow and Natural Lake Level Program ("ISF Rule(s)"), 2 CCR 408-2. At its regularly scheduled meeting on [date], the CWCB determined that it is appropriate to enter this Agreement and that the best use of the acquired interest in the Shoshone Water Rights is use up to the full decreed amount of 1,408 c.f.s., for instream flow use to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach. Such use of the Shoshone Water Rights for instream flow purposes can occur within the Shoshone Reach to the extent the Shoshone Water Rights are not being exercised for hydropower generation purposes at the Shoshone Power Plant, up to the full amount of 1,408 c.f.s. of Natural Flow (hereinafter, the "ISF Rate"), subject to the limitations described in Paragraphs 7 and 9 below.

K. The CWCB, the River District, and PSCo wish to cooperate to implement such legal mechanisms and to obtain such court decree and approvals as are necessary to change the Shoshone Water Rights to include instream flow use for the purpose of preserving and improving the natural environment within the Shoshone Reach, and to protect the Natural Flow ISF Rate through the Shoshone Reach to the extent it is not being exercised for hydropower generation purposes at the Shoshone Power Plant.

AGREEMENT

NOW THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the parties agree as follows:

DEDICATION

1. The Recitals to this Agreement are incorporated by this reference and shall constitute part of this Agreement.

2. The River District hereby dedicates to the CWCB, effective as of the date of closing of the PSA, at no additional cost to the CWCB, the exclusive right to use the Shoshone Water Rights for instream flow use within the Shoshone Reach, to the extent such water rights are not being used for hydropower generation purposes at the Shoshone Power Plant pursuant to the Lease, and subject to the requirements of Paragraph 9 below. The River District shall retain title to the Shoshone Water Rights.

3. This Agreement acknowledges the CWCB's consideration of the Colorado Parks and Wildlife analysis showing a biological need to preserve and improve the natural environment of the Shoshone Reach of the Colorado River to a reasonable degree.

4. The parties intend that the Decree, as further described in Paragraphs XX and XX below, shall confirm that the water attributable to the Shoshone Water Rights up to the available ISF Rate will remain in the stream to preserve and improve the environment to a reasonable

degree within the Shoshone Reach where the CWCB does not presently have a decreed instream flow right, to the extent the Shoshone Water Rights are not being used for hydropower generation purposes.

5. The parties intend that the Decree shall confirm that the Shoshone Water Rights shall be administered by the State Engineer and the Division Engineer for Water Division No. 5 ("Engineers") based on the Natural Flow at the Dotsero Gage. Instream flow use of the Shoshone Water Rights will be administered through the Shoshone Reach where the intended instream flow use will occur with the goal of utilizing the Shoshone Water Rights up to the available ISF Rate without diversion or exchange by intervening water users. The parties intend that the Decree shall also contain an affirmative finding which confirms that the change of the Shoshone Water Rights for the additional instream flow use is administrable by the Engineers and is capable of meeting all applicable statutory requirements.

6. In the event any new infrastructure or stream gaging stations are either necessary or desirable for the implementation of this Agreement, or in the event that any new infrastructure—including measuring devices—are deemed necessary by the Engineers with respect to the Shoshone Water Rights, the parties agree to work cooperatively with each other in good faith to accommodate the installation of any such infrastructure or gaging stations, which are necessary to make water available for use under this Agreement, in an efficient and economical manner.

CONDITIONS ON THE ADMINISTRATION AND EXERCISE OF THE SHOSHONE WATER RIGHTS FOR INSTREAM FLOW USE

7. It is the intent of the parties that the Shoshone Water Rights will be protected for instream flow use to the maximum extent possible as allowed under the Water Court Decree, to the extent the Shoshone Water Rights are not being used for power generation. To implement this mutual intent, the CWCB agrees that it will request administration of the Shoshone Water Rights for instream flow use in the Shoshone Reach of the Colorado River to preserve and improve the natural environment to a reasonable degree at all times when the Natural Flow of the Colorado River as measured at the Dotsero Gage is less than 1,408 c.f.s., subject only to the limitations set forth below:

   a. Any terms, conditions, and limits set forth in the Decree;

   b. Any reduction in instream flow use made pursuant to the terms and conditions of Paragraph 9, below, due to use or planned use of the Shoshone Water Right for power generation; and

   c. During any period wherein the CWCB and the River District jointly agree in writing to reduce the flow rate requested for administration of the Shoshone Water Rights for instream flow purposes.

8. Pursuant to ISF Rule 10, 2 CCR 408-2, the parties shall cooperate in the administration and monitoring of the instream flow use of the Shoshone Water Rights dedicated to the CWCB under this Agreement so that, subject to the terms of this Agreement and the Decree, the CWCB will maximize the use of the Shoshone Water Rights for instream flow purposes to the extent the rights are not being used for hydropower generation purposes at the Shoshone Power Plant. PSCo, the CWCB and the River District shall coordinate with DWR to monitor the flow and calculate the Natural Flow of the Colorado River at the Dotsero Gage as the point of administration for the Shoshone Water Rights for hydropower generation and instream flow use.

9. The CWCB and the River District shall notify PSCo of any request for administration required by the provisions of this Agreement. PSCo shall provide advance written notice to the River District and the CWCB at least thirty (30) days prior to any scheduled operations or maintenance activities that result in a full or partial shutdown of the Shoshone Power Plant, and shall provide notice as soon as reasonably possible of any unscheduled shutdown or reduction of Shoshone Power Plant operations. During the term of the Lease, the parties will coordinate on at least an annual basis to determine how the Shoshone Water Rights will be allocated between hydropower generation and instream flow use in a manner consistent with the terms and conditions of the Decree that (1) maximizes PSCo's ability to exercise the Shoshone Water Rights for hydropower generation purposes; and (2) maximizes the ability to use the Shoshone Water Rights for instream flow purposes to the extent the water rights are not being used for hydropower generation purposes at the Shoshone Power Plant, in a manner that does not reduce the availability of the Shoshone Water Rights for subsequent hydropower use. Upon termination of the Lease, this paragraph, and any other restrictions on the Shoshone Water Rights throughout this Agreement due to hydropower use, shall no longer be in effect, and, subsequent to any permanent decommissioning of the Shoshone Power Plant, instream flow shall be the only use of the Shoshone Water Rights.

10. Each party to this Agreement shall also immediately report, in writing, to the other parties the nature of any communications with the Engineers concerning the administration of the Shoshone Water Rights as contemplated by this Agreement. Following the closing of the PSA, the parties shall identify those persons and provide such contact information (including email and telephone number) to the other parties necessary to effectuate the purposes hereof.

11. Any rights created by this Agreement are contractual rights. Use by the CWCB for instream flow purposes in accordance with this Agreement does not provide the CWCB an ownership right in the Shoshone Water Rights or in any of the River District or PSCo's facilities or water rights as they exist now or may exist in the future.

12. The CWCB's contractual rights to and interest in the Shoshone Water Rights dedicated to the CWCB for use in the Shoshone Reach under this Agreement extends to and terminates at the downstream termination point of the Shoshone Reach, which is the stream accrual point for the current Shoshone Power Plant Discharge Outlets.

NO CREATION OF RIGHT OF SUCCESSIVE USE OF THE SHOSHONE WATER RIGHTS DOWNSTREAM OF THE SHOSHONE REACH

13. This Agreement does not recognize any use or create any right of use by the River District of the Shoshone Water Rights downstream of the Shoshone Reach. Notwithstanding the foregoing, this Paragraph 13 does not prevent any use by the River District or its constituents of the natural stream flow downstream of the Shoshone Reach within the priority system and in accordance with Colorado law and the Decree.

WATER COURT PROCEEDINGS

14. The parties shall file and diligently pursue a Water Court application and any necessary appeals to obtain the Decree in a final, unappealable form confirming a change of water right for the Shoshone Water Rights to include the additional use for instream flow purposes by the CWCB and confirming that the water attributable to the Shoshone Water Rights will be used for instream flow to preserve and improve the natural environment in the Shoshone Reach of the Colorado River to a reasonable degree up to the full amount of the ISF Rate , subject to the terms and conditions of the Decree and this Agreement. In such water court application, the CWCB, the River District, and PSCo shall be co-applicants for the purpose of advancing and protecting their contractual rights under this Agreement, including adjudicating a decreed right to use of the Shoshone Water Rights by the CWCB to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach. Except as otherwise provided in the PSA, to which the CWCB is not subject, each party shall bear its own attorney fees and costs related to its participation in any water court adjudication contemplated under this Paragraph 14. Except for its own attorney fees and court filing fees, the CWCB is not responsible for paying costs of prosecuting the water court application, including the costs of hiring a consulting engineer or other witnesses in furtherance of such application, or attorney fees of any other party incurred in relation thereto.

15. The parties intend that the Decree shall confirm that to the extent the water dedicated under this Agreement is not being used for hydropower generation at the Shoshone Power Plant, such water shall be beneficially used by the CWCB for instream flow purposes to preserve and improve the natural environment of the Colorado River within the Shoshone Reach to a reasonable degree, subject to the terms and conditions of the Decree and this Agreement.

16. The parties agree that the Decree shall not confirm any new appropriation of water. N or shall any claim be included in the Water Court application except as expressly described in this Agreement. The parties further agree that, upon the successful prosecution of the Water Court application described in Paragraph 14, above, and upon the issuance of the Decree by the Water Court, no further claim for approval of any change of water right with respect to the Shoshone Water Rights shall be sought by any of the parties to this Agreement in the future without first obtaining the prior written consent of all the parties hereto. The River District agrees it will not transfer or otherwise encumber the rights to any other person or entity without the express written consent of the CWCB, with the exception of the right to enter into a promissory note and deed of trust to the benefit of

PSCo as provided by paragraph 3.1.d.2 of the PSA. The parties agree to request that the Water Court include an express statement in the Decree setting forth the limitations described in this Paragraph 16, to wit:

a. the decree does not confirm any new appropriation or change except to add instream flow;
b. no further claim for approval of any change of the Shoshone Water Rights will be sought by any of the applicants without written consent of the other applicants hereto; and
c. the River District will not transfer or otherwise encumber the Shoshone Water Rights to any other person or entity without the express written consent of the CWCB.

RECORDS AND ACCOUNTING

17. The River District shall be responsible for maintaining all records and accounting necessary for the implementation of this Agreement, using forms mutually agreeable to the parties, and all records required by the Engineers for the administration of the changed Shoshone Water Rights.

18. The River District will provide accounting related to the operation of this Agreement to the CWCB and PSCo.

MISCELLANEOUS PROVISIONS

19. The term of this Agreement is perpetual unless terminated in accordance with the terms of this Agreement.

20. This Agreement will automatically terminate and be of no further effect in the event that (i) the sale of the Shoshone Water Rights from PSCo to the River District does not close or occur, or (ii) the PSA is terminated or otherwise expires. Except as otherwise provided in the immediately preceding sentence in this Paragraph 20, this Agreement may be amended or terminated by the written agreement of the parties, and any such termination or amendment shall take effect only when signed by all of the parties to this Agreement or their successors in interest.

21. Neither the CWCB nor PSCo is responsible for construction or modification of any structures that may be necessary for use of the Shoshone Water Rights for instream flow purposes.

22. This Agreement shall not be assignable by any party without the written consent of all the parties hereto. Notwithstanding the foregoing, an assignment by PSCo of this Agreement to any successor or assign of its rights under the Lease is approved by the CWCB and River District without separate written consent, however thirty (30) days advanced written notice of the assignment to the River District and the CWCB is required, and PSCo may assign the Lease only to a successive owner or operator of the Shoshone Power Plant for power generation purposes. Notice and contact information shall be provided to all parties concurrent with any assignment. In the event of the termination of the Lease by PSCo or

its successors or assigns pursuant to Paragraph 26, below, the River District and CWCB will not be required to obtain the written consent of PSCo or its successors or assigns to assign this Agreement.

23. Pursuant to section 37-92-102(3), C.R.S., this Agreement shall be enforceable by each of the parties hereto as a water matter according to the terms and conditions of this Agreement. The parties further agree that the exclusive venue for and jurisdiction of any dispute pertaining to the interpretation or enforcement of this Agreement shall be the Water Court (as defined herein); *provided, however*, that before commencing any action for enforcement of this Agreement, the party alleging the violation shall notify the other parties in writing of the alleged violation and the parties shall make a good faith effort to resolve their differences through informal consultation.

24. The parties hereto acknowledge and agree that specific performance of this Agreement shall be the exclusive remedy for failure of any party to comply with any provision of this Agreement. The parties hereby waive any right to seek or collect damages for any breach or violation of this Agreement.

25. Enforcement of this Agreement and all rights and obligations hereunder are reserved solely to the CWCB, the River District, and PSCo, and not to any third party. Any services or benefits which third parties may receive or provide as a result of this Agreement are incidental to the Agreement and do not create any rights for such third parties.

26. The parties anticipate that at some point in the future, PSCo may permanently decommission the Shoshone Power Plant, and the Lease will terminate. In the event that the Lease terminates, then PSCo shall provide written notice to the parties of the termination of the Lease and PSCo's rights and obligations under this Agreement will also be deemed to be terminated; however, all rights and responsibilities between the CWCB and the River District will remain in effect. Upon termination of the Lease, all restrictions on the Shoshone Water Rights throughout this Agreement due to hydropower use shall no longer be in effect, and, subsequent to any permanent decommissioning of the Shoshone Power Plant, instream flow shall be the only use of the Shoshone Water Rights.

27. The provisions of §§37-92-102(3) and 305(3)(b), C.R.S. that require that all contracts or agreements for interests in water, and the water court decree implementing the contracts or agreements, to state the board or the lessor, lender, or donor may bring about beneficial use of the historical consumptive use of the leased, loaned, or donated water right downstream of the instream flow reach as fully consumable water are not relevant and do not apply to this acquisition.

28. In the event the Decree and this Agreement are inconsistent, the Decree shall control.

29. This Agreement shall be construed in accordance with the laws of the State of Colorado and shall be interpreted broadly to give effect to its purposes.

30. Any failure or delay by a party in exercising any of its rights, power, and remedies hereunder or in accordance with laws shall not lead to a waiver of such rights, and the waiver of any single or partial exercise of a party's rights shall not preclude such party from exercising such rights in any other way and exercising the remaining part of the party's rights.

31. Any notice, consent, waiver, request or other communication required or provided to be given under this Agreement shall be in writing and shall be sufficiently given and shall be deemed delivered when: (a) delivered personally; (b) transmitted by email to the then-designated address of the party, provided that a delivery receipt sent by the recipient is received by the sender, provided if the delivery receipt is sent on a non-business day, or after 5:00 p.m. local time at the physical address of the recipient, then the notice will be deemed received on the next business day; (c) two (2) business days after deposit with the United States Postal Service by certified or registered mail, return receipt requested, postage prepaid; or (d) one (1) business day following deposit with a nationally recognized overnight delivery service, in any event, addressed to the applicable party as set forth below, or at such address as either party may from time-to-time specify in writing to the other:

If to the CWCB:

Section Chief
Colorado Water Conservation Board
Stream and Lake Protection Section
1313 Sherman Street, Room 721
Denver, CO 80203
DNR_CWCBISF@state.co.us

and

Jen Mele
First Assistant Attorney General
Natural Resources and Environment Section
1300 Broadway, 7th Floor
Denver, CO 80203
jen.mele@coag.gov

If to PSCo:

Public Service Company of Colorado
Attn: Environmental Services
1800 Larimer Street, Suite 1300
Denver, CO 80202

and

Public Service Company of Colorado
Attn: Legal Dept. – Real Estate
1800 Larimer Street, Suite 1400
Denver, CO 80202

(303) 294-2222
Frances.A.Folin@xcelenergy.com

and

Welborn Sullivan Meck & Tooley, P.C.
Carolyn F. Burr, Esq.
James M. Noble, Esq.
1401 Lawrence Street, Suite 1800
Denver, CO 80202
(303) 830-2500
cburr@wsmtlaw.com
jnoble@wsmtlaw.com

If to the River District:

Colorado River Water Conservation District
General Manager
Andrew Mueller
201 Centennial St., Suite 200
Glenwood Springs, CO 81601
edinfo@crwcd.org

and

General Counsel,
Peter Fleming, Esq.
201 Centennial St., Suite 200
Glenwood Springs, CO 81601
(970) 945-8522
pfleming@crwcd.org

32. Each provision contained herein shall be severable and independent from each of the other provisions such that if at any time any one or more provisions herein are found to be invalid, illegal, or unenforceable, the validity, legality, or enforceability of the remaining provisions herein shall not be affected as a result thereof.

33. The effective date of this Agreement shall be the last date shown on the signature page or pages of this Agreement, provided however that parties' rights and obligations under this Agreement with specific regard to the exercise of the Shoshone Water Rights for instream flow purposes shall not commence until the closing date of the PSA. If the PSA is terminated according to its terms, then this Agreement shall also automatically terminate. This Agreement may be executed in two or more counterparts, each of which when so executed shall be deemed to be an original and all of which when taken together shall constitute one and the same instrument. The counterparts of this Agreement may be executed and delivered by electronic means (including portable document format) by either of the parties and the receiving party may rely on the receipt of such document so executed and delivered electronically as if the original had been received.

[remainder of page intentionally blank]

[signature page(s) follow]

IN WITNESS WHEREOF, the CWCB, the River District, and PSCo have executed this Agreement as of the last date of execution.

COLORADO WATER CONSERVATION BOARD

By: _____
Lauren Ris, Director

Date: _____

[signatures continue on next page]

[signature page to Water Right Dedication Agreement (Shoshone Water Rights)]

COLORADO RIVER WATER CONSERVATION DISTRICT

ATTEST:

By: _____
Andy Mueller, General Manager

BY: _____

Date: _____

[signatures continue on next page]

[signature page to Water Right Dedication Agreement (Shoshone Water Rights)]

PUBLIC SERVICE COMPANY OF COLORADO

By:_____
Robert Kenney, President

Date:_____

[signature page to Water Right Dedication Agreement (Shoshone Water Rights)]

Exhibit A
(Shoshone Diversion Dam and Tunnel)

Exhibit B
(Purchase and Sale Agreement)

Final Report (CA23044)

Shoshone Reach Instream Flow Habitat Data Analysis, Habitat Simulations and Habitat Evaluation of Colorado River from the Shoshone Diversion to the Shoshone Power Plant Outfall

Submitted to:

Peter Fleming
Colorado River District
Glenwood Springs, Colorado

Submitted By:

William J. Miller, PhD
Freshwater Consulting, LLC
2404 Thoroughbred Ln.
Bozeman, Montana

September 30, 2024

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Table of Contents

Executive Summary vi

Introduction 1

Study Area 2

Methods 6

Two-Dimensional Hydraulic Modeling 8

Hydrology 8

Water Right Administration 9

Habitat Suitability Curves 10

Habitat Modeling 12

Habitat Time Series 12

Results 13

Habitat Modeling Results 20

Habitat Time Series Results 23

Aquatic Ecosystem Considerations 30

Conclusions 32

Literature Cited 35

Appendix A – Habitat Suitability Criteria for Trout, Flannelmouth Sucker and Mountain Whitefish. 38

Appendix B – Hydraulic Modeling Report 43

Appendix C – Hydrographic Survey Report 44

List of Figures

Figure 1. Shoshone Reach study area and study site. Colorado River flows from upper right to lower left. Source: Google Earth Pro July 17, 2023..... 4
Figure 2. Approximate gradient of Colorado River in the Shoshone Reach (Shoshone diversion dam to Shoshone Power Plant outfall) Source: Google Earth Pro Aerial Image July 19, 2023..... 5
Figure 3. Aerial image of Shoshone Reach Study Site with approximate delineation of habitat types. Source: Google Earth Pro Aerial Image July 19, 2023. 6
Figure 4. Flow chart of analysis sequence for instream flow study..... 7
Figure 5. Shoshone Reach Colorado River channel wetted area as a function of discharge. 15
Figure 6. Shoshone Reach, Colorado River comparison of existing and future average year (2000) hydrology..... 17
Figure 7. Shoshone Reach, Colorado River comparison of existing and future dry year (2001) hydrology. 17
Figure 8. Shoshone Reach, Colorado River comparison of existing and future wet year (1997) hydrology. 18
Figure 9. Shoshone Reach average year (2000) daily wetted area comparison of existing and future conditions..... 18
Figure 10. Shoshone Reach dry year (2001) daily wetted area comparison of existing and future conditions. 19
Figure 11. Shoshone Reach wet year (1997) daily wetted area comparison of existing and future conditions..... 19
Figure 12. Habitat area as a function of discharge for trout in the Shoshone Reach Colorado River..... 21
Figure 13. Habitat area as a function of discharge for Mountain Whitefish and Flannelmouth Sucker in the Shoshone Reach Colorado River..... 21
Figure 14. Adult Brown Trout average hydrologic year daily habitat for existing and future conditions. 24

Figure 15. Adult Brown Trout dry hydrologic year daily habitat for existing and future conditions. 25
Figure 16. Adult Brown Trout wet hydrologic year daily habitat for existing and future conditions. 25
Figure 17. Adult Rainbow Trout average hydrologic year daily habitat for existing and future conditions. 26
Figure 18. Adult Rainbow Trout dry hydrologic year daily habitat for existing and future conditions. 26
Figure 19. Adult Rainbow Trout wet hydrologic year daily habitat for existing and future conditions. 27
Figure 20. Adult Mountain Whitefish average hydrologic year daily habitat for existing and future conditions 27
Figure 21. Adult Mountain Whitefish dry hydrologic year daily habitat for existing and future conditions. 28
Figure 22. Adult Mountain Whitefish wet hydrologic year daily habitat for existing and future conditions. 28
Figure 23. Adult Flannelmouth Sucker average hydrologic year daily habitat for existing and future conditions 29
Figure 24. Adult Flannelmouth Sucker dry hydrologic year daily habitat for existing and future conditions. 29
Figure 25. Adult Flannelmouth Sucker wet hydrologic year daily habitat for existing and future conditions. 30
Figure 26. Stream Functions Pyramid showing hierarchical relationship of functions. (Source: Stream Mechanics https://stream-mechanics.com) 31

List of Tables

Table 1. Habitat type and percentage for Shoshone Reach, Colorado River (source: Google Earth Pro aerial images July 19, 2023). 5

Table 2. Species of interest for habitat analysis..... 11

Table 3. Percent of habitat area provided by 3000 cfs and winter and summer average year base flows compared to maximum potential habitat by species. 22

Executive Summary

This report documents the evaluation of instream flows for the purpose of protecting and enhancing aquatic resources in the Shoshone Reach of the Colorado River between the point of diversion for the Shoshone Water Rights at the Shoshone diversion dam and the Shoshone Power Plant outfall. The objectives were to determine the current state of the aquatic habitat and aquatic ecosystem in the Shoshone Reach and determine expected changes to the aquatic habitat and aquatic ecosystem due to hydrologic change. The hydrologic change would be from a potential dedication of the Shoshone Hydropower Plant water rights which include a senior right for 1,250 cfs and a junior right of 158 cfs for a total of 1,408 cfs to an instream flow use. This change in water right would allow the total 1,408 cfs to remain in the river as a dedicated instream flow rather than diverted through the hydropower plant.

The instream flow analysis used the general guidelines from the Instream Flow Incremental Methodology (IFIM) which was developed by the US Fish and Wildlife Service in the late 1970s and early 1980s. IFIM is a multi-disciplinary methodology based on ecosystem principles and includes analysis of hydrology, habitat suitability criteria for species of interest, channel hydraulics and predictions of hydraulic-habitat as a function of discharge. In addition, the data from an IFIM approach can be used to interpret other ecosystem responses to change in stream flow. IFIM is specifically designed to evaluate and compare alternative flow regimes. The IFIM approach has been applied to other rivers and streams throughout Colorado.

The Colorado River in the Shoshone Reach is confined on the right by the interstate highway and on the left by the railroad. Habitat within the Shoshone Reach includes rapids, high gradient riffles, deep pools and runs. The Shoshone Reach is approximately 2.4 miles long and has an elevation drop of 170 feet from the diversion dam to the Shoshone Power Hydropower Plant outfall.

One study site was selected based on habitat characteristics that were generally representative of the non-rapid sections of the reach. The site included multiple repeats of riffle, pool and run habitat. The confined, steep gradient river channel does not allow safe access for in-channel measurements at all sections of the Shoshone Reach. The final decision on study site location from those areas deemed representative was determined during the field measurements and based on representativeness of the site and safety for personnel.

Two flow regimes were compared for this analysis, which were existing flows and future flows. Existing flows for the Shoshone Reach were calculated by substracting the amount of water diverted for hydro power production from the flow at the Dotsero gage. The future flows for the Shoshone Reach were the flows that would have been diverted at the power plant but instead allowed to remain in the channel through the Shoshone Reach. The analysis included the comparison of the existing flow regime to the future flow regime for hydrology in average, dry and wet years. The existing flow regime in the

reach includes days of zero flow when the hydropower plant is operating and total river flow is equal to or less than 1,408 cfs. The proposed future flow regime would not have zero flows and the water currently diverted for hydropower production would remain in the river.

A two-dimensional hydraulic model was developed to simulate stream hydraulics for flows from 50 cfs up to 3000 cfs. Specific flows of 50, 250, 700, 1,020, 1,250, 1,400 and 3000 cfs were simulated. The model was calibrated to the field measured flow of 1,020 cfs. Predictions from the simulated flows for wetted area, depth, and velocity were used in the hydraulic habitat analysis.

The species of interest and habitat suitability criteria for the hydraulic habitat analysis were determined in consultation with Colorado Parks and Wildlife and Colorado Water Conservation Board. The species selected were Rainbow Trout, Brown Trout, Flannelmouth Sucker and Mountain Whitefish. Habitat suitability criteria came from existing data sets that were previously used in other IFIM studies in Colorado.

Wetted area predictions were used to evaluate other biota that were not specifically modeled with habitat suitability criteria. These biota included the lower trophic levels of algae and macroinvertebrates that provide food resources for fish. The wetted area for the existing flow regime has many days at or near zero area due to diversion for hydro power production. The loss of wetted area results in partial or total mortality of algae and macroinvertebrates and the loss of food resources for fish. The loss of wetted area also requires fish to move out of the reach or be stranded. Research in other portions of the Colorado River has demonstrated that 1.5 to 2 months are required for algae and macroinvertbrate productivity to recover to the density and biomass that was present prior to the loss. The future flow regime does not have zero flow days and has stable consistent wetted area in all year types. These stable flows would allow macroinvertebrates to complete their annual life cycles and provide stable habitat area for algae and macroinvertebrates.

The hydraulic-habitat analysis predicted the maximum habitat availability for fish species at flows from 700 cfs to 1,400 cfs depending on the species. The zero flow days with the existing conditions results in total loss of habitat over extended periods of time. This habitat loss coupled with the concurrent loss of food productions results in substantial impacts to fish species in the Shoshone Reach. Future condition flows result in habitat conditions that are near the maximum potential habitat for the Shoshone Reach for all fish species. The future conditions result in stable flows during base flow periods that provide stable habitat and stable food resources for the fish species in the Shoshone Reach.

Based on the available hydrology and the habitat-discharge functions, the future flows (the Shoshone Hydropower Plant water rights which include a senior right for 1,250 cfs and a junior right of 158 cfs for a total of 1,408 cfs plus the bypassed/shepherded flows, which can result in a total flow of up to approximately 2,500 cfs to 3,000 cfs at the Dotsero Gage) would provide a substantial increase in habitat and benefit aquatic biota

during summer, fall, winter, and early spring as compared to the existing conditions. These flows up to approximately 2,500 cfs to 3,000 cfs therefore will help to preserve and improve the natural environment in the Shoshone Reach.

There also are indirect benefits to other sections of the Colorado River from the Shoshone Hydropower Plant water rights. These water rights are administered at the Dotsero Gage upstream from the Shoshone Reach, however, the water is conveyed from the upper sections of the Colorado River upstream of the Dotsero gage downstream to the Shoshone Reach and benefits all of the intervening reaches of the upper Colorado River. Similarly, the Colorado River downstream of the Shoshone Reach benefits from the Shoshone Hydropower Plant water rights.

In summary, the future conditions with the Shoshone Hydro Power Plant water right in place as an instream flow in the Shoshone Reach would result in the following:

- Stable base flow conditions with no zero flow days.
- Stable wetted area during future conditions in late summer, fall, winter and spring for better conditions for macroinvertebrates and algae which are food sources for fish species.
- Average year hydraulic-habitat conditions in summer and winter base flows that provide from 81% to 99% of the potential maximum hydraulic habitat.
- Continuation of indirect benefits upstream and downstream of the Shoshone Reach from water delivered to the Shoshone Reach.
- Flows from 1,400 to 3,000 cfs provide additional benefit to the aquatic habitat in the Shoshone Reach.
- Overall improved instream conditions to preserve and enhance the aquatic habitat.

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Introduction

This report documents the evaluation of instream flows for aquatic resources in the Shoshone Reach of the Colorado River between the point of diversion for the Shoshone Water Rights at the Shoshone diversion dam and the Shoshone Power Plant outfall (Figure 1). Habitat within the Shoshone Reach includes rapids, high gradient riffles, deep pools and runs. The objectives were to determine the current state of the aquatic habitat and aquatic ecosystem in the Shoshone Reach and determine expected changes to the aquatic habitat and aquatic ecosystem due to hydrologic change. The hydrologic change would be from a potential dedication of the Shoshone Hydropower Plant water rights which include a senior right for 1,250 cfs and a junior right of 158 cfs for a total of 1,408 cfs to an instream flow use. This change in water right would allow the total 1,408 cfs to remain in the river rather than diverted through the hydropower plant.

The report and analysis included input of data from hydraulic model simulations and calculation of habitat area by life stage for each simulated flow. Hydraulic and habitat model simulations included analysis for a range of flows (50, 250, 700, 1,020, 1,250, 1,400 and 3,000 cfs). A two-dimensional hydraulic model was developed for a single study site in the reach (River Restoration 2023). The modeled site was approximately 1,850 feet long and included multiple habitat types found within the Shoshone Reach (Figure 1). The species of interest for the Shoshone Reach study were determined in consultation with Colorado River Water Conservation District (River District) and other entities (Colorado Parks and Wildlife (CPW) and the Colorado Water Conservation Board (CWCB)) as determined by River District staff. Habitat suitability criteria for the species of interest were used in previous studies on what is now the Upper Colorado River Wild and Scenic Alternative Management Plan section of the Colorado River (Miller and Swaim 2011; See also Appendix A this report) with modifications as determined by CPW staff. Hydrology data for habitat time series analysis was provided by the River District.

This study followed the general guidelines of the Instream Flow Incremental Methodology (IFIM) (Bovee et al. 1998). IFIM is a multi-disciplinary approach to evaluating instream flow alternative management scenarios and includes components of hydrology, river hydraulics, and biological data. River hydraulics include simulation of a range of discharges to predict change to the wetted area, depth and velocity that may affect the aquatic biota. The output of the combination of hydraulic model results with habitat use data is generally referred to as hydraulic-habitat. Biological data analysis included evaluation of wetted area as it may affect aquatic biota such as periphyton, macroinvertebrates and available fish habitat.

Study Area

The Colorado River in the Shoshone Reach is subject to several human induced factors. The river channel is bordered by Interstate Highway 70 on river right and the railroad on river left. River discharge is impacted by large headwater reservoirs, transbasin diversions, and diversions for off-channel uses. The Shoshone Reach study area extends from the diversion dam near the Hanging Lake Trailhead parking lot adjacent to I-70 downstream to the Shoshone Power Plant outfall (Figure 1). The total distance for the Shoshone Reach is approximately 2.4 miles. The Shoshone Reach has sections of rapids, high gradient riffles, runs and deep pools. The overall gradient is steeper than the upstream reaches of the Colorado in non-canyon reaches. The river elevation drops over 170 vertical feet over the 2.4-mile distance with extremely steep gradients in areas with rapids (Figure 2).

The total area for each major habitat type (riffle, pool and run) for the Shoshone study reach was approximated from the aerial images from Google Earth Pro based on surface characteristics. The Shoshone reach is dominated by high gradient riffle and rapids with smaller proportions of pools and runs (Table 1). The study site was selected based on the presence of multiple habitat types and the ability to safely obtain the data needed for the hydraulic and habitat models. The study site within the Shoshone Reach has multiple

repeats of habitat types of riffle, run and pool habitat that are representative of the lower gradient, non-rapids habitat within the Shoshone Reach (Figure 3). The Shoshone Reach supports multiple fish species of trout, native suckers, mountain whitefish and sculpins (Kendall Bakich CPW, personal communication 2024; CPW file data). These same species have been collected by CPW upstream and downstream of the Shoshone Reach in the Colorado River. There are no quantitative data on fish populations in the Shoshone Reach due to the river conditions that restrict safe access for population sampling efforts. Shoreline sampling by CPW in 2023 showed the presence of Brown Trout and Rainbow Trout. In addition to fish, the river also supports the lower trophic levels of periphyton, algae, and benthic macroinvertebrates. These trophic levels are important food resources for the higher trophic levels and are dependent on continuous river flow for completing their life cycle. The periphyton supports benthic invertebrates and fish, benthic macroinvertebrates support fish species.



Figure 1. Shoshone Reach study area and study site. Colorado River flows from upper right to lower left. Source: Google Earth Pro July 17, 2023.

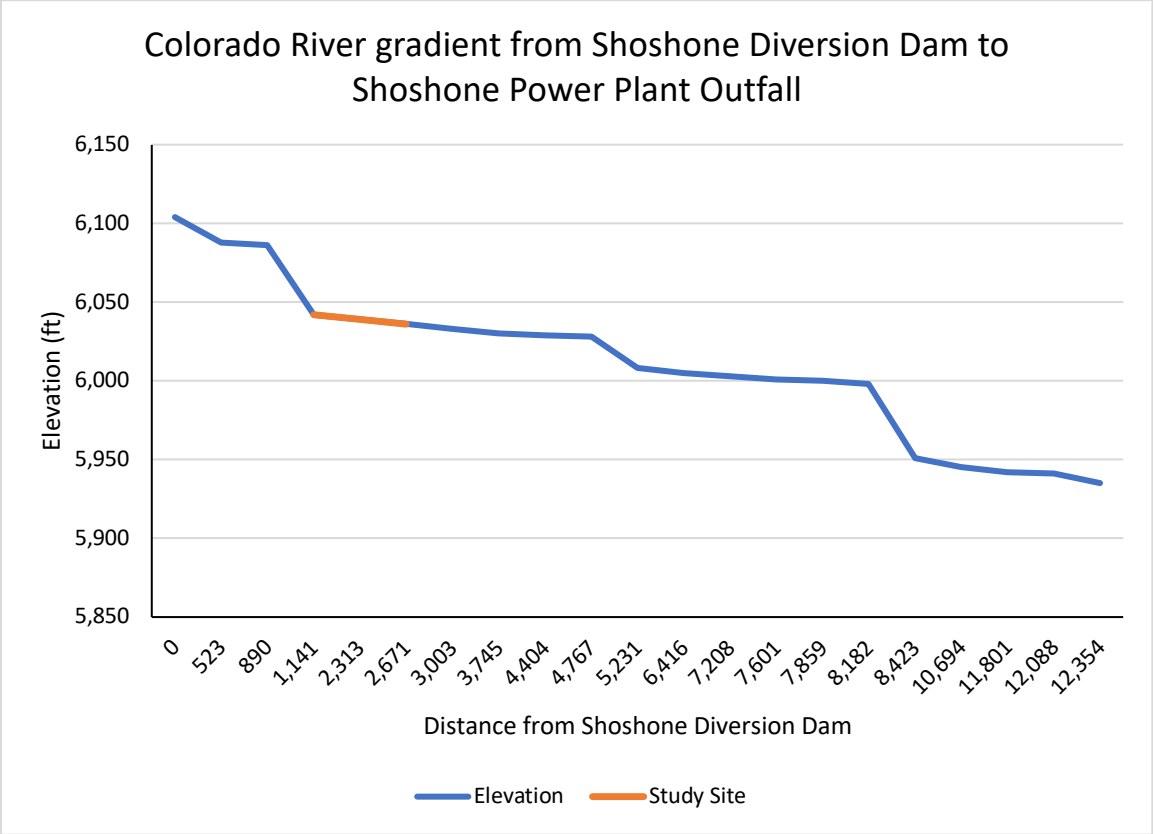


Figure 2. Approximate gradient of Colorado River in the Shoshone Reach (Shoshone diversion dam to Shoshone Power Plant outfall) Source: Google Earth Pro Aerial Image July 19, 2023.

Table 1. Habitat type and percentage for Shoshone Reach, Colorado River (source: Google Earth Pro aerial images July 19, 2023).

Habitat Type	Summed length (ft)	Percent
Riffle	5363	42%
Rapid	5045	39%
Run	332	3%
Pool	2121	16%
Total	12861	100%



Figure 3. Aerial image of Shoshone Reach Study Site with approximate delineation of habitat types. Source: Google Earth Pro Aerial Image July 19, 2023.

Methods

There are several methodologies available to evaluate riverine habitat (Annear et al. 2004; Stalnaker et al. 1995). These include simple standard setting methods such as R2Cross up to more complex methods that evaluate multiple parameters to better address complex water management problems. The Instream Flow Incremental Methodology (IFIM) is a multidisciplinary methodology and was developed to evaluate complex water management problems (Bovee, 1982; Bovee et al. 1998; Stalnaker, 1995). IFIM includes sound ecological principles in the methodology (Bovee et al. 1998). The IFIM approach has been used in other instream flow evaluations in Colorado including the Colorado River, Dolores River, Cache La Poudre River and South Platte River basins.

The general approach to evaluating instream habitat in the Shoshone Reach follows the guidelines of IFIM. The analysis sequence includes collection of field data for stream topography, bathymetry, and hydraulic parameters, and fish habitat use data. These field data are the input parameters for hydraulic modeling and habitat suitability analysis. The hydraulic model output and habitat suitability are combined to calculate habitat area as a function of discharge for a range of flows. This function is combined with hydrology scenarios to determine change in habitat over time (Figure 4). In addition to the data used for fish habitat, hydraulic model results for wetted area were used to infer changes to other non-modeled biological conditions such as changes to habitat for benthic macroinvertebrates.

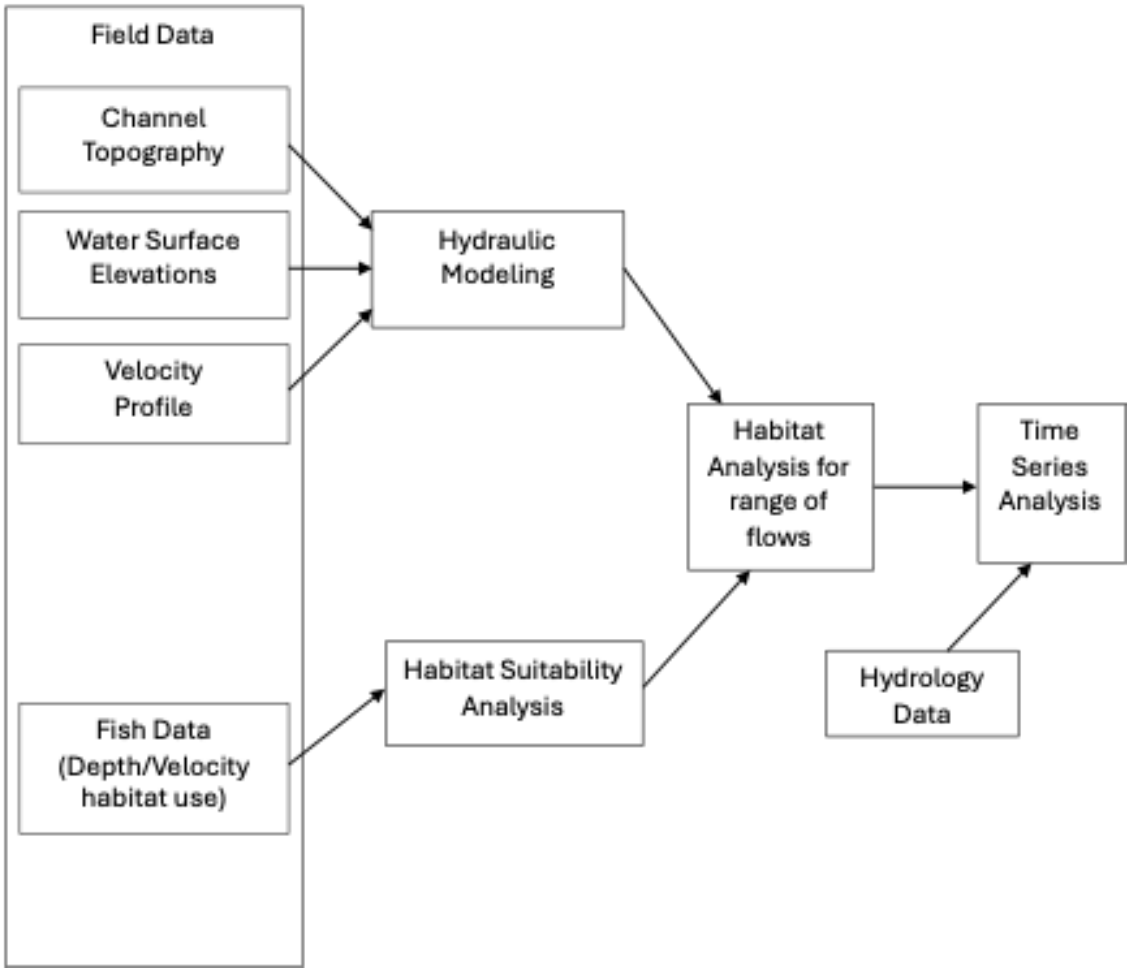


Figure 4. Flow chart of analysis sequence for instream flow study.

Two-Dimensional Hydraulic Modeling

Two-dimensional hydraulic modeling was completed by River Restoration (River Restoration 2023, See Appendix B and Appendix C). The 2-D model uses the georeferenced field data collected from the site. Data inputs include site topography, substrate, and flow impediments; a stage-discharge relationship at the downstream end of the site; and calibration and validation data throughout the site. The survey data was used to develop a grid system to represent the stream geometry as a mesh. Model mesh was approximately 4 ft by 4 ft for the site (River Restoration 2023). This mesh was combined with the hydraulic data to simulate water depths and depth averaged velocities for the range of flow conditions for 50, 250, 700, 1,020, 1,250, 1,400, and 3,000 cfs. The water depth and depth averaged velocity from the hydraulic model are required to be consistent with the data collected for the fish habitat use, which also is water depth and depth averaged velocity.

Hydrology

The River District provided the hydrology time series for the Shoshone Reach. The hydrology data included hydrology from actual gage data using the USGS Colorado River near Dotesero gage (Dotsero Gage) located just upstream of the Shoshone Reach over a period of record of 1973-2003. The data are presented as an irrigation year (Nov 1-Oct 31) with three typical hydrologic conditions based on the following years: Wet – 1997, Average – 2000, and Dry - 2001. The years were selected to get a range of hydrologic conditions from wet to dry and also were years the Shoshone Hydropower plant operated. The hydropower plant operation data was needed so "existing" conditions in the Shoshone Reach could be evaluated. Actual gage data is the "future" or proposed condition of the Shoshone Reach for each of these sample years, assuming the scenario that the Shoshone Water Rights are not used for hydro-power generation

purposes but are instead being exercised by the CWCB for instream flow purposes, causing all flow to go through the Shoshone Reach. Existing conditions were assumed to be historical flow at Dotsero Gage flow less 1,408 cfs to mimic the typical historical operations of the Shoshone Power Plant of diverting all available flow up to 1,408 cfs as described further below. The three sample year types for existing and future conditions were used in the habitat time series.

Water Right Administration

The Dotsero Gage (USGS 09070500) is an administrative point utilized by the Colorado Division of Water Resources ("DWR") to measure all streamflow in the river at the location of the gage. In addition, DWR has historically relied on the Dotsero Gage as the point of administration for the Shoshone Water Rights. DWR uses the Dotsero Gage to measure both the amount of un-depleted, natural flow as well as the amount of bypassed flow associated with shepherded releases from reservoirs located upstream of the gage. For purposes of this report, the "natural flow" includes the amount of water divertible by the Shoshone Water Rights when those water rights are in priority but does not include any bypassed water or releases from upstream reservoirs administered for downstream water use below the Shoshone Reach. Those bypass flows (i.e., shepherded releases), which are also administered at the Dotsero Gage, are those reservoir releases made for the purposes of increasing streamflow at certain downstream locations in excess of the natural flow that would exist at these locations but for the bypass water, such as releases for irrigators in the Grand Valley or for environmental flows to benefit the 15-Mile Reach.

Importantly, DWR does not administer the shepherded bypass water at the Dotsero Gage to satisfy any calls for administration of the senior and junior Shoshone Water Rights. Instead, DWR accounts only for the available natural flow at the Dotsero Gage whenever a Shoshone Call is placed to determine whether upstream junior water rights must be curtailed to ensure that sufficient natural flow is available for beneficial use at the Shoshone Power Plant where such water is diverted from the river. Similar operating

conditions have been assumed for the future-conditions hydrology in this Report such that if the Shoshone Water Rights are utilized for instream flow purposes the Shoshone Call would be based solely on the amount of natural flow as measured at the Dotsero Gage, not including the amount of shepherded bypass water. Thus, the Shoshone Reach could have flows greater than 1,408 cfs at certain periods when the Shoshone Call has been placed but is not being fully satisfied. This is because DWR administers the Shoshone Call based solely on available natural flow at the Dotsero Gage but does not administer any shepherded bypass water to satisfy the call even though such bypass water does eventually flow through the Shoshone Reach for downstream beneficial uses.

Habitat Suitability Curves

Species habitat suitability criteria are required for the hydraulic-habitat analysis. Habitat suitability criteria that accurately reflect the habitat requirements of the species of interest are essential to conducting meaningful and defensible habitat analyses (Bovee 1982). A previous study in the Colorado River from Kremling to Dotsero, Colorado (Miller and Swaim 2011) incorporated habitat suitability criteria for the same species of interest as in this study (Table 2). The habitat suitability criteria include adult trout, adult Mountain Whitefish, and adult Flannelmouth Sucker. Other species considered for this analysis were Bluehead Sucker and Mottled Sculpin. Habitat suitability criteria were not available for Mottled Sculpin. Bluehead Sucker were not explicitly modeled in the study due to a lack of sufficient number of data observations, however, the data that was available shows an overlap in the depth and velocity used with Flannelmouth Sucker (Miller 2024).

Table 2. Species of interest for habitat analysis.

Common Name	Scientific Name
Rainbow Trout	*Oncorhynchus mykiss*
Brown Trout	*Salmo trutta*
Mountain Whitefish	*Prosopium williamsoni*
Flannelmouth Sucker	*Catostomas latipinnus*

The habitat data for the species of interest came from several sources and have been used in previous studies on the Colorado River (Miller and Swaim 2011). The data for adult trout was collected by direct observation at several locations in rivers in Colorado. The data was collected by personnel from Colorado Division of Wildlife (now CPW) and US Fish and Wildlife Service in 1988 and 1989 (Colorado Division of Wildlife 1989). Those observations were used to develop habitat preference suitability indices for depth and velocity and corrected for habitat presence (Wilding 2012).

Criteria for Mountain Whitefish used for this analysis came from Bovee (1978). The criteria for adult Flannelmouth Sucker were updated in early 2024 from a combination of data from radio telemetry studies on the Colorado River near Grand Junction, existing data from a range of rivers and literature review of habitat and population studies (Miller 2024). Additional habitat criteria for Flannelmouth Sucker were incorporated into the final suitability criteria as documented by Miller (2024). The habitat suitability criteria for Flannelmouth Sucker are also being used as a proxy for Bluehead Sucker criteria for this study. Bluehead Sucker feed by scaping on hard substrates and are known to feed in faster riffle habitat with cobble and boulders whereas Flannemouth Sucker feed on softer substrates in somewhat slower velocities so the habitat response shown for Flannelmouth Sucker may approximate habitat response to flow for Bluehead Sucker but not fully depict all areas suitable for Bluehead Sucker. The suitability indices for all species are listed in Appendix A.

Habitat Modeling

The habitat modeling for this analysis will follow the concepts of IFIM (Bovee 1982, Stalnaker et al. 1995). IFIM requires hydraulic data and simulations; habitat use data expressed as habitat suitability criteria; and hydrology data for a range of stream discharge conditions. The 2-D hydraulic analysis and simulations were described above.

Habitat suitability modeling for each species of interest was accomplished through a spreadsheet model. The spreadsheet instream habitat model relies on inputs from both the two-dimensional hydraulic modeling and the habitat suitability criteria described above. Data corresponding to flow depths and depth averaged velocities provided by the two-dimensional hydraulic modeling were developed for each flow rate within the study site. Specific habitat criteria developed from the suitability analyses described above were then used to calculate habitat area. Multiple data sets of usable habitat were generated, corresponding to each species and flow of interest. The usable habitat area for each species of interest is the result of combining the hydraulic simulations for each flow with the habitat suitability function for each species. Summation of total habitat for each species and simulated flow results in a habitat-discharge relationship by species that becomes input for the habitat-time series analysis.

The habitat–discharge relationships are a set of theoretical functions based on channel shape and hydraulics. The actual habitat realized by the species is a function of the discharge at the site over time combined with the habitat–discharge function and results in the habitat time series.

Habitat Time Series

The actual habitat experienced by the fish in any river depends on the flow regime of the river. The relative abundance of habitat conditions over time is an integral part of the comparison of flow regimes. Generally, the habitat time series is the comparative

analysis used for the decision point in IFIM. Habitat time series produces the data needed to compare a range of flow conditions over time and to compare different flow scenarios. The habitat-discharge relationships for each study site were used as input data for the habitat time series. This analysis allowed a comparison between the existing flow regime and alternate flow regimes to determine available habitat with each time series.

Habitat time series evaluations were conducted on two flow regimes representing the existing hydrologic condition and the potential future condition with water flowing in the Shoshone Reach. For each flow regime assessed, we conducted both hydrology and habitat time series analysis for wet, average and dry hydrology to calculate both flow and habitat statistics. These values allowed a direct comparison of the changes that occur in both flow and habitat under a range of conditions. These tabular data were displayed for each flow scenario to represent the spatial habitat distributions.

Habitat time series was completed using a spreadsheet format that combines the hydrology over time with the habitat use as a function of discharge. These values are converted to area of habitat for the study site and then area of habitat for the Shoshone Reach to compare change in habitat over time for each flow of interest.

Results

The study components include results from the hydraulic model for depth, velocity, and wetted area at each simulated flow, available hydraulic-habitat at each modeled flow and comparison of daily habitat for a range of hydrologic year types. Wetted area is used to infer changes to the non-modeled biological data and to more fully understand the range of conditions that may be available to fish species. The hydraulic-habitat analysis provides the data needed to determine change in available habitat at specific discharges and provides the data to evaluate change in habitat with changes to hydrology on a daily time step.

The hydraulic model mesh and hydraulic parameters provide the basic physical data for the analysis. These data include the area for wetted channel area for each flow. The wetted area for the study site has the sharpest decline in area as the flow declines from 250 cfs to 50 cfs (Figure 5). Flows higher than 250 cfs have a gradual increase in wetted area up to the highest simulated flow of 3,000 cfs.

Wetted area or wetted channel perimeter is a measure of the total aquatic habitat available under varying flow levels and can also be used as an indicator of stream food web function. Primary and secondary trophic levels (algae and benthic macroinvertebrates, respectively) are positively correlated to stable wetted area (Rees et al. 2008). Many of the key macroinvertebrates such as Mayflies, Stoneflies, and Caddisflies, have annual life cycles and require continuous flow for a year or more to complete their life cycles. Any disruption or loss of habitat due to loss of wetted area during a single year results in either a decrease or total loss in productivity and directly impacts the food resources available to other species. A day or days of zero flow can eliminate primary and secondary food productivity due to mortality of algae and macroinvertebrates and take weeks to return to previous levels (Rees et al. 2008).

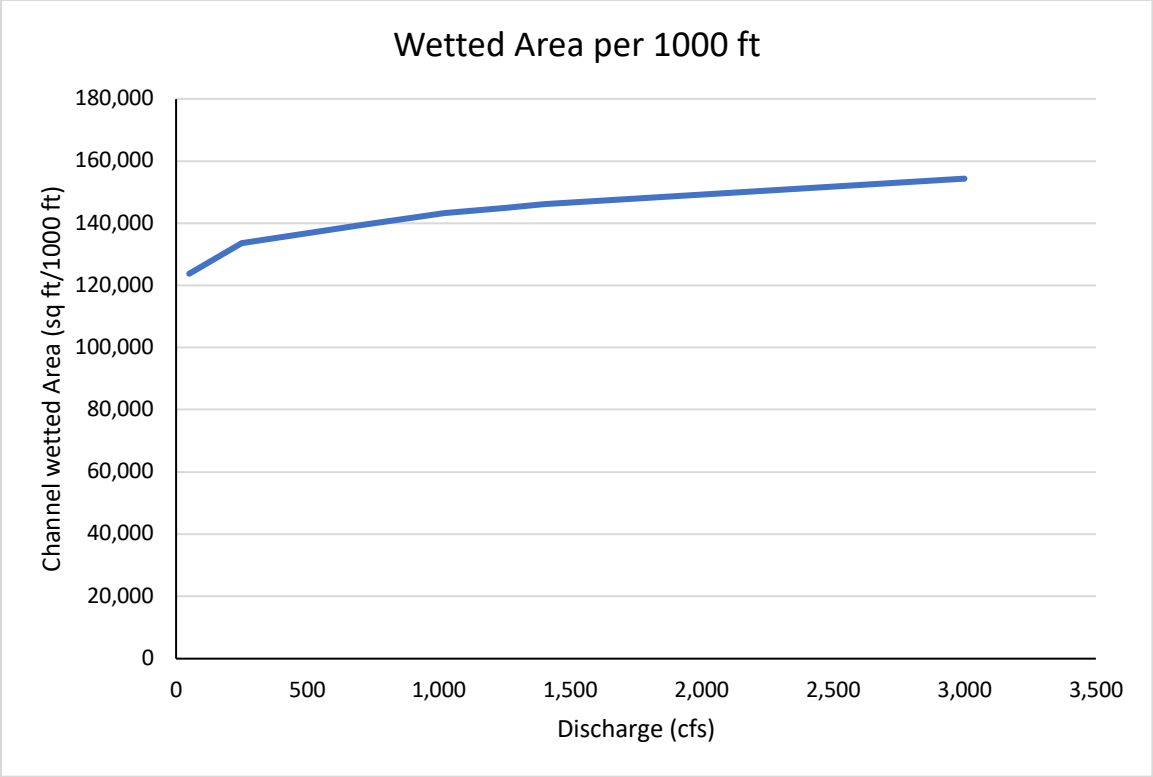


Figure 5. Shoshone Reach Colorado River channel wetted area as a function of discharge.

The hydrology for the reach was graphed to display the comparison between the existing conditions and future conditions for average (Figure 6), dry (Figure 7) and wet (Figure 8) hydrologic conditions. There are extended periods of zero flow days, particularly in winter, for the existing conditions in all hydrologic years. The number of zero flow days are 235, 183 and 134 with existing conditions for dry, average, and wet hydrologic years, respectively. Peak flows during runoff range from approximately 2,500 cfs in dry years to approximately 14,000 cfs in wet years for existing conditions. The base flows under future conditions (when the Shoshone Hydropower Plant is offline) are lowest in winter with flows ranging from approximately 750 cfs in dry years to approximately 1,000 cfs in average and wet years. There are no zero flow days in future conditions. This is a substantial change in flows during base flow periods under future conditions compared to the existing hydrologic conditions in all hydrologic years.

The hydrologic time series comparing existing and future conditions demonstrates that the existing flows result in a total loss of wetted area in all sample year types (Figure 9, Figure 10, Figure 11). Daily flows greater than 3,000 cfs (the highest flow in the 2-D model) were not plotted to limit the data analysis to the range of the hydraulic model. There are also sporadic losses to wetted area during late summer into the fall for existing conditions. There are extended periods of total loss of wetted area from late fall through spring for existing conditions. The loss of wetted area is most impactful to the algae and benthic macroinvertebrates. These species are not as mobile as fish species and require longer times to recolonize the channel after flows return. The general annual life cycle for macroinvertebrates includes adult emergence and egg deposition in late spring through summer, eggs hatch and nymph stages mature from summer through the next spring to early summer when adults emerge and the cycle repeats. Loss of wetted area, either partial or complete, results in a loss of food resource productivity and loss of habitat for mobile fish species. Stable wetted area as shown in the future condition's hydrology time series with the 1,408 cfs water right in the Shoshone Reach is beneficial to primary and secondary trophic levels and fish habitat. In addition, the bypassed/shepherded flow that is added to the 1,408 cfs water right provides an additional amount of wetted area (approximately 4% at 3,000 cfs) and is beneficial to the aquatic ecosystem. The additional wetted area provides more area for macroinvertebrate emergence. The shoreline areas with large substrate provide velocity refuge habitat for fish. The benefit to the lower trophic levels would provide improved ecological conditions for the higher trophic levels and result in more robust ecological conditions in the Shoshone Reach.

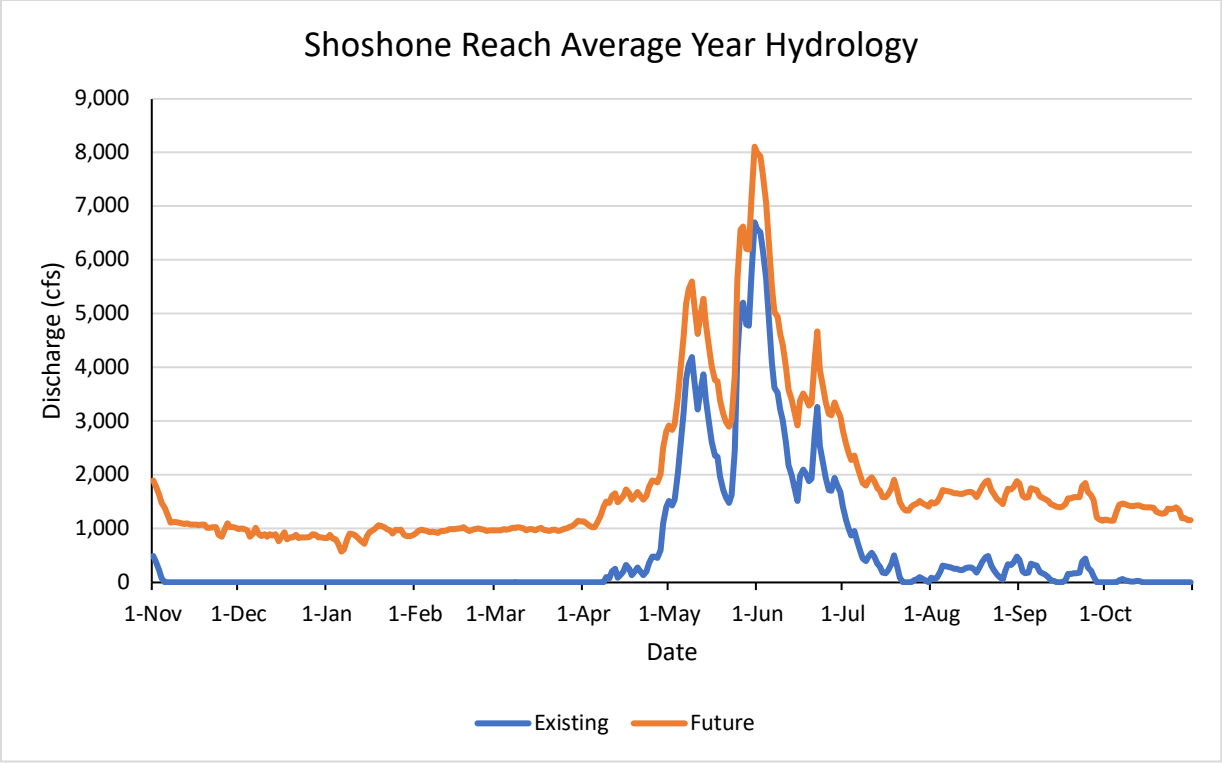


Figure 6. Shoshone Reach, Colorado River comparison of existing and future average year (2000) hydrology.

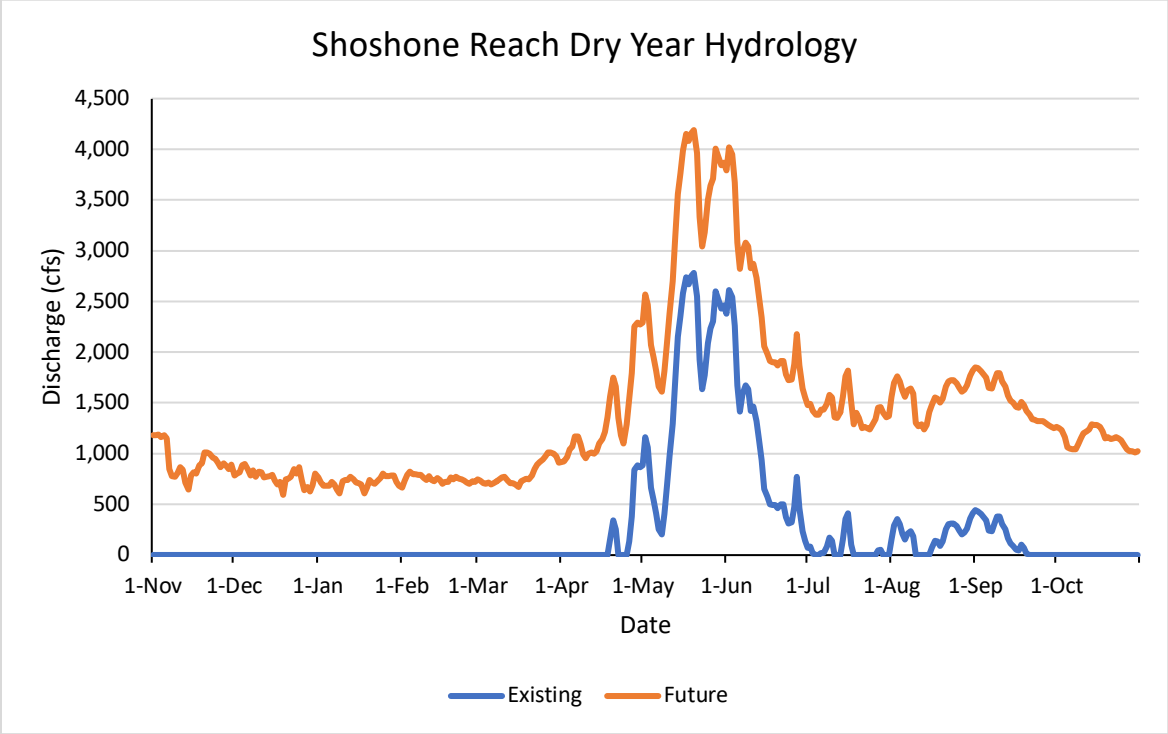


Figure 7. Shoshone Reach, Colorado River comparison of existing and future dry year (2001) hydrology.

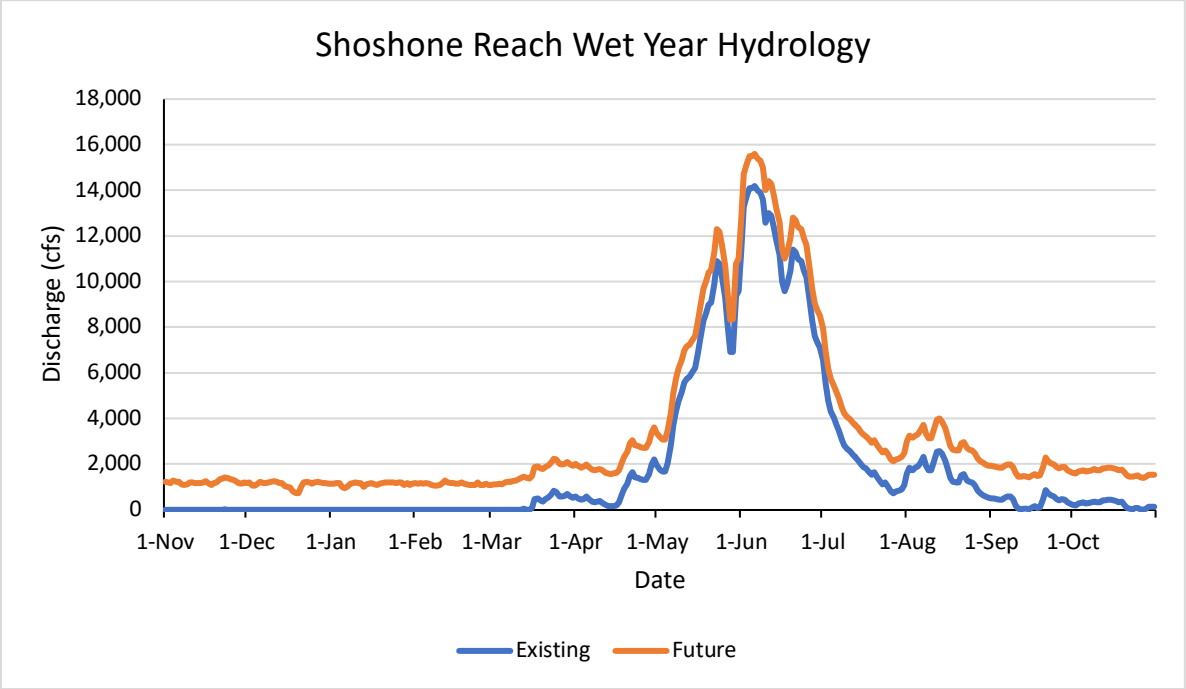


Figure 8. Shoshone Reach, Colorado River comparison of existing and future wet year (1997) hydrology.

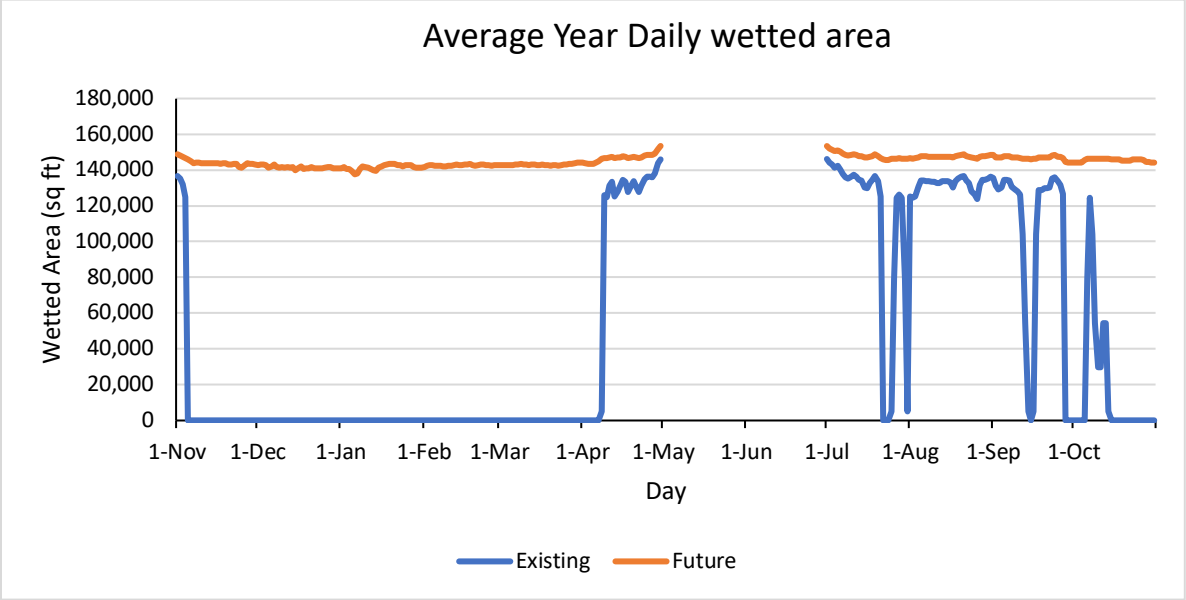


Figure 9. Shoshone Reach average year (2000) daily wetted area comparison of existing and future conditions.

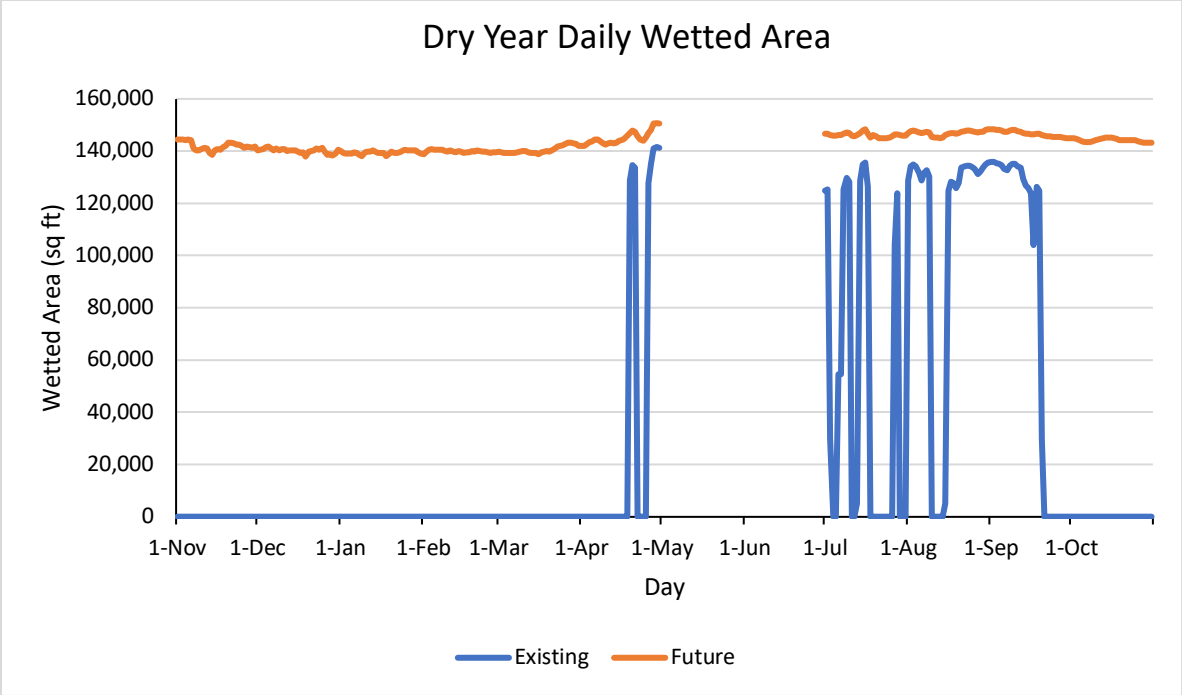


Figure 10. Shoshone Reach dry year (2001) daily wetted area comparison of existing and future conditions.

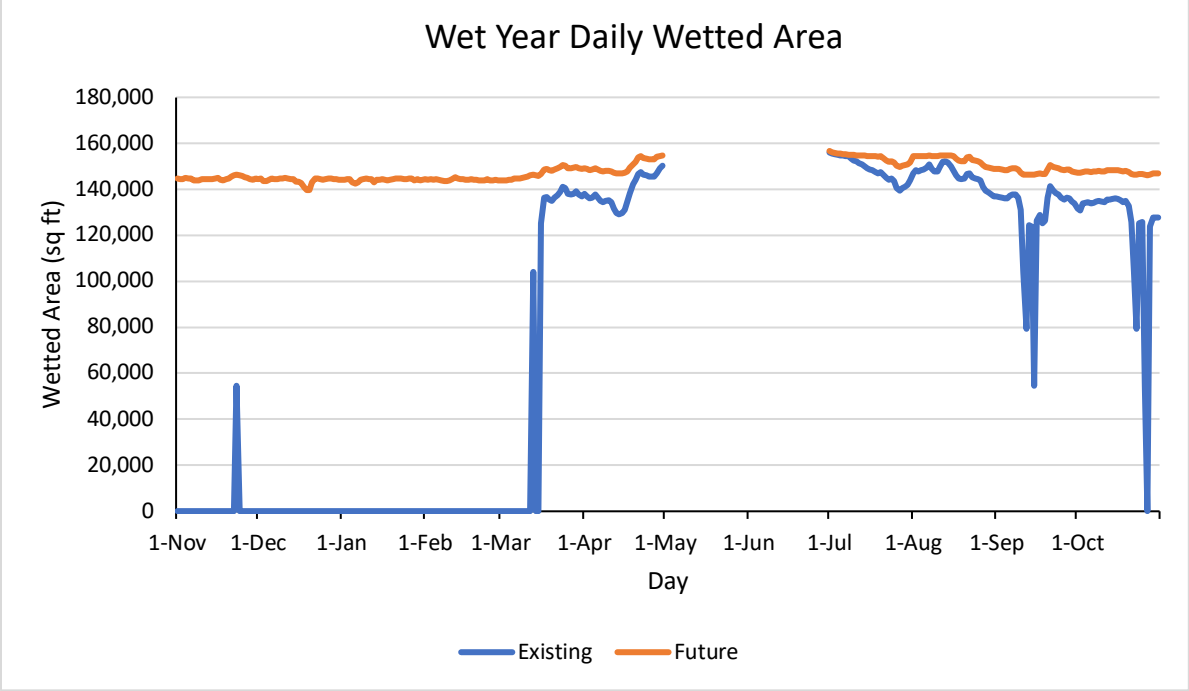


Figure 11. Shoshone Reach wet year (1997) daily wetted area comparison of existing and future conditions.

Habitat Modeling Results

Habitat for each species is a function of both habitat quantity and habitat quality. These characteristics vary with discharge. Habitat area with IFIM is an indicator of usable habitat for each species but does not directly reflect population level changes due to other contributing factors that determine population change. The amount of usable habitat area is an indication of aquatic conditions for the species and can reflect long-term population trends. Small short-term changes in habitat area (other than zero flows) should not be equated with a one-to-one correspondence to short term change in population.

The model results for Rainbow Trout, Brown Trout, Mountain Whitefish and Flannelmouth Sucker show the highest habitat availability at flows that range from 700 cfs to 1,400 cfs (Figure 12, Figure 13). Habitat availability declines quickly as flow decreases from 700 cfs likely caused by decline in wetted area and less suitable depth and velocity characteristics. There is a gradual decline in habitat availability as flow increases up to 3,000 cfs. The reduction in habitat at high flows is likely due to higher water velocities that are less suitable for the species. There is still usable habitat available for fish species as flows increase from 1,500 cfs to 3,000 cfs.

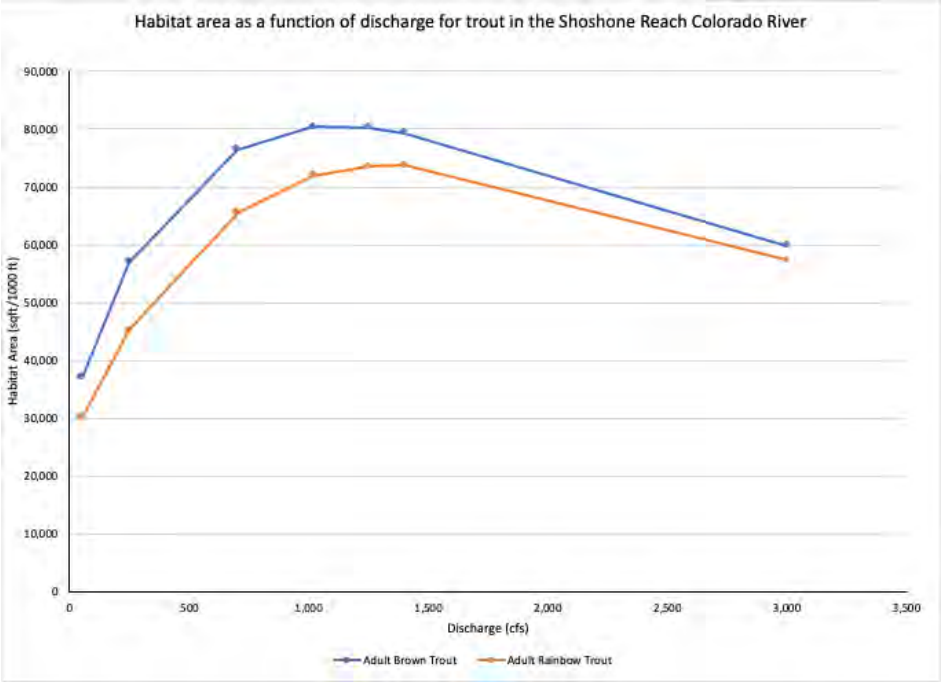


Figure 12. Habitat area as a function of discharge for trout in the Shoshone Reach Colorado River.

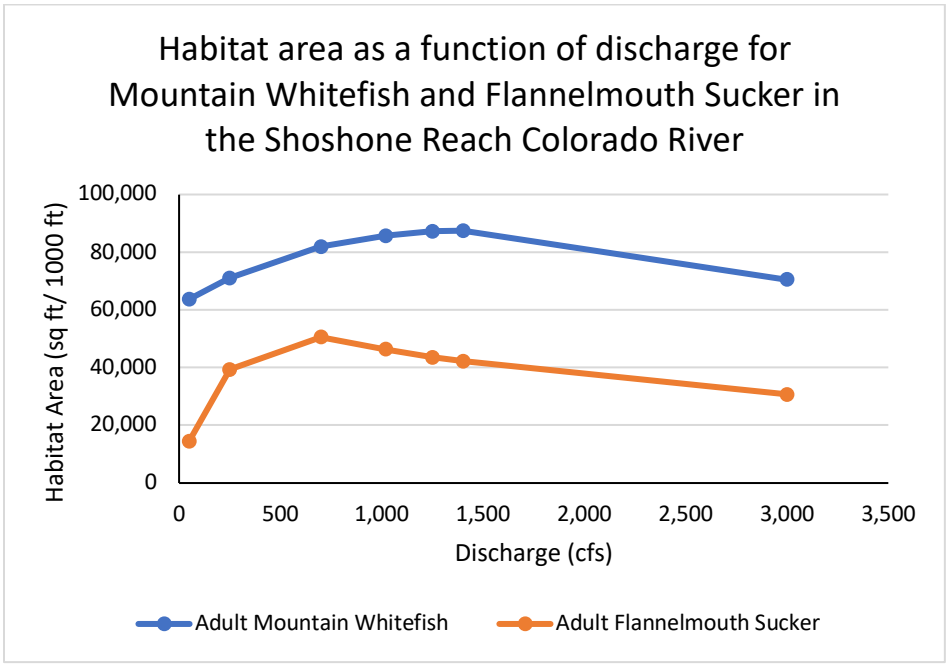


Figure 13. Habitat area as a function of discharge for Mountain Whitefish and Flannelmouth Sucker in the Shoshone Reach Colorado River.

Bypassed/sheperded flows at the Dotsero Gage may increase the discharge up to approximately 2,500 cfs to 3,000 cfs. These bypass/shepherded flows add to the wetted area, which benefits macroinvertebrates while maintaining usable habitat for fish species. The additional wetted area when flows are approximately 2,500 cfs to 3,000 cfs would also provide areas of velocity refuge habitat for fish species in the large boulders and rip-rap present in the reach.

There is a substantial amount of suitable habitat at flows of 3,000 cfs for all species. The amount of habitat for each species and life stage at 3,000 cfs compared to the maximum potential habitat area for each species ranges from 61% up to 81% of the maximum (Table 3). The higher baseflows in winter and late summer to fall are also beneficial to fish. The future condition winter base flow in average years would provide 93% to 99% of the maximum potential habitat for fish species. The future condition late summer to fall base flows in average years would provide 81% to 98% of the potential habitat for fish species (Table 3).

Table 3. Percent of habitat area provided by 3000 cfs and winter and summer average year base flows compared to maximum potential habitat by species.

Species and life stage	Percent of habitat area at 3000 cfs compared to maximum potential habitat	Percent of habitat area at average year winter base flow (973 cfs) compared to maximum potential habitat	Percent of habitat area at average year summer base flow (1581 cfs) compared to maximum potential habitat
Adult Brown Trout	74%	99%	98%
Adult Rainbow Trout	78%	96%	98%
Mountain Whitefish	81%	97%	98%
Flannelmouth Sucker	61%	93%	81%

Habitat Time Series Results

The actual habitat conditions experienced by the fish depend on the daily flows in the Shoshone Reach. These variations are shown in the time series plots of habitat. The data for dry, average, and wet year types were used to display the daily change in habitat for those hydrologic conditions.

The habitat-discharge functions were combined with hydrology data for the Shoshone Reach to display habitat over time for dry, average, and wet years. The existing flows range from zero during many days to nearly 14,000 cfs during wet year peak flows. Daily habitat at flows greater than 3,000 cfs (the highest flow in the 2-D model) were not plotted to limit the data analysis to the range of the hydraulic model. Flows higher than 3,000 cfs generally occur during runoff from May through June. The current zero flow days in the Shoshone Reach occur when the total river flows are 1,408 cfs or less which is the full capacity of the Shoshone Hydroelectric Plant. The future flow regime, if the Shoshone Plant is offline and the Shoshone Water Rights are exercised for instream flow purposes would allow the flow to remain in the Shoshone Reach channel downstream of the diversion dam. Such a flow regime would result in a substantial increase in habitat with no days of zero flow for all species in average, dry and wet hydrologic conditions (Figure 14-Figure 25). The future flows result in stable habitat conditions during all year types for all species.

The intermittent nature of the existing flow patterns with days of zero flow among the days of higher flows does not provide productive habitat. When all flow is diverted the Shoshone Reach experiences drying or zero flow which results in a loss of periphyton and macroinvertebrates. Those lower trophic levels provide the food base for the fish species in the reach. Studies on the 15-Mile Reach of the Colorado River near Grand Junction, Colorado demonstrated that the periphyton and macroinvertebrate communities require approximately two months of continuous flow to reach the same pre-disturbance biomass and density (Rees et al. 2008). The loss of the food resources is a negative impact to the fish within the Shoshone Reach. Loss of the food resources in late summer

when fish are feeding to prepare for winter could result in a substantial impact to fish condition and population size. Therefore, under the future flow regime the entire aquatic ecosystem in the Shoshone Reach would be improved with the stable flows and absence of zero flow days. The future flow regime provides consistently stable base flows at levels that provide a substantial increase in habitat for all species compared to existing conditions. Average year hydrology for future conditions show that winter and summer base flows provide 80% or more of the total maximum potential suitable habitat (Table 3).

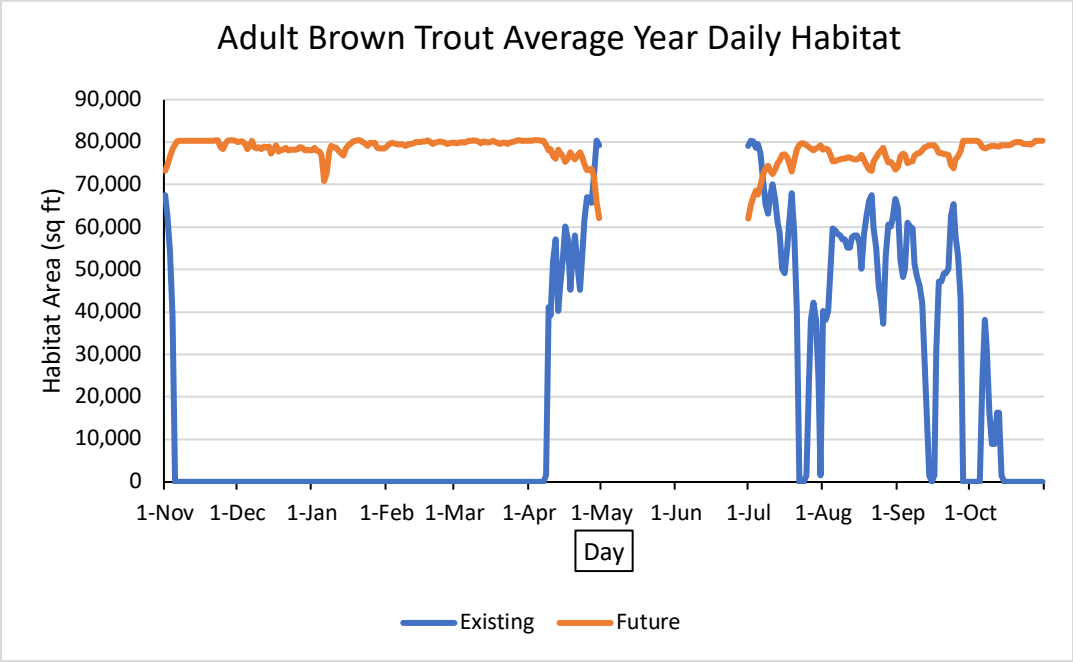


Figure 14. Adult Brown Trout average hydrologic year daily habitat for existing and future conditions.

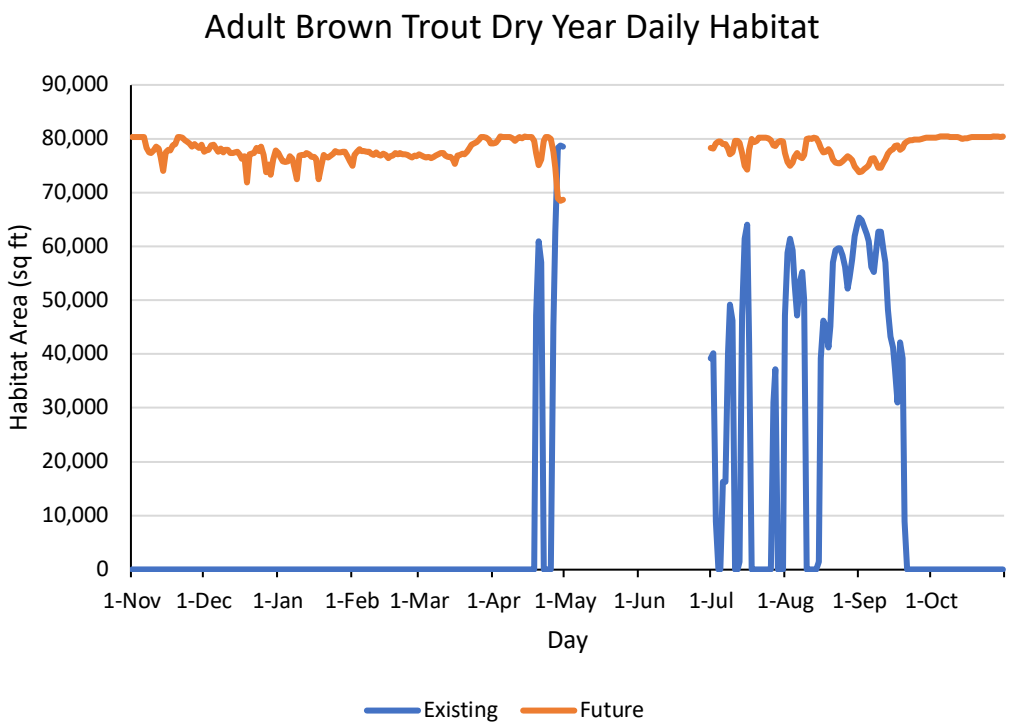


Figure 15. Adult Brown Trout dry hydrologic year daily habitat for existing and future conditions.

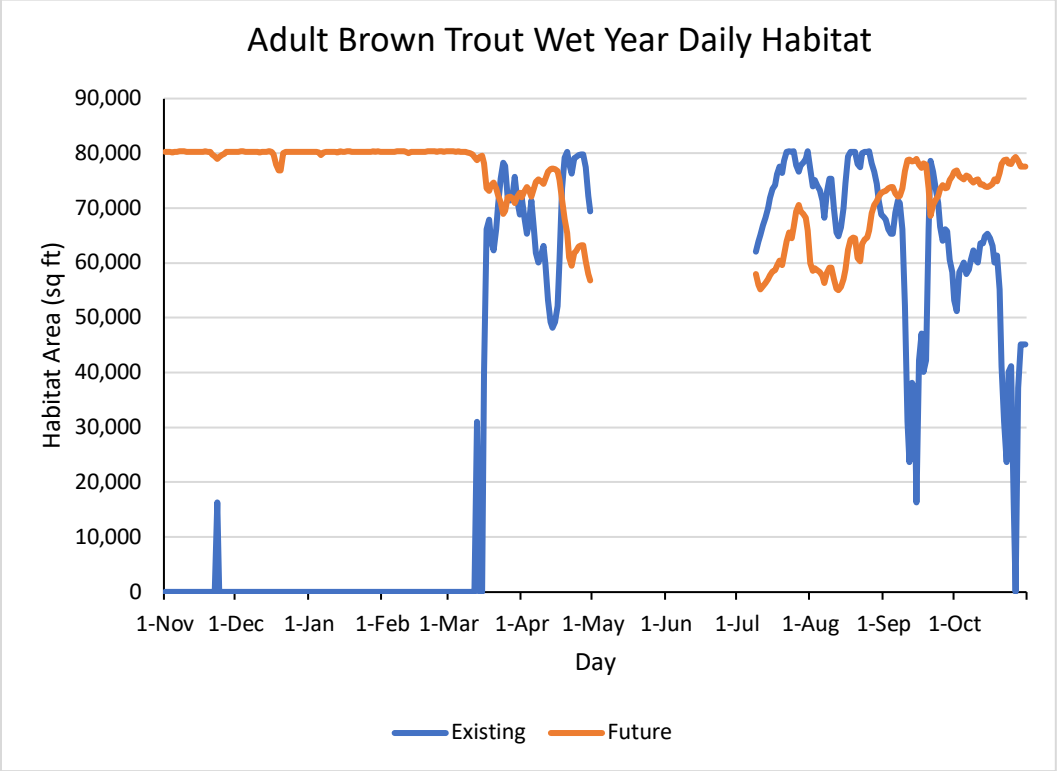


Figure 16. Adult Brown Trout wet hydrologic year daily habitat for existing and future conditions.

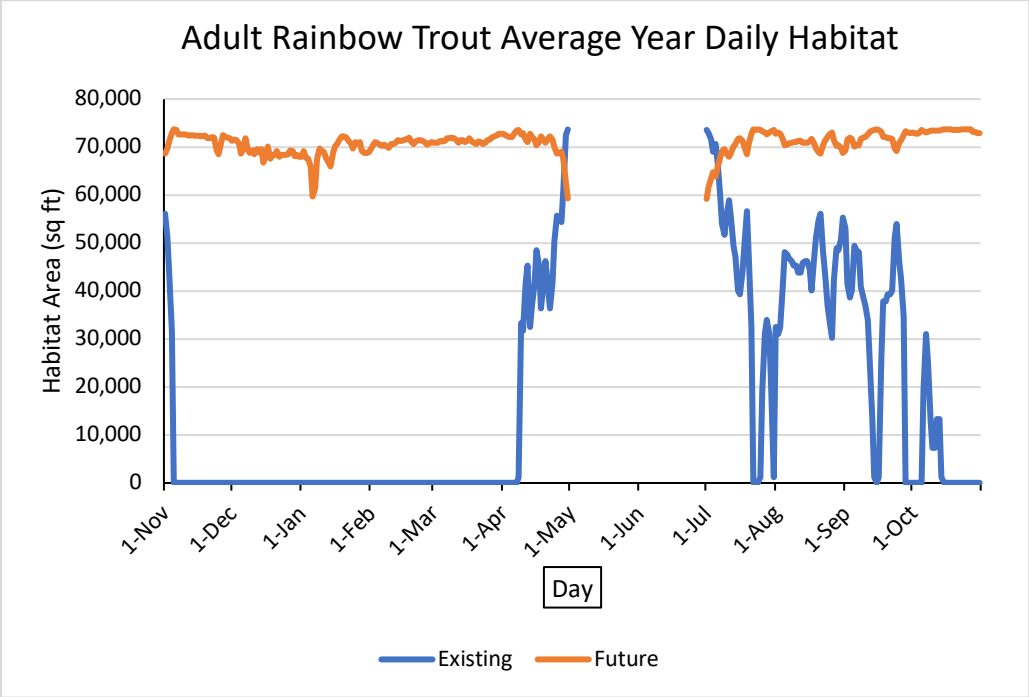


Figure 17. Adult Rainbow Trout average hydrologic year daily habitat for existing and future conditions.

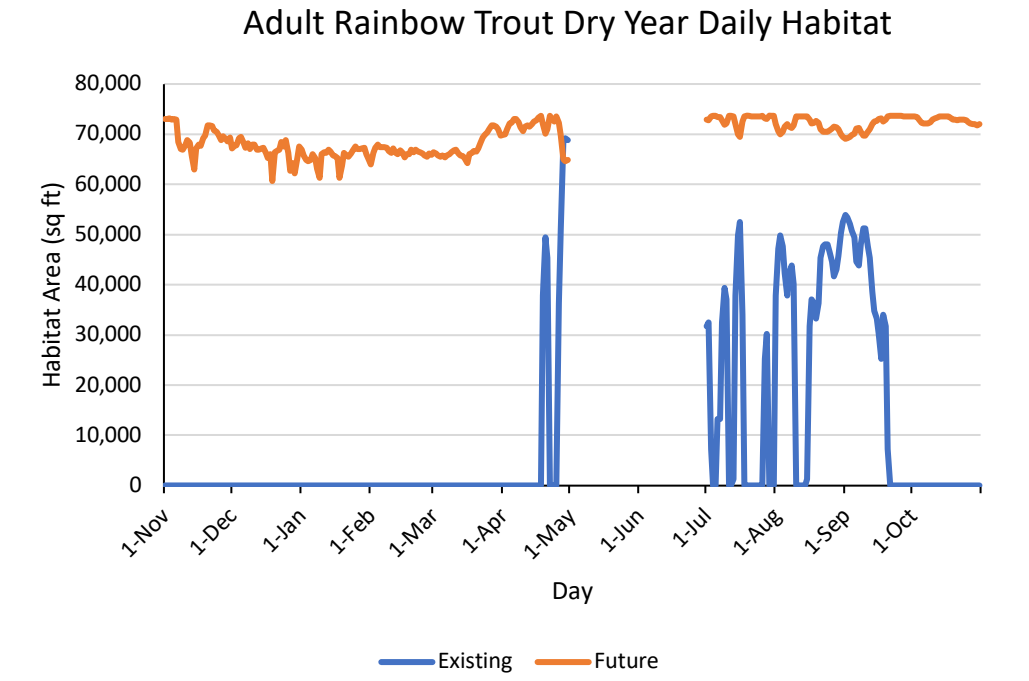


Figure 18. Adult Rainbow Trout dry hydrologic year daily habitat for existing and future conditions.

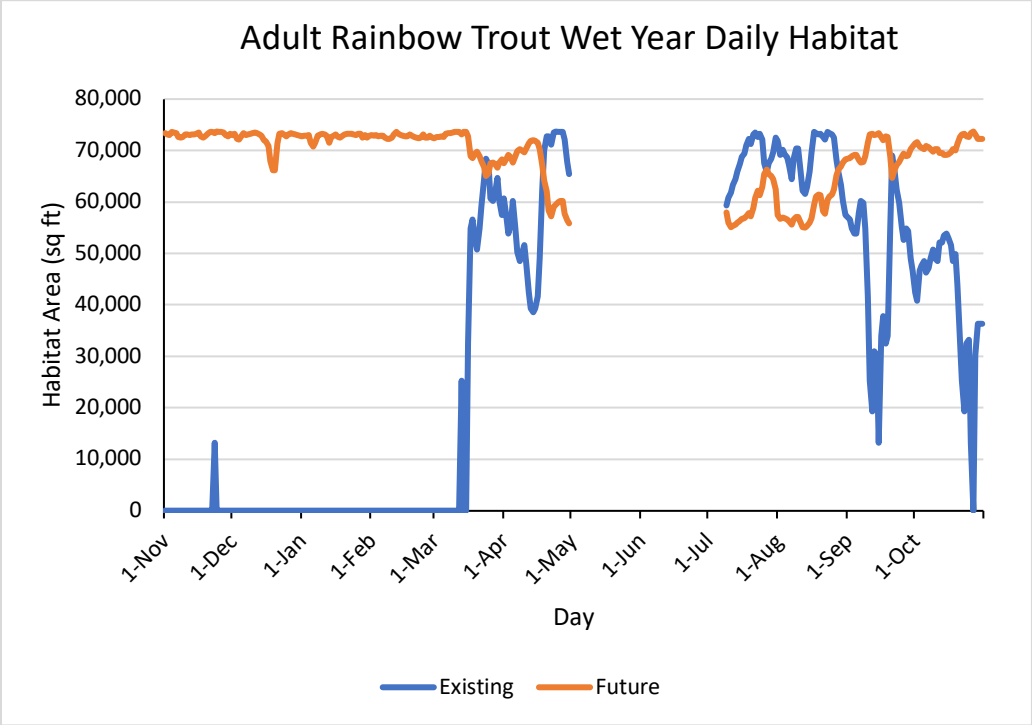


Figure 19. Adult Rainbow Trout wet hydrologic year daily habitat for existing and future conditions.

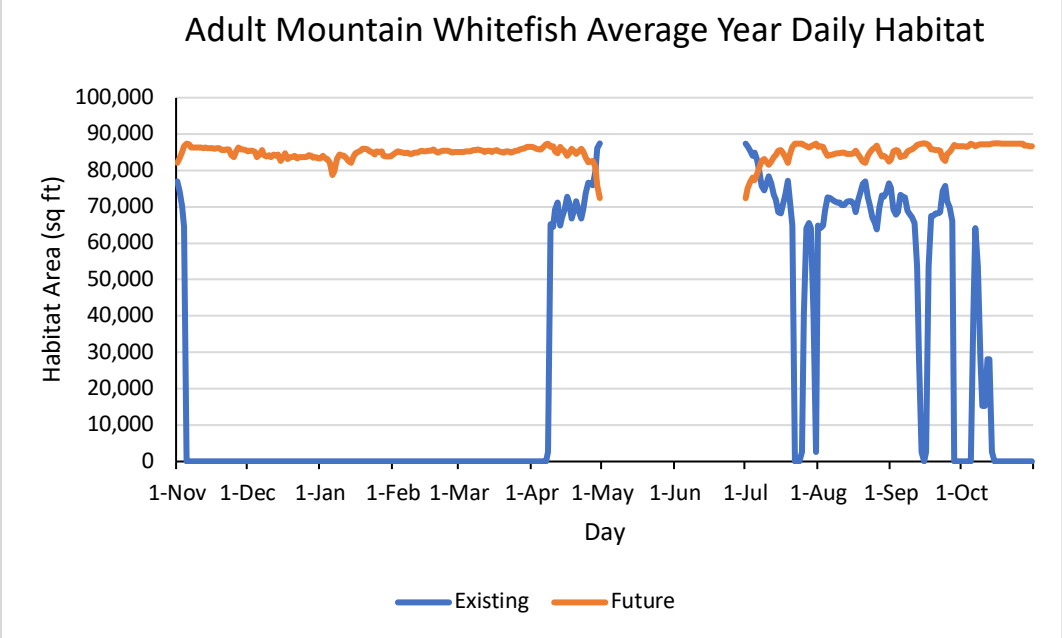


Figure 20. Adult Mountain Whitefish average hydrologic year daily habitat for existing and future conditions.

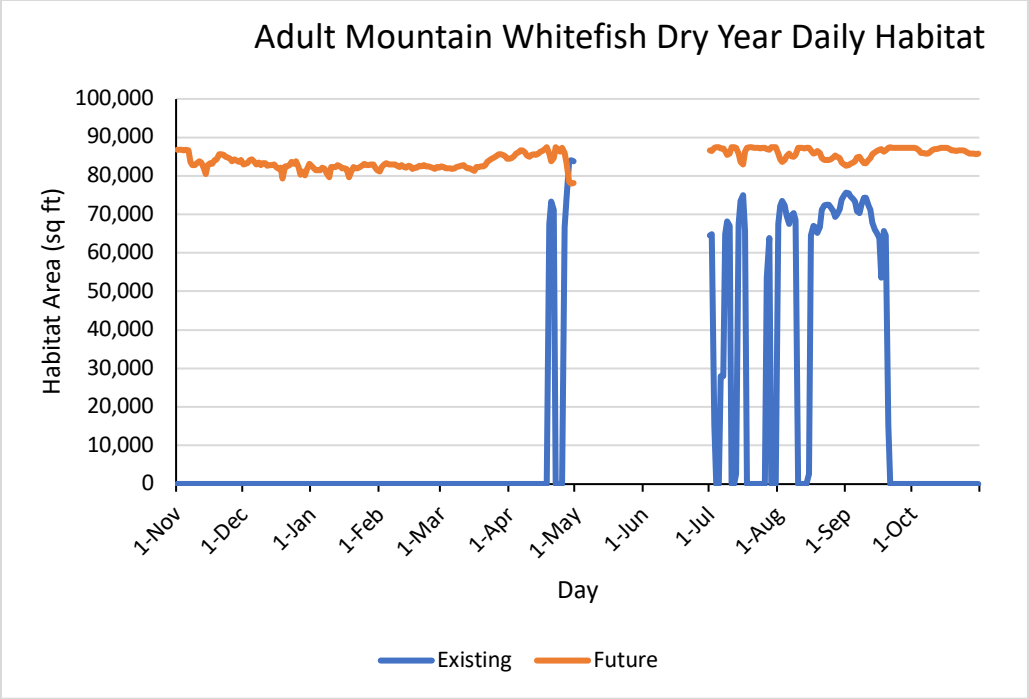


Figure 21. Adult Mountain Whitefish dry hydrologic year daily habitat for existing and future conditions.

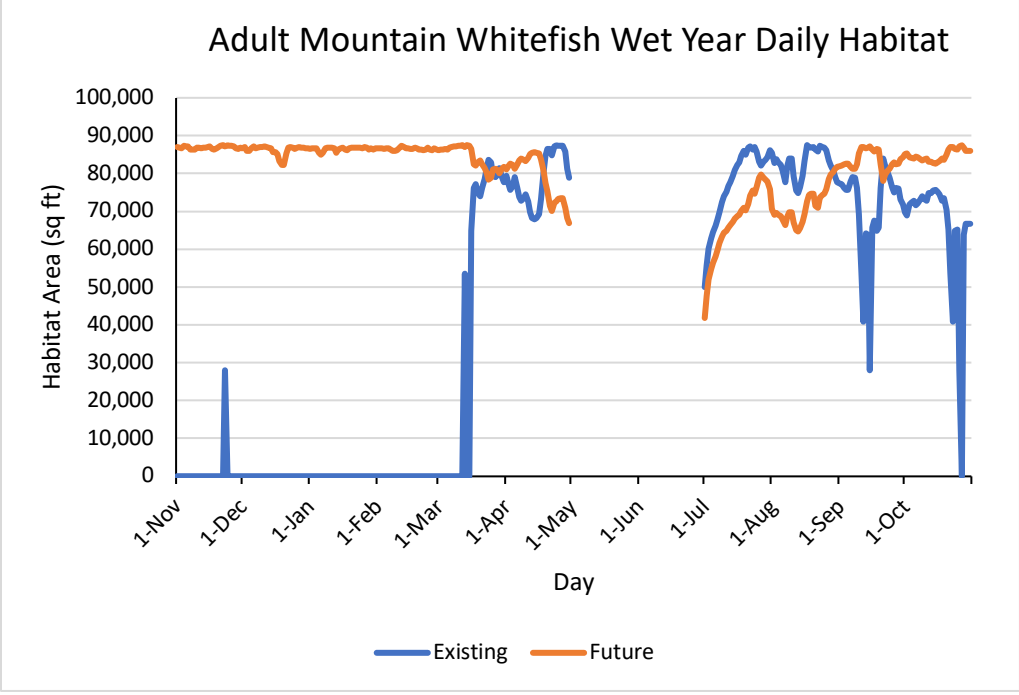


Figure 22. Adult Mountain Whitefish wet hydrologic year daily habitat for existing and future conditions.

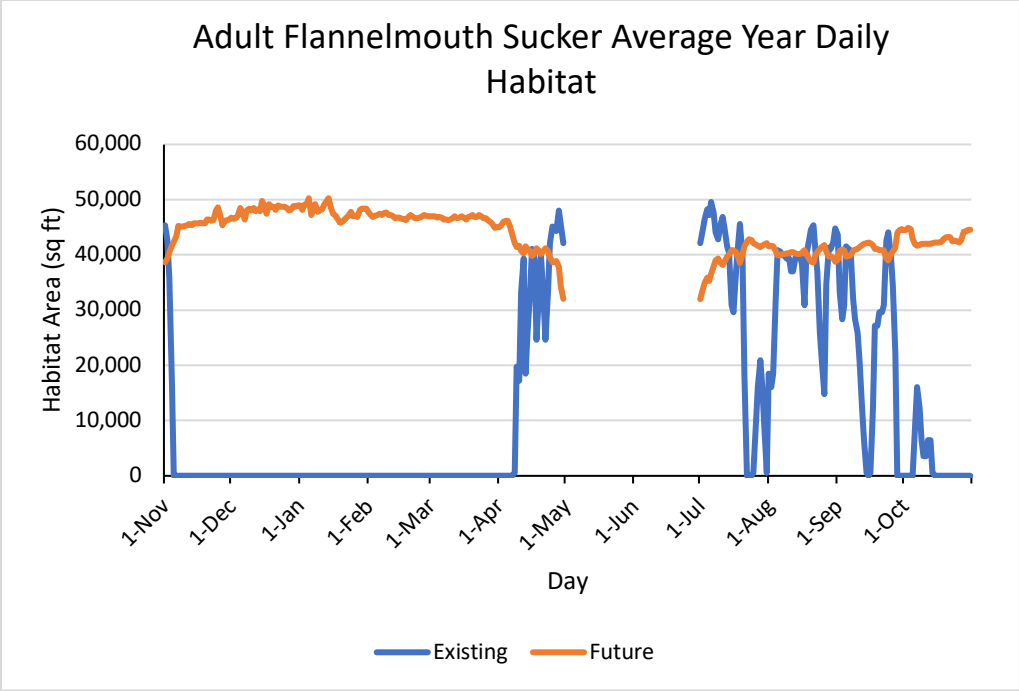


Figure 23. Adult Flannelmouth Sucker average hydrologic year daily habitat for existing and future conditions.

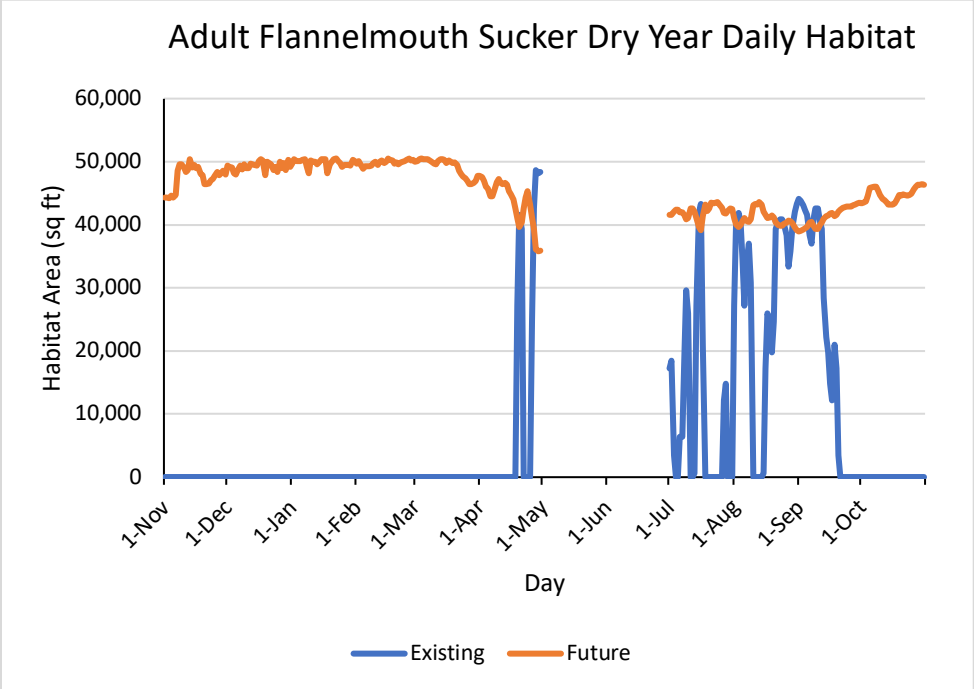


Figure 24. Adult Flannelmouth Sucker dry hydrologic year daily habitat for existing and future conditions.

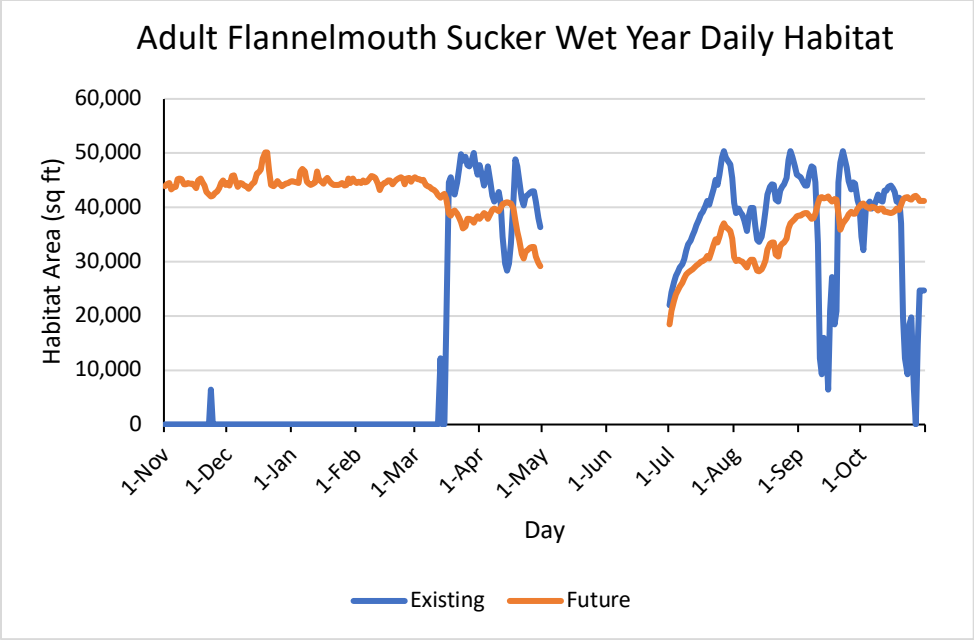


Figure 25. Adult Flannelmouth Sucker wet hydrologic year daily habitat for existing and future conditions.

Aquatic Ecosystem Considerations

Instream flow analysis with IFIM is grounded on ecological principles including flow regime (hydrology), habitat structure, water quality, food sources (trophic considerations), and biotic conditions (Bovee et al. 1998). While IFIM can provide quantitative hydraulic-habitat data from the analysis, these data require interpretation based on other ecological functions. These ecological functions are depicted in hierarchical fashion with the stream function pyramid as developed by Stream Mechanics (Figure 26). Data for all the biological conditions in the Shoshone Reach has not been collected due to logistical limitations, however, biological conditions can be inferred from data collected upstream and downstream of the reach and general knowledge on how riverine aquatic ecosystems function.

The biota in the Colordo River ecosystems and the Shoshone Reach are adapted to a snowmelt-runoff flow regime. The biological adaptation is the response to changes in the physical environment to high runoff flows and low base flows (Lytle and Poff, 2004). Another important component of river ecosystem function is connectivity. Consistent, non-interupted flow is important to connect longitudinal river reaches and allow migration for long distance directed movement such as spawning migration or localized movement of resident fish species (Annear et al. 2004; Cathcart et al. 2015; Thompson and Hooley-Underwood 2019). Colorado River native sucker larvae (Flannelmouth Sucker and Bluehead Sucker) drift downstream after hatch and upstream migration of mature life stages is needed to maintain populations. Maintaining longitudinal connectivity is important to maintaining these native sucker populations. These two sucker species occur upstream and downstream of the Shoshone Reach. A continuous flow in the Shoshone Reach would help to maintain longitudinal connectivity.

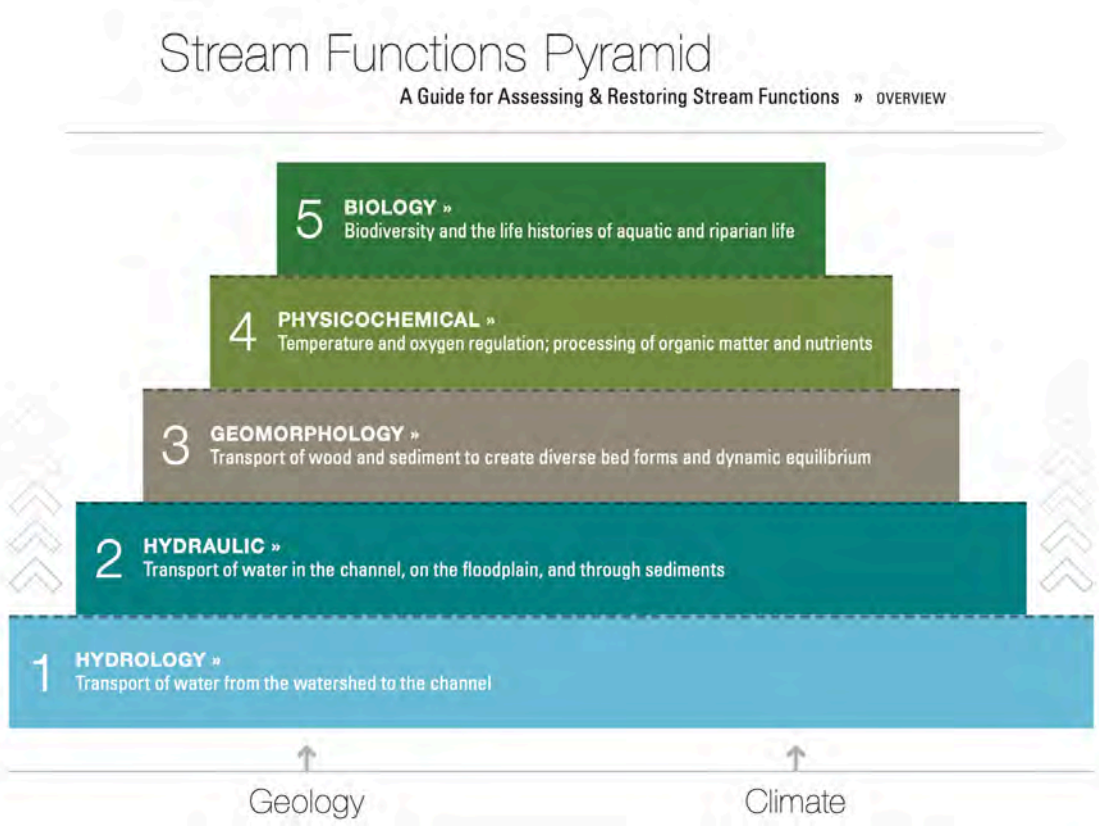


Figure 26. Stream Functions Pyramid showing hierarchical relationship of functions. (Source: Stream Mechanics https://stream-mechanics.com)

Physical components of riverine systems that affect the biota both in the riparian and instream areas include hydrology, geomorphology, and water quality. Hydrology within snowmelt riverine systems usually have spring or early summer peak flows with base flows occurring in summer through fall and winter. The species in the Colorado River are adapted to a snowmelt runoff hydrograph and have adapted their life histories to these events. Fish species use the deeper pools and velocity shelters provided by large boulders and other large instream objects as refuge habitat during high flows.

Base flows are important to maintaining stream productivity and available habitat for both macroinvertbrates and fish. Stable base flows provide consistent habitat conditions and allow long term habitat for less mobile species such as macroinvertebrates. The existing flow regime in the Shoshone Reach does not include stable base flows which are present in the Colorado River upstream and downstream from the Shoshone Reach. The higher, stable future condition base flow could also have a beneficial effect on water temperature in the Shoshone Reach. There are areas with hot springs in this canyon reach of the Colorado River. Higher summer base flow would provide more flow volume and deeper habitats which could provide thermal refuge for aquatic species in the Shoshone Reach.

Conclusions

The Colorado River in the Shoshone Reach is confined by canyon or steep topography throughout the reach and is bounded on the north by the interstate highway and on the south by the railroad. Canyon-bound confined reaches have steeper gradients and larger bed material on the river bottom than the lower-gradient meandering reaches in other sections of the river. These confined reaches have less lateral space for floodplains and less lateral channel movement than lower gradient meandering reaches.

Hydrology in the reach is typical of snowmelt-dominated rivers. Peak flows occur during May and June. Stable flows during non-runoff months provide the conditions needed for

productive food sources for fish and other trophic levels. The existing flow regime in the Shoshone Reach has both sporadic times in summer of zero flow and extended winter periods of zero flow. Zero flow is detrimental to primary and secondary trophic levels, is a negative impact to species that rely on these trophic levels for food and eliminates fish habitat which results in outmigration of fish or mortality. The stable flow regime and stable wetted area under the future conditions are beneficial for productivity at all trophic levels.

Habitat for most species and life stages is most abundant at flows between 700 and 1,400 cfs. Habitat abundance for most species and life stages decreases rapidly at flows less than 700 cfs. There is a gradual decrease in habitat as flows increase from 1,400 cfs to 3,000 cfs when the bypassed/shepherded flows are present in late summer, however, there is still much greater habitat availability compared to the habitat availability for flow less than 700 cfs. The future condition summer and late summer wetted area is relatively stable for the flows from 1,400 cfs to 3,000 cfs and provides stable habitat for algae, macroinvertebrates and fish.

Based on the available hydrology and the habitat-discharge functions, the future flows (the Shoshone Hydropower Plant water rights which include a senior right for 1,250 cfs and a junior right of 158 cfs for a total of 1,408 cfs plus the bypassed/shepherded flows, which can result in a total flow of up to approximately 2,500 cfs to 3,000 cfs at the Dotsero Gage) would provide a substantial increase in habitat and benefit aquatic biota during summer, fall, winter, and early spring as compared to the existing conditions. These flows up to approximately 2,500 cfs to 3,000 cfs therefore will help to preserve and improve the natural environment in the Shoshone Reach. The higher continuous summer base flow for future conditions would benefit all aquatic biota and eliminate the abrupt loss of food and habitat as seen during the zero flow days with existing condition flows. Stable winter flows would allow macroinvertebrates to complete their life cycles within the Shoshone Reach, which increases overall trophic productivity, and provide over winter habitat for all fish species.

There also are indirect benefits to other sections of the Colorado River from the Shoshone Hydropower Plant water rights. These water rights are administered at the Dotsero Gage upstream from the Shoshone Reach, however, the water is conveyed from the upper sections of the Colorado River upstream of the Dotsero gage downstream to the Shoshone Reach and benefits all of the intervening reaches of the upper Colorado River. Similarly, the Colorado River downstream of the Shoshone Reach benefits from the Shoshone Hydropower Plant water rights.

In summary, the future conditions with the Shoshone water right in place as an instream flow in the Shoshone Reach would result in the following:

- Stable base flow conditions with no zero flow days.
- Stable wetted area during future conditions in late summer, fall, winter and spring for better conditions for macroinvertebrates and algae which are food sources for fish species.
- Average year hydraulic-habitat conditions in summer and winter base flows that provide from 81% to 99% of the potential maximum hydraulic habitat.
- Continuation of indirect benefits upstream and downstream of the Shoshone Reach.
- Flows from 1,400 to 3,000 cfs provide additional benefit to the aquatic habitat in the Shoshone Reach.
- Overall improved instream conditions to preserve and enhance the aquatic habitat.

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Appendix A – Habitat Suitability Criteria for Trout, Flannelmouth Sucker and Mountain Whitefish.

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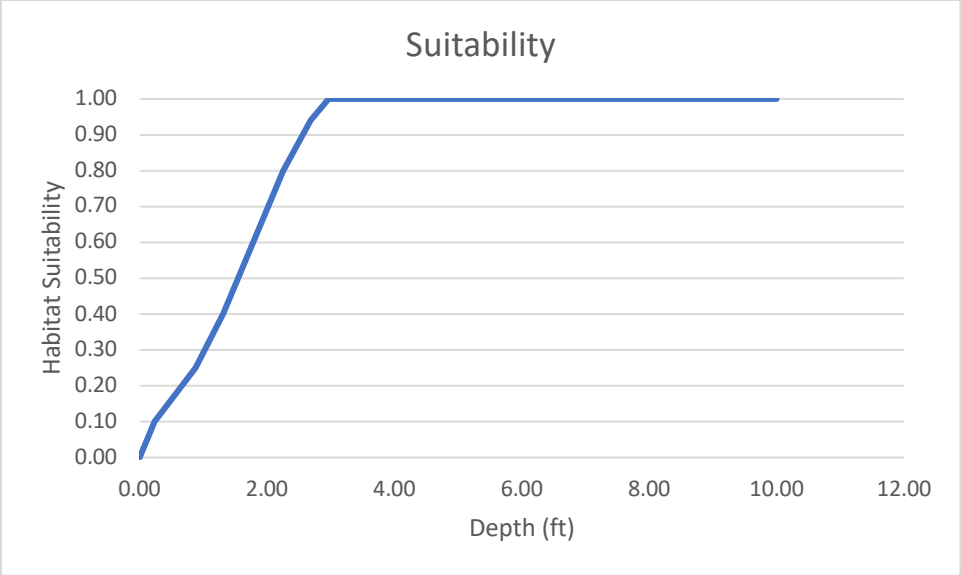


Figure A-1. Adult Brown Trout Depth Suitability Criteria.

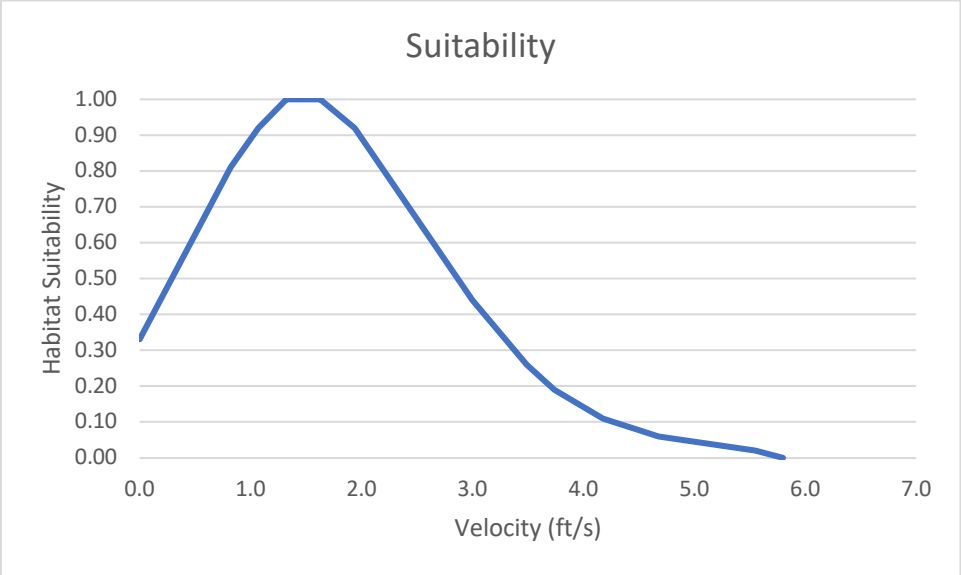


Figure A-2. Adult Brown Trout Velocity Suitability Criteria.

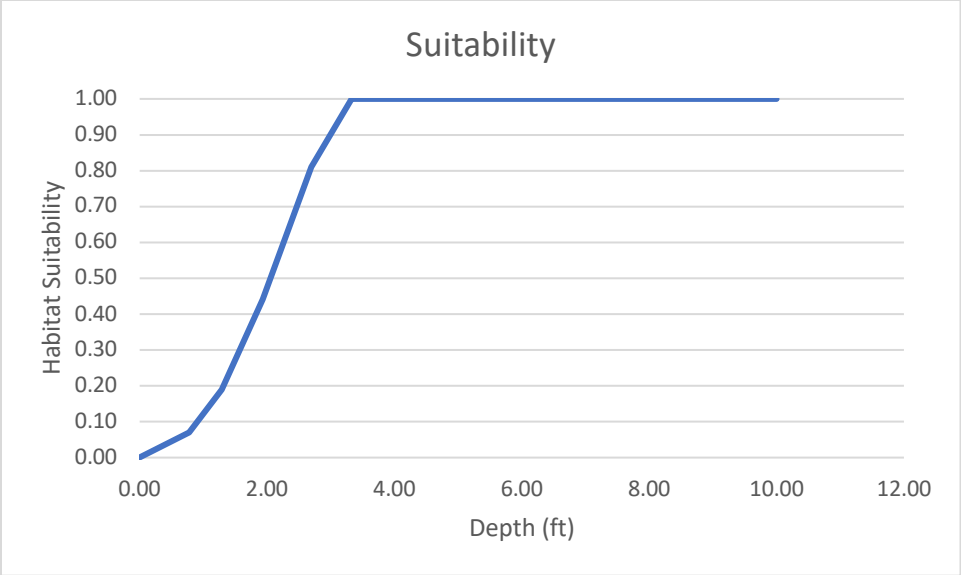


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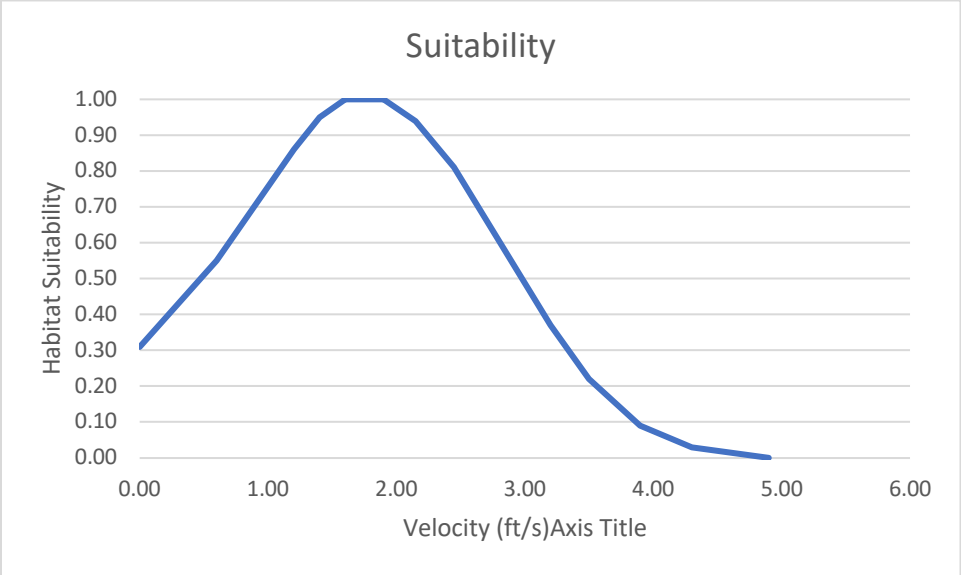


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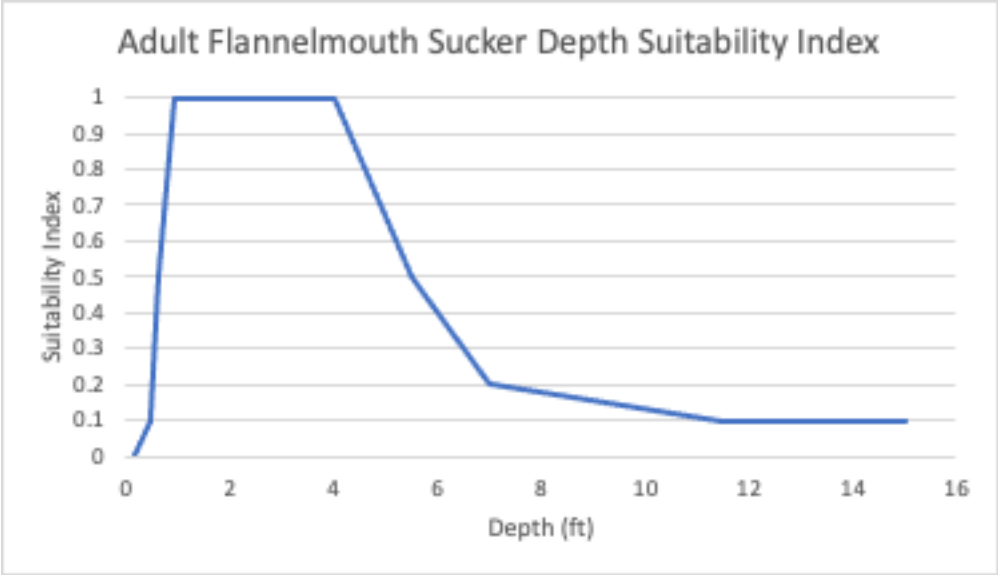


Figure A-5. Adult Flannelmouth Sucker Depth Suitability Criteria

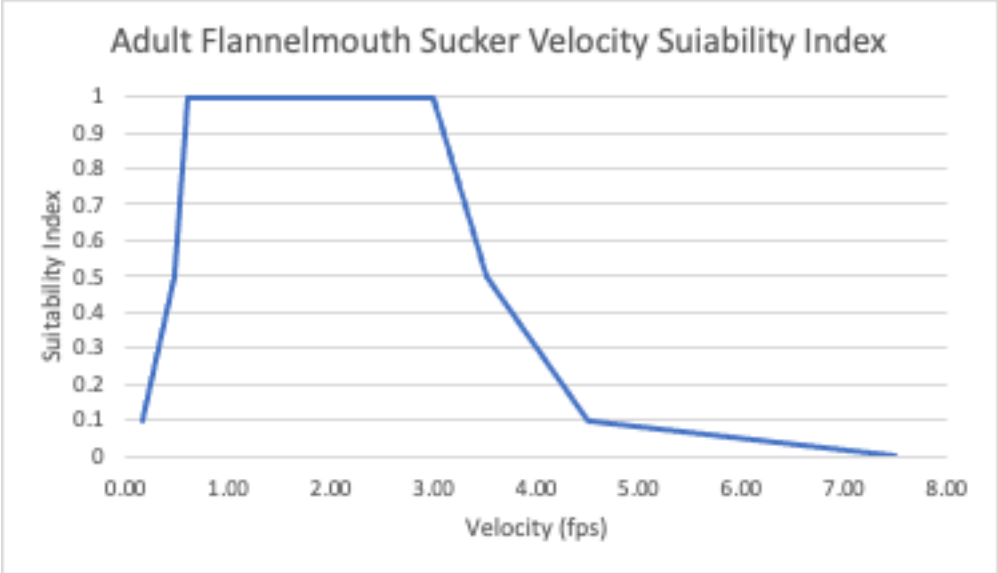


Figure A-6. Adult Flannelmouth Sucker Velocity Suitability Criteria

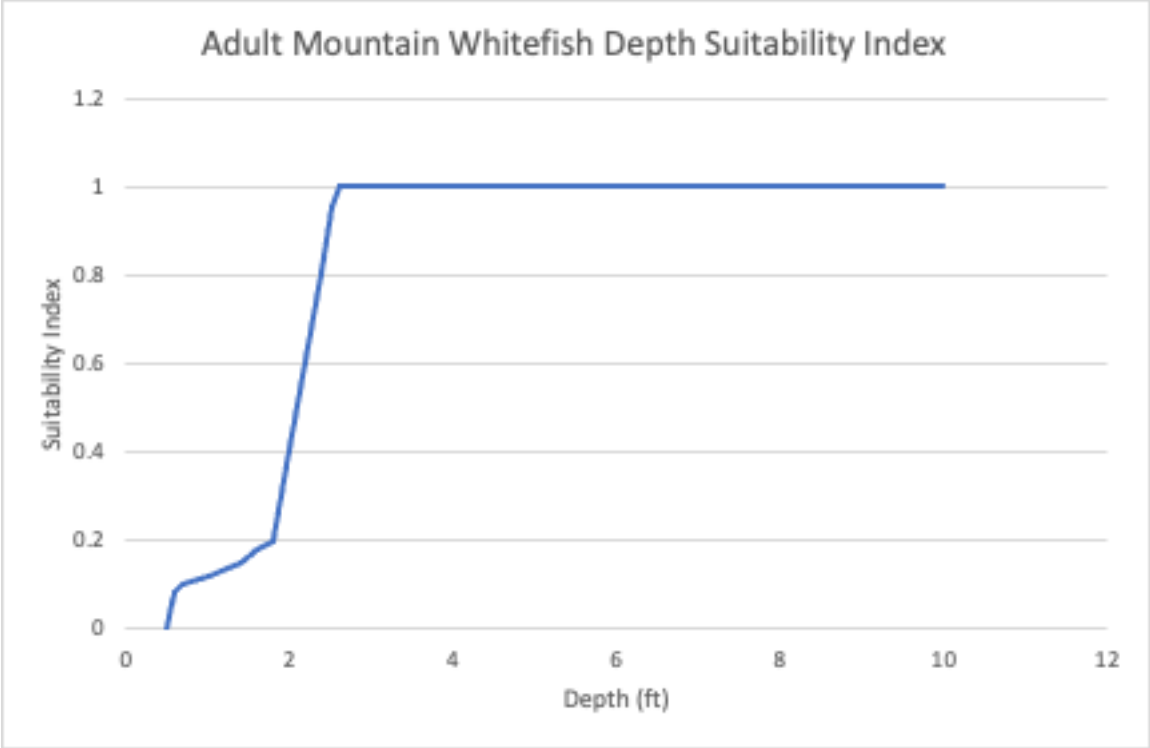


Figure A-7. Adult Mountain Whitefish Depth Suitability Criteria.

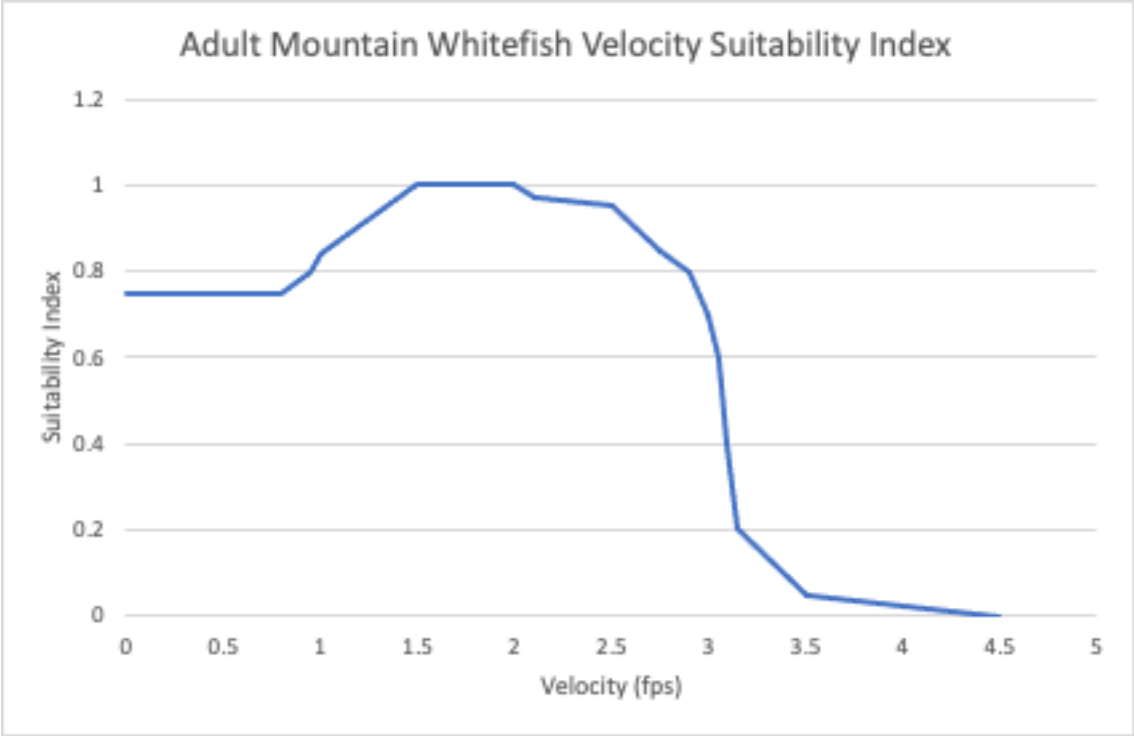


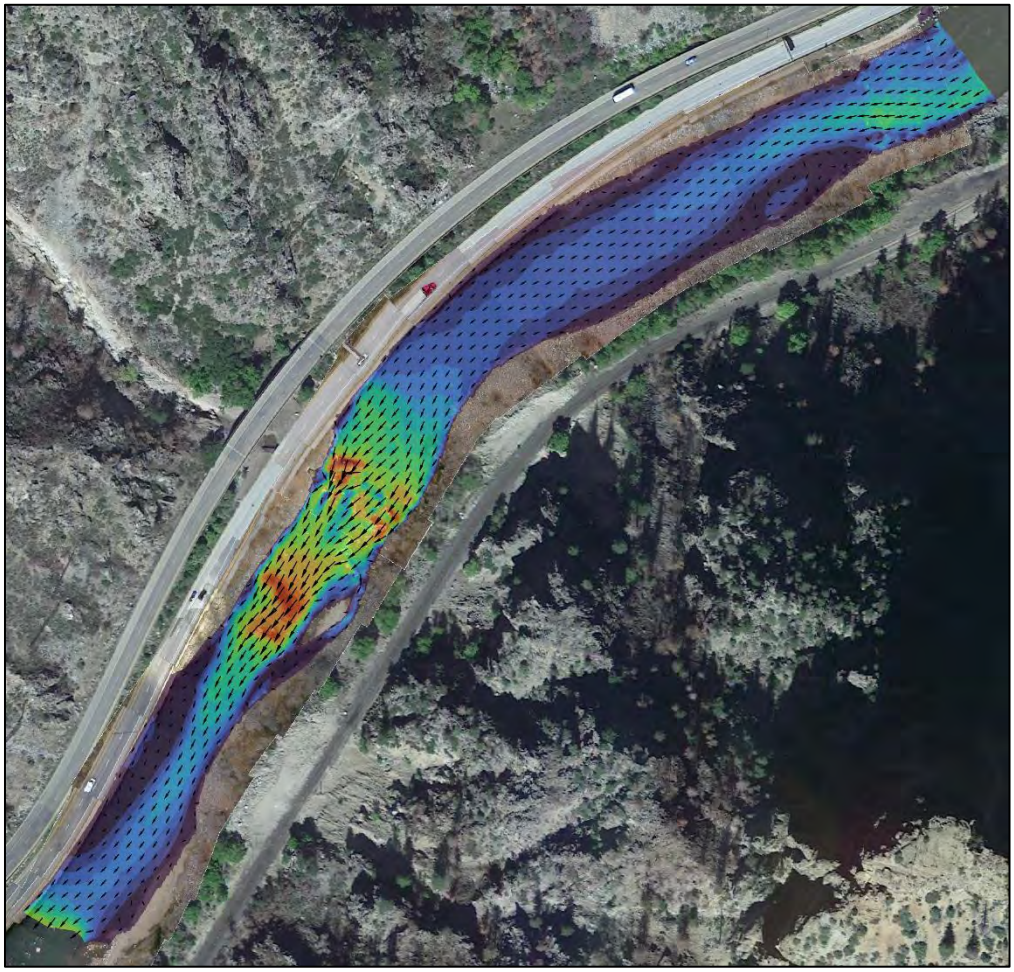
Figure A-8. Adult Mountain Whitefish Velocity Suitability Criteria.

Appendix B – Hydraulic Modeling Report

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GLENWOOD CANYON AQUATIC HABITAT STUDY
COLORADO RIVER, COLORADO

HYDRAULIC MODELING REPORT – 2023



PREPARED BY RIVERRESTORATION.ORG, DECEMBER 2023

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TABLE OF CONTENTS

1. Introduction 1
2. Modeling Methodology 1
   2.1. Model Overview 1
   2.2. Model Calibration 2
3. Results 3
   3.1. Model Outputs 3
   3.2. Model Results Discussion 3
4. Summary 5

TABLE OF FIGURES AND TABLES

Figure 1. Glenwood Canyon model domain DEM 1
Figure 2. Final spatially distributed Manning's n values used in the SRH-2D hydraulic model 2
Figure 3. Model Calibration Results 3
Figure 4. Glenwood Canyon model domain 3
Figure 5. Model results showing velocity at the flows of interest 4
Figure 6. Model results showing depth at the flows of interest 5

RESULTS DATA APPENDICES

GlenwoodCanyon_DEM_ft.tif
50cfs_results.xlsx
250cfs_results.xlsx
700cfs_results.xlsx
1020cfs_results.xlsx
1250cfs_results.xlsx
1400cfs_results.xlsx
3000cfs_results.xlsx

1. INTRODUCTION

A 2 dimensional (2D) hydrodynamic model was used to simulate a variety of low flow conditions for a study reach on the Colorado River in Glenwood Canyon. The model was based on a digital elevation model (DEM) developed from hydrographic survey data collected over an 1854 foot reach (Figure 1). The goal was to provide spatially discrete data and weighted values of water depth, velocity, shear stress, and a Froude value for use in a usable habitat analysis.

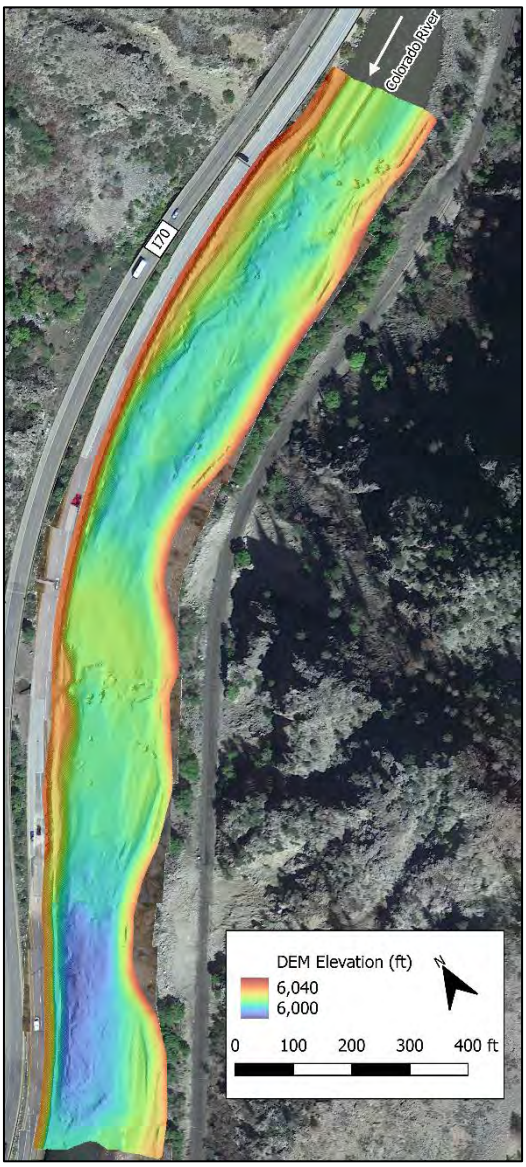


Figure 1. Glenwood Canyon model domain DEM

2. MODELING METHODOLOGY

2.1. Model Overview

Hydrographic survey data (see Glenwood Canyon Survey Report) was used to develop a DEM for the study reach. Point elevations and breaklines were used to characterize bed features like pools, rapids, and individual boulder features. This DEM is available in a geotiff format in the associated data appendices. This DEM was converted into an irregular 2D mesh with a cell sides targeted to a length of 4' within the channel using SMS software. Due to the SMS software interpolating an irregular mesh, a range of cell side lengths were modeled. Both three and 4 sided cells exist in the irregular grid, leading to a range in cell areas. These cells represent the elevations of the bed and provides calculations locations with discrete boundaries for a solver to calculate a depth-averaged result within. Depth-averaged two-dimensional velocity modeling simulates hydraulics in the streamwise and lateral directions, averaging values through the water column in the vertical. SRH-2D is a two-dimensional numerical model widely implemented for hydraulic applications and was used to simulate conditions within the project reach.

The SRH-2D model requires a spatially distributed friction element in addition to elevation for each cell. This can be provided in the form of a Manning's n value layer. For the model, we used spatially discrete Manning's n values based on the bed sediments observed during the survey. The final values for each area can be found in Figure 2, these values were adjusted within a reasonable range during the model calibration process, discussed below.

The upstream end of the 2D mesh was artificially extrapolated 100' upstream. This is visible in Figure 1 where the channel geometry appears stretched. The extra 100' was added to provide an area for the modeled inflow to non-uniformly distribute before entering the area of interest in the model domain. The extrapolated geometry was developed with the upstream cross section of survey data copied to the

upstream location and directly interpolated in between. Results provided from the modeling process used for the habitat analysis excluded all values in this extrapolated area.

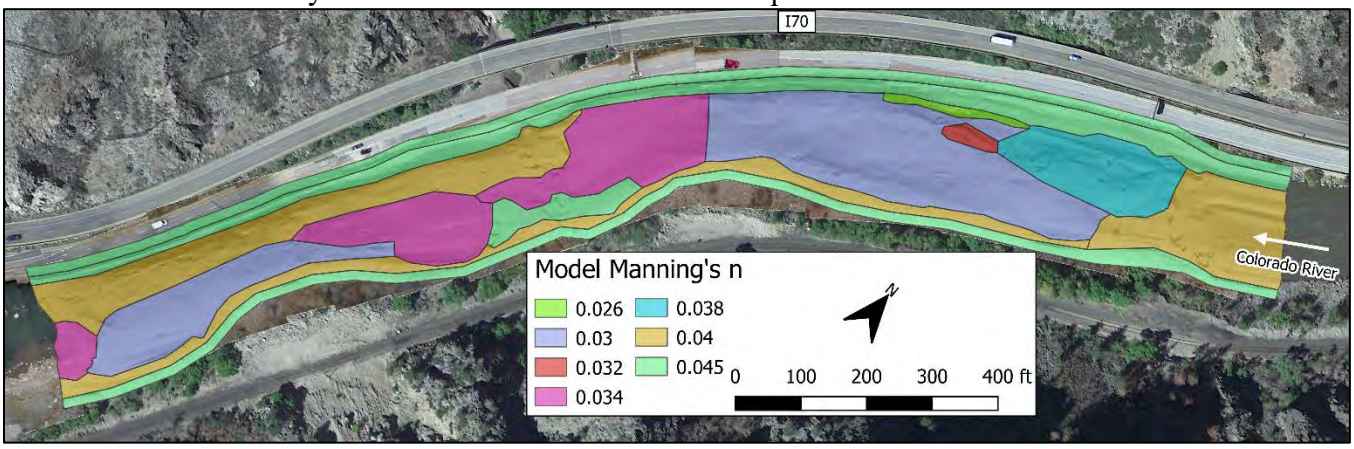


Figure 2. Final spatially distributed Manning's n values used in the SRH-2D hydraulic model

SRH-2D requires an upstream and downstream boundary condition. A steady flow rate was used as the upstream boundary condition for each different flow of interest and the model time was run until a steady state was achieved throughout the model domain. A constant water surface elevation (WSE) was used as the downstream boundary condition for each flow. The downstream boundary in the model domain was set at the crest of a rapid, where the flow exited the pool and passed through the critical state. A known water surface elevation was measured for the survey flow (1020 cfs) and used during the calibration process (discussed below). A 1D critical flow area equation (Eq. 1) based on the geometry of the downstream section of the model was used to calculate the water surface elevation boundary condition for each additional flow of interest. Flows of interest for this study were: 50 cfs, 250 cfs, 700 cfs, 1020 cfs (survey flow), 1250 cfs, 1400 cfs, and 3000 cfs.

Eq. 1 $$Q = \left(\frac{Area^3 * g}{Top\ Width}\right)^{1/2}$$

2.2.Model Calibration

The 2D hydraulic model was calibrated to WSE points captured during the survey flow of 1020 cfs. Calibration consisted of adjusting Manning's n values for different areas of the model within a reasonable range and adjusting the geometry of the DEM at observed control sections that were not sufficiently surveyed for bathymetric data. DEM adjustments were primarily focused on the grade controlling rapid in the middle of the survey area that impacted the large pool upstream and were a challenge to survey in great detail due to safety concerns in the field. The largest adjustment was made on the thalweg on the left side of the channel near the crest of each rapid, where conveyance needed to be increased to match the surveyed upstream water surface slope exiting the pool. After the calibration adjustments were made, the majority of the WSE calibration points were within +/- 0.2' of the model result (Figure 3), which is in line with the expected vertical accuracy of the survey. The majority of the outliers from this range, and the largest outliers, were in the steepest section of the rapid. Here, any given WSE in the model represents a smaller area of the channel. Additionally, less consistent WSE in rapids in the field decreases the accuracy of a given survey value. The large pools and areas of more gradually varying WSE slope all were well matched within the model. Mannings 'n' values were held consistent for all model runs between 50 cfs and 3,000 cfs based on the calibration at 1,020 cfs.

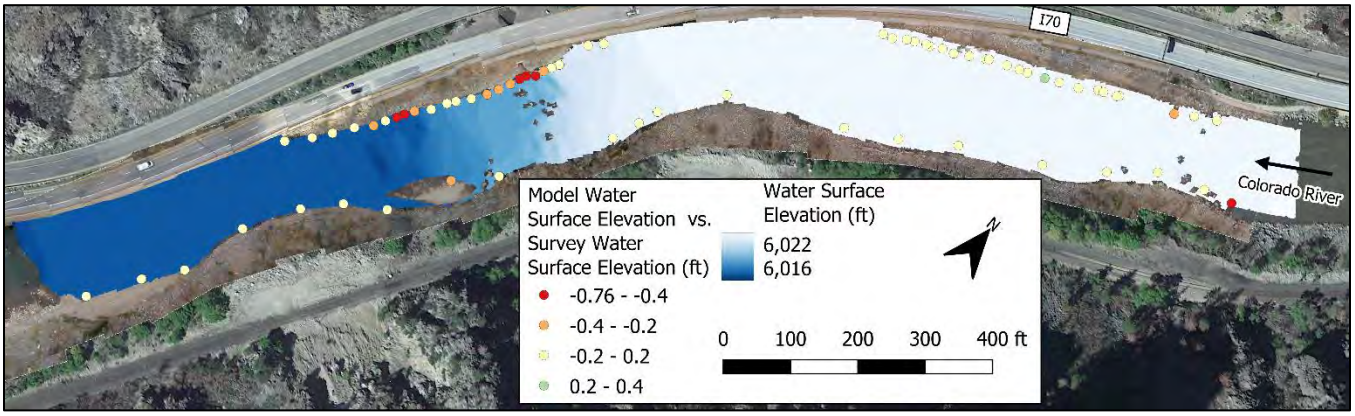


Figure 3. Model Calibration Results

3. RESULTS

3.1. Model Outputs

The model simulations were run until the flowrate into the model came to an equilibrium with the flow rate out of the model and was considered steady state. Results for each were then output for use in the habitat analysis. Results were sampled at the centroid location of each computation cell in the model 2D mesh (Figure 4). These cells represent areas ranging from less than 1 ft^2 to 70 ft^2, with the majority of the cells in the active channel between 5 ft^2 and 15 ft^2. Table 1 lists each of the hydraulic outputs that were sampled at the centroid of each cell.

Table 1. Model Outputs

Output	Unit
Cell Area	ft^2
Centroid X Coordinates	ft
Centroid Y Coordinates	ft
Bed Elevation	ft
Water Surface Elevation	ft
Water Depth	ft
Velocity in X direction	ft/s
Velocity in y direction	ft/s
Velocity Magnitude	ft/s
Froude Number	Dimensionless
Shear Stress	lb./ft^2

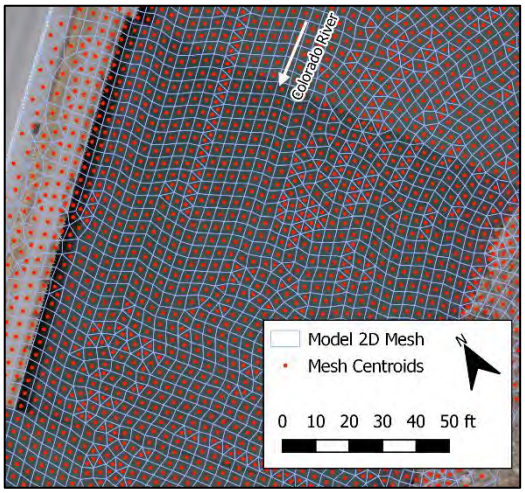


Figure 4. Glenwood Canyon model domain

3.2. Model Results Discussion

The model reach is bound on both sides by steep banks, including areas of vertical concrete in the highway embankment. Across the flow range evaluated the wetted flow area increased 23%. The largest changes in flow area occur around shallow areas of sand deposits near the up and downstream ends of the model as well as in some of the shallow cobble areas of the riffle in the middle of the model. The flow generally increases in velocity and depth as discharge increases (Figure 5). At the lowest modeled flow of 50 cfs

some unwetted areas emerge at the top of the rapid grade control that are larger than just single elevated boulders. At such extreme low flows, it may be reasonable to assume that some of the control section flow would be hyporheic flow between the large bed materials and infiltrate subsurface. The model also represents areas where the channel geometry is overhung by a suspended concrete bike path on the right bank in both pools. The modeled WSE in these areas remains several feet below the path elevations at the highest flow modeled for this analysis, 3000 cfs, but field observations have shown that extreme high flows in the river can reach these vertical obstructions, limiting the applicability of this model to flow levels less than or equal to 3,000 cfs.

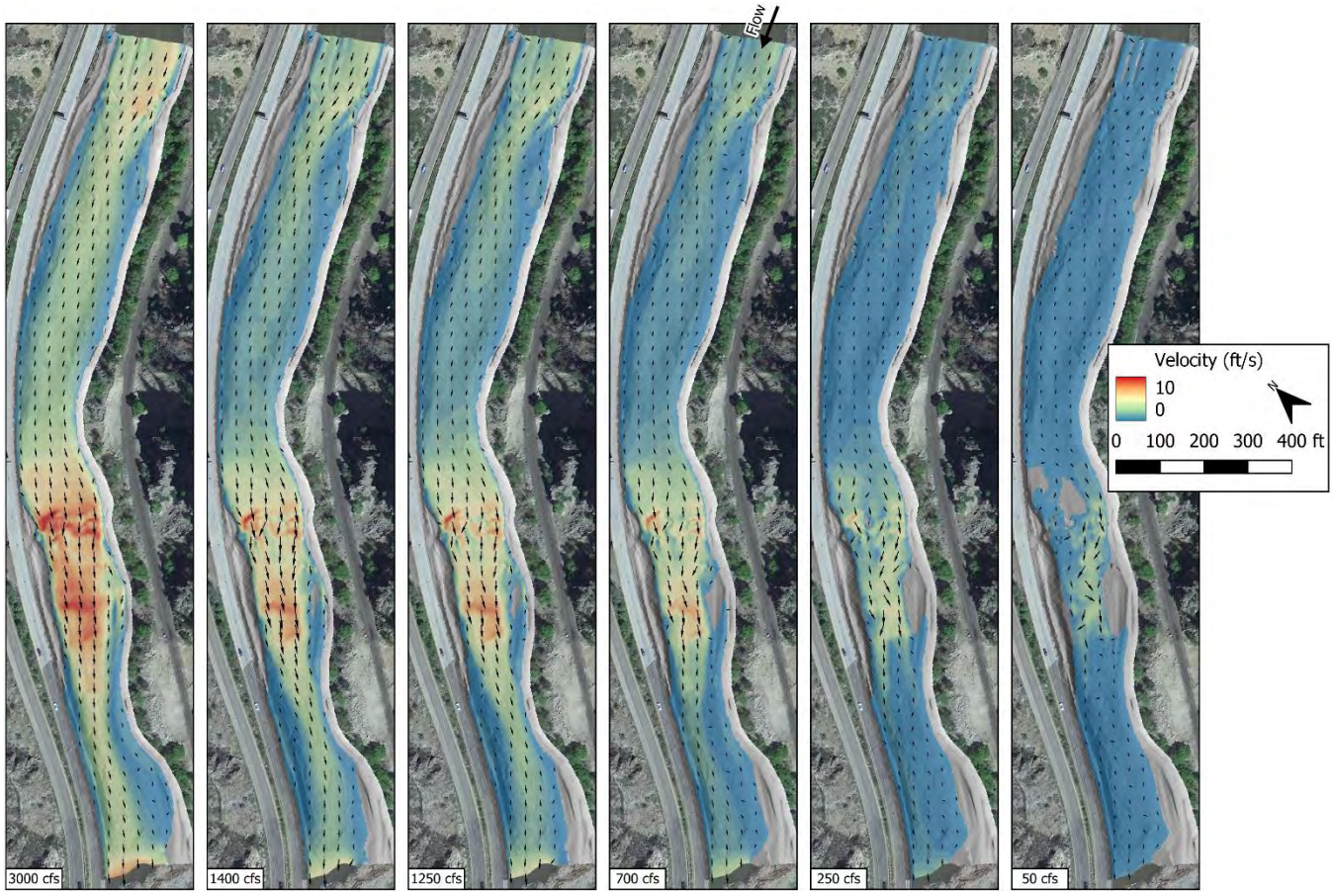


Figure 5. Model results showing velocity at the flows of interest

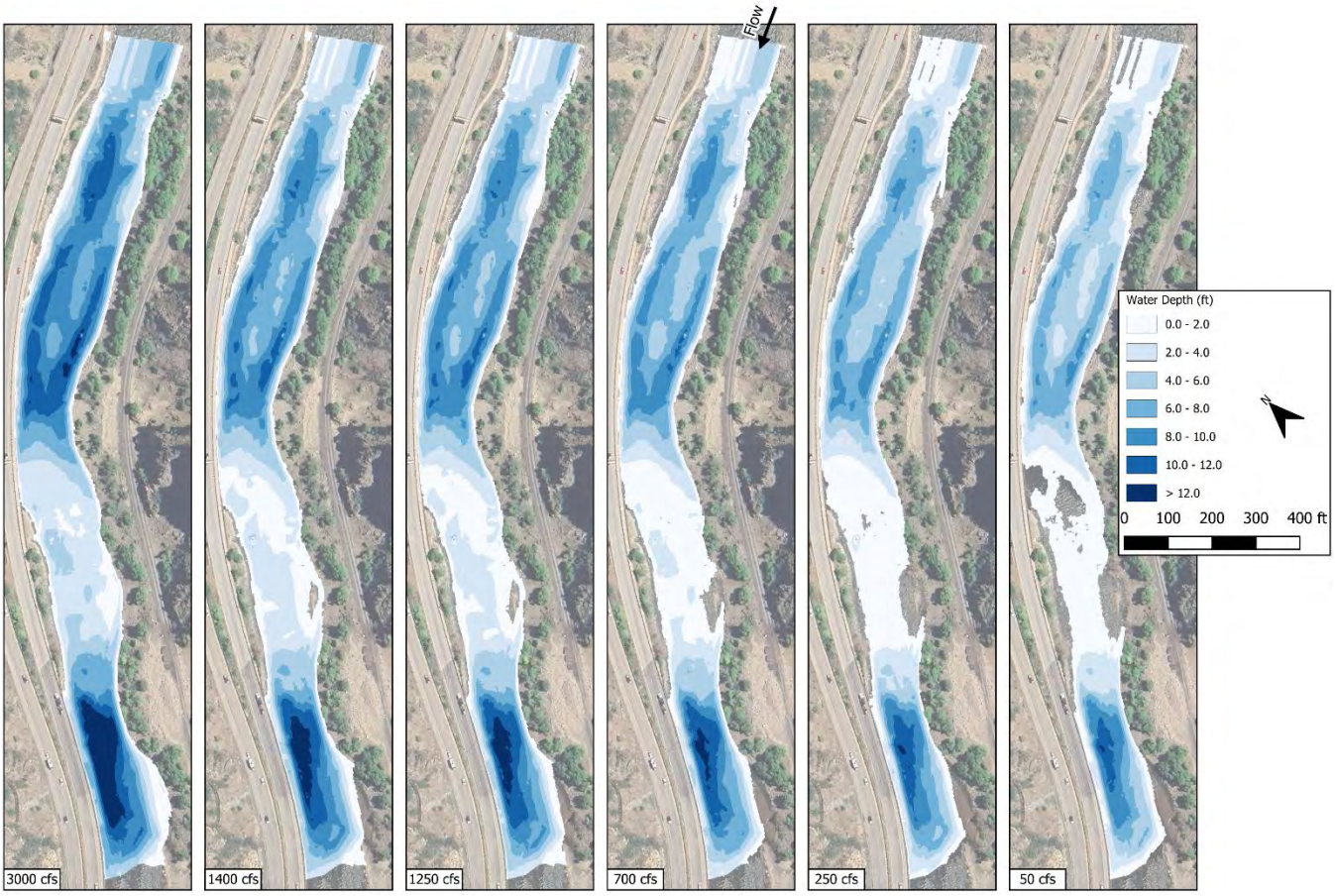


Figure 6. Model results showing depth at the flows of interest

4. SUMMARY

This report explains how survey data collected in Glenwood Canyon were used to create a calibrated 2D hydraulic model. This model was then used to predict hydraulic conditions of the study reach at a range of flows of interest to aquatic habitat at a resolution of approximately 4 ft x 4 ft. The model may have limitations at resolutions less than 4 feet length scale or at flows less than 50 cfs or greater than 3,000 cfs. Results available in the included data appendices can be used in an analysis of the available habitat within the study reach at the specified study flows.

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Appendix C – Hydrographic Survey Report

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GLENWOOD CANYON AQUATIC HABITAT STUDY
COLORADO RIVER, COLORADO

HYDROGRAPHIC SURVEY REPORT – 2023



PREPARED BY RIVERRESTORATION.ORG, DECEMBER 2023

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TABLE OF CONTENTS

1. Introduction and Survey Methods 1
2. Survey Control 2
3. Survey Conditions 3
4. Survey Results and Observations 3
5. Base Map and DEM Development 5
6. Summary 6

TABLE OF FIGURES AND TABLES

Figure 1. Survey Area Overview Map 1
Figure 2. Survey Methods. GNSS rover (left) and boat mounted GNSS integrated SBES (right) 2
Figure 3. Discharge of Colorado River near Dotsero, Colorado (USGS Gage 09070500) during survey and data aquisition 3
Figure 4. Substrate Areas and DEM 4
Figure 5. (Left) Looking downstream from the right bank at the rapid in the middle of the survey area. (Right) Aerial oblique drone photo looking downstream from near the upstream end of the survey area. The riprap and concrete nature of the banks can be seen. 5

RESULTS DATA APPENDICES

GlenwoodCanyon_DEM_ft.tif
SubstrateAreas_Polygons.shp

1. INTRODUCTION AND SURVEY METHODS

A hydrographic survey covering 1854 feet of the Colorado River in Glenwood Canyon was conducted on November 6th and 8th, 2023. The survey extent encompassed two pool sections divided by a boulder/cobble rapid and bounded by a rapid on the downstream end. Survey was conducted in the channel up the ordinary high water mark (OHWM) evident in the field. A combination of wading and boat-based survey was used to cover the areas of various depths and velocities (Figure 1). The survey was performed using a combination of RTK GNSS, Single Beam Echo Sounder (SBES), and total station. The survey was conducted using the NAD83 State Plane Colorado Central coordinate reference system (CRS) in US survey feet, vertical datum of NAVD88, and using the CONUS18 geoid model. Survey control was based on points provided by CDOT and tied in local control monuments via GNSS observations. Instruments utilized included Trimble R780 and R10 GNSS units, a boat mounted Ohmex SonarMite SBES, and a Trimble 5603 DR 200+ total station.

In addition to the bathymetric survey, the bed material was characterized at each topographic survey point throughout the survey reach and high-resolution ortho imagery was captured from 100' and 200' AGL throughout the reach.



Figure 1. Survey Area Overview Map



Figure 2. Survey Methods. GNSS rover (left) and boat mounted GNSS integrated SBES (right)

2. SURVEY CONTROL

The survey was based on control provided by CDOT for monuments recovered in the vicinity of the Hanging Lake rest area. Two control monuments were utilized with the coordinates provided in Table 1; Point 2528 was held as the location of the RTK GNSS base station during both days of the survey and point 2541 was used to check the initial base set up with RTK GNSS rovers. Eight additional control monuments were found and tied into the control network using 180 second RTK GNSS observations. These monuments were on the bike path that paralleled the survey reach and consisted of brass survey markers and "X" marks scrawled in the concrete placed by CDOT. These monuments were used for internal survey checks and as the basis for a total station set up and backsight but coordinates in Table 1 should not be considered survey control quality based on the limited GNSS constellation observed at the bottom of the Glenwood Canyon. Single beam sonar sound speed was adjusted in the field to match stadia rod depth measurements and integrated with either a total station prism or a RTK GNSS rover at different times to measure locations.

Table 1. Control Point information. NAD83 State Planes Colorado Central US Survey Feet, NAVD88, Geoid CONUS18. Coordinates are based on RTK GNSS survey holding 2528 and should not be considered survey control quality for future surveys.

Source	Point	Northing	Easting	Elevation	Description
CDOT	2528	1643610.52	2523096.51	6125.178	CDOT 1075--Type 5S IN CONC BIKE PATH
CDOT	2541	1644023.31	2523811.81	6117.827	CDOT 1075--Type 5S IN CONC BIKE PATH
GPS est.	193	1640379.889	2519661.18	6023.026	Brass Marker PT 193
GPS est.	194	1640815.124	2519923.869	6027.73	Brass Marker PT 194
GPS est.	195	1641175.599	2520304.564	6026.45	Brass Marker PT 195
GPS est.	196	1641401.255	2520778.948	6029.373	Brass Marker PT 196
GPS est.	300	1641308.444	2520530.666	6027.274	Concrete Scrawl X
GPS est.	301	1641008.418	2520098.404	6027.054	Concrete Scrawl X
GPS est.	302	1640601.825	2519781.121	6024.546	Concrete Scrawl X
GPS est.	303	1640170.93	2519540.383	6022.625	Concrete Scrawl X

3. SURVEY CONDITIONS

Site survey took place on November 6th and 8th, 2023. November 6th conditions were cold and clear while on November 8th, scattered snow showers fell throughout the day. The project reach is located approximately 8.5 miles downstream of USGS stream gage 09070500 on the Colorado River near Dotsero, CO. Shoshone Power Plant was shut down during survey and no diversions were expected between the gage and the site during data collection efforts. There are no major inflows between the project reach and gage, so the gage is assumed to well represent the project reach flows. Figure 3 shows the range of flows during the survey, as well as the slightly lower flows during the acquisition of aerial imagery.

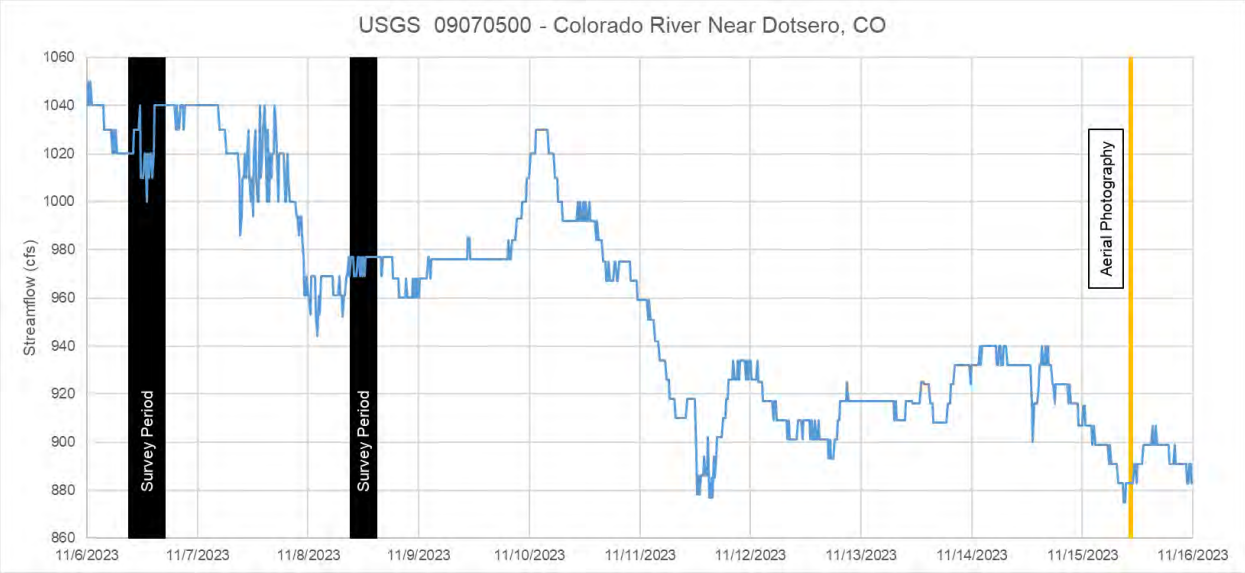


Figure 3. Discharge of Colorado River near Dotsero, Colorado (USGS Gage 09070500) during survey and data aquisition

4. SURVEY RESULTS AND OBSERVATIONS

The survey reach was selected to represent hydraulic characteristics present in the pool/rapid Glenwood Canyon reach of the Colorado River. The survey included two pools divided by one cobble/boulder rapid and was bounded by rapids on the upstream and downstream ends. The rapids generally comprised of large colluvial, and mud and debris flow materials supplied to the main channel from tributaries. Bathymetric and topographic data points were collected to represent bed elevations throughout the survey reach. Information on bed materials including sediment classes and vegetation types were recorded with the points. Areas with depositional sediments and signs of recent maximum high water levels were also recorded, as were water surface elevations (WSE) throughout the reach for the survey flow. There were areas within the survey extent where water was too deep and swift to safely survey on foot or via boat, particularly in some areas around the rapid in the middle of the project reach. Survey was completed to allow for the most accurate interpolation possible in these areas. Additionally, aerial ortho-imagery was collected to help locate larger topographic features such as mid channel boulders.

Survey observations revealed that the bed material varied throughout the study reach. Longitudinal and lateral influences impacted the bed composition. Higher up elevations near the OHWM on each bank consisted of mechanically placed riprap rock materials supporting the highway on river right and railroad on river left (Figure 5). A substantial portion of the river right bank was a vertical concrete wall under a cantilevered bike path with riprap along the right toe (Figure 5). The midchannel consisted of areas of

boulder and large cobbles on the outside of the bend and through the rapids, and large areas of sand deposition on the inside of bends in the pools. Depositional sand included areas of transporting sand over boulders in the upstream pool and also large areas of sand dunes in each pool. A large sandy beach deposit was observed on the inside river left side of the downstream pool. The rapid in the middle of the survey reach and the rapid at the downstream end both consist of large cobble and boulder material (Figure 5) that was delivered from steep tributaries that were impacted by the Grizzly Creek Fire in 2020 and the subsequent debris flows during heavy rain in 2021. The crests of these rapids act as grade controls controlling the water surface elevation of the pools immediately upstream. Sand deposits transition to a lens of alluvially transported large cobble material on the upstream approach of each rapid crest. These cobble materials acted as the hydraulic grade control of each pool at the survey flow. Larger boulders deposited by the tributaries define the main drop in WSE across the rapids. A matrix of small boulders and large cobbles surround the largest boulders with minimal areas of finer depositional material through the rapids until the hydraulic gradient reaches the next pool elevation controlled by the downstream rapid crest and the flow slows. Figure 4 shows the different substrate areas that were identified during the survey overlaid on the final digital elevation model that was created.

Riprap banks throughout the reach were not densely vegetated, but a variety of riparian plant species including willows and cottonwoods were scattered on the banks in pockets around boulders and riprap. Willows, grasses, shrubs, and smaller trees dominated the right bank, while the left bank had more mature cottonwoods.

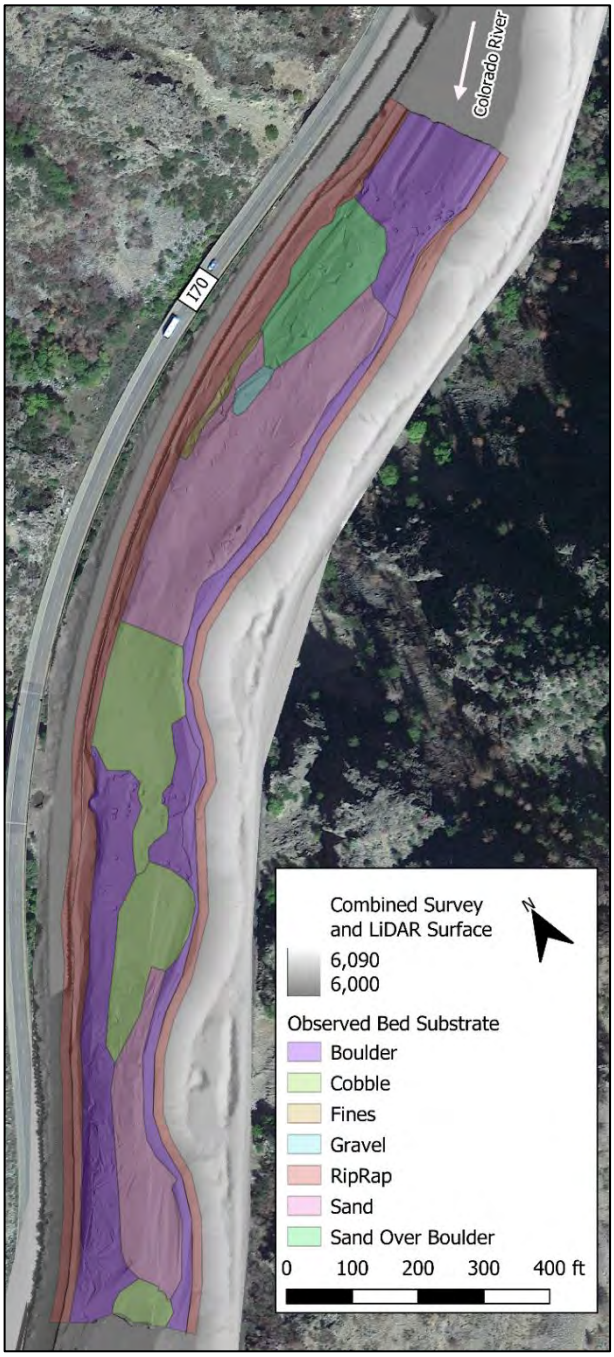


Figure 4. Substrate Areas and DEM



Figure 5. (Left) Looking downstream from the right bank at the rapid in the middle of the survey area. (Right) Aerial oblique drone photo looking downstream from near the upstream end of the survey area. The riprap and concrete nature of the banks can be seen.

5. BASE MAP AND DEM DEVELOPMENT

Survey data were post-processed to remove potential spurious data, mostly in the form of inaccurate SBES depth readings. Interpolation of some topographic data was required in areas that were unsafe to survey, but this was expected from the outset, and the majority of the survey extent was covered by on the ground field survey. A digital elevation model (DEM) was created for the entire surveyed project reach using a triangular irregular network (TIN) to connect surveyed points along with breaklines to represent the existing conditions in the field. Additional breaklines were included to represent boulder clusters and pour overs in rapids based on the collected aerial ortho-images. Elevations for some of these features had to be estimated based on nearby similar elevation features that were surveyed or nearby water surface elevations.

Field survey only took place up to the OHWM. For areas above this elevation, LiDAR data was added to the DEM. This LiDAR DEM data is publicly available data collected on flights in June of 2016 for the Colorado Water Conservation Board (https://coloradohazardmapping.com/lidarDownload). The data is formatted as a geotiff with 3 ft resolution. The LiDAR survey was carried out in the same coordinate reference system as this ground based survey; State Plane Colo. Central, NAD83, NAVD88. The LiDAR survey used the 12B geoid model as opposed to the more recent CONUS18 geoid model, but in the area of interest, this difference is not expected to have an impact. The LiDAR data inserted was well aligned with the surveyed ground elevations and required minimal editing of the DEM to mesh to two surfaces. Because the ground survey went to the elevation of the OHWM, the LiDAR based data inserted at elevations higher than this are not expected to have a meaningful impact on the flow levels of interest for this project.

A continuous bathymetric and topographic DEM surface was created using these data described above. This DEM was used in hydraulic modeling efforts, discussed in the Hydraulic Modeling Report.

6. SUMMARY

This survey was successful in collecting sufficient data to develop a detailed DEM of the study reach in Glenwood Canyon. The DEM developed from this survey and the bed material observations were used to model 2D river hydraulics, which is described in the Hydraulic Modeling Report. The data collection described in this report was sufficient for modeling 2D river hydraulics at, or finer than the target resolution for the habitat analysis which was specified as a 25 sqft computational cell size area.

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SHOSHONE REACH

Instream Flow Beneficial Use and Hydraulic Habitat Suitability Assessment

Shoshone Reach,
Colorado River, Colorado

April 22, 2025

Ecosystem Sciences, LLC

Science · Planning · Design

Shoshone Reach Colorado River

Instream Flow, Beneficial Use and

Hydraulic Habitat Suitability Assessment

Prepared:

April 22, 2025

Prepared for:
Colorado River Water Conservation District

Prepared by:

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1.0 INTRODUCTION **3**

2.0 SETTING AND CONTEXT **6**

2.1 SHOSHONE WATER RIGHTS 6
2.2 INSTREAM FLOW ACQUISITIONS TO PRESERVE AND IMPROVE 8
2.3 SHOSHONE REACH HISTORICAL CONDITIONS, HYDROLOGY, AND HABITAT 8
2.3.1 Changes After the Shoshone Power Plant and Other Water Diversions 9

3.0 SHOSHONE INSTREAM FLOW USE BENEFITS **10**

3.1 WATERSHED BENEFITS 10
3.1.1 Upstream Reaches 10
3.1.2 Downstream Reaches 11
3.1.3 Shoshone Water Rights and Federally Listed Fish Species 12
3.2 SHOSHONE REACH BENEFITS 13
3.2.1 Fishery and Aquatic Habitat Conditions 13
3.2.2 Macroinvertebrates 14

4.0 INSTREAM FLOW ASSESSMENT OF THE SHOSHONE REACH **15**

4.1 SHOSHONE REACH HYDROLOGY 15
4.1.1 Shoshone Reach Flow Scenarios 15
4.2 EVALUATION OF INSTREAM FLOWS 17
4.2.1 Objectives 18
4.2.2 Discharge Flows Modeled 18
4.3 METHODS 19
4.3.1 Two-Dimensional Habitat Modeling—General Approach 20
4.3.2 Habitat Suitability Curves 21
4.3.4 Application in Geographic Information System (GIS) 21
4.4 RESULTS 22
4.4.1 Site 1 23
4.4.2 Site 2 26

5.0 DISCUSSION AND CONCLUSION **30**

5.1 DISCUSSION 30
5.2 CONCLUSION 33

6.0 REFERENCES **35**

Appendix A - Hydraulic Habitat Suitability Results, Maps and Weighted Useable Area Graph
Appendix B – Species Suitability Curves
Appendix C – Hydraulic Modeling and Hydrographic Survey Reports

LIST OF FIGURES

Figure 1: Map of Glenwood Canyon and Location of Shoshone Reach 5
Figure 2: Shoshone Reach - Location of Dam, Intake and Power Plant / Return 7
Figure 3: Shoshone Reach Mean Daily Discharge during low flow years 1989, 1990, 2001, and 2002, for each of the three Scenarios. 16
Figure 4: Shoshone Reach - Sites 1 and 2 19
Figure 5. Simplified Process of Creating HHS Layers in ArcPro. 22
Figure 6. Site 1 Wetted Area Results, all Discharge (cfs) per 1,000 linear feet. 23
Figure 7. Weighted Usable Area per discharge flow (cfs) for Brown Trout at Site 1. 24
Figure 8. Weighted Usable Area per discharge flow (cfs) for Rainbow Trout at Site 1. 25
Figure 9. Weighted Usable Area per discharge flow (cfs) for Flannelmouth Sucker at Site 1. 25
Figure 10. Weighted Usable Area per discharge flow (cfs) for Mountain Whitefish at Site 1. 26
Figure 11. Site 2 Wetted Area Results, all Discharge (cfs) per 1,000 linear feet 27
Figure 12. Weighted Usable Area per discharge flow (cfs) for Brown Trout at Site 2. 28
Figure 13. Weighted Usable Area per discharge flow (cfs) for Rainbow Trout at Site 2. 28
Figure 14. Weighted Usable Area per discharge flow (cfs) for Flannelmouth Sucker at Site 1. 29
Figure 15. Weighted Usable Area per discharge flow (cfs) for Mountain Whitefish at Site 2. 29
Figure A-1: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Rainbow Trout 43
Figure A-2: Study Site 1 - Adult Rainbow Trout HHS Maps per Flow (cfs) 44
Figure A-3: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Brown Trout 45
Figure A-4: Study Site 1 - Adult Brown Trout HHS Maps per Flow (cfs) 46
Figure A-5: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Mountain Whitefish 47
Figure A-6: Study Site 1 - Adult Mountain Whitefish HHS Maps per Flow (cfs) 48
Figure A-7: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Flannelmouth Sucker 49
Figure A-8: Study Site 1 - Adult Flannelmouth Sucker HHS Maps per Flow (cfs) 50
Figure A-9: Study Site 1 - WUA All Species 51
Figure A-10: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Rainbow Trout 52
Figure A-11: Study Site 2 - Adult Rainbow Trout HHS Maps per Flow (cfs) 53
Figure A-12: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Brown Trout 54
Figure A-13: Study Site 2 - Adult Brown Trout HHS Maps per Flow (cfs) 55
Figure A-14: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Mountain Whitefish 56
Figure A-15: Study Site 2 - Adult Mountain Whitefish HHS Maps per Flow (cfs) 57
Figure A-16: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Flannelmouth Sucker 58
Figure A-17: Study Site 2 - Adult Flannelmouth Sucker HHS Maps per Flow (cfs) 59
Figure A-18: Study Site 2 - WUA All Species 60

EXECUTIVE SUMMARY

The Colorado River Water Conservation District (River District), in collaboration with partners and stakeholders within the Colorado River watershed, is currently working to acquire the water rights (Shoshone Water Rights) associated with the Shoshone Hydroelectric Power Plant (Shoshone Power Plant), located on the Colorado River, in Glenwood Canyon, Colorado. The Shoshone Water Rights are some of the most senior water rights in the Colorado River Basin, making them a central component in future water management strategies and the protection of ecological, economic, and recreational resources in the region.

Currently, Public Service Company of Colorado (PSCo), an Xcel Energy company, owns and operates the Shoshone Power Plant and Shoshone Water Rights. There are two Shoshone Water Rights totaling 1,408 cubic feet per second (cfs), which may be diverted from the river for non-consumptive hydropower generation and returned to the river 2.4 miles (3.8 km) downstream (Shoshone Reach).

The River District proposes to purchase and change the Shoshone Water Rights to include instream flow use. The River District will dedicate the exclusive right to use the Shoshone Water Rights for instream flow purposes to the State of Colorado to protect the non-consumptive flows associated with these rights which will benefit aquatic and terrestrial ecosystems. This assessment includes an instream flow assessment to evaluate the Hydraulic Habitat Suitability (HHS) benefits of various flow scenarios through the Shoshone Reach. This assessment examines the potential effects of a wide range of flow conditions, from very low flow (50 cfs) up to 3,000 cfs. This approach aims to provide a comprehensive understanding of how varying flows would preserve and improve aquatic habitat for species in the Shoshone Reach under different hydrologic scenarios resulting from the Shoshone Water Rights. The flow regime is analyzed in increments to explore the effects of both reduced and increased flows on habitat availability and suitability, with an emphasis on maintaining ecological integrity.

The assessment utilizes broadly accepted scientific procedures for two-dimensional hydraulic habitat suitability modeling. The HHS criteria used for the Shoshone Reach are specific to the fish species of interest. The selected modeling locations include habitat types that are representative of Glenwood Canyon, including pools, riffles, rapids, and runs. This assessment conducts HHS modeling for two study sites within the Shoshone Reach (Site 1 and Site 2). Assessment results include habitat suitability, weighted useable area, and available wetted area for each flow and fish species.

Several fish species occupy the Shoshone Reach, but for this assessment, the primary interest is in determining the needs for adult Rainbow Trout (*Onchoryncus mykiss*), Brown Trout (*Salmo trutta*), Mountain Whitefish (*Prosopium williamsoni*) and Flannelmouth Sucker (*Catostomus latipinnis*). The species of interest were selected by Colorado Parks and Wildlife (CPW) biologists and represent a range of species, including native non-game fish.

The main conclusions of the assessment are strongly supported by habitat modeling results from two representative sites (Sites 1 and 2) in the Shoshone Reach. Together, these sites characterize 29% of the total Shoshone Reach and are highly representative of the overall reach area. At Site 1, habitat suitability and weighted useable area (WUA) scores increase with flow, up to the high range of discharge modeled flows. At the high discharge range modeled, the WUA scores plateau and moderate.

In comparison, Site 2 shows ongoing improvements in habitat suitability and WUA as discharge flows increase, due in part to its greater habitat complexity. Features like large boulders, cobble substrates, islands, high-flow channels, and deep pools create diverse conditions suitable for fish across a wider range of flows than Site 1, providing critical refuges and feeding zones during high flows.

The geomorphic characteristics of Site 2 promote gradual changes in hydraulic parameters (depth and velocity) and wetted extent as flow increases. The progression in overall wetted area as flows increase allows fish to exploit newly wetted areas, that support both primary (e.g., algae) and secondary (e.g., macroinvertebrates) production that underpins the food web.

While Site 1 exhibits higher suitability and WUA at the median range of evaluated flows, Site 2 maintains consistent upward suitability trends at all flows due to its complexity, highlighting the ecological advantages of the physical diversity in the Shoshone Reach. Although hydraulic suitability and WUA scores are useful, they may underestimate the ecological benefits of increased flows. The velocity refuges created by boulders and cobble substrates provide essential microhabitats that the hydraulic model does not fully capture. Higher flows increase wetted area and improve habitat diversity and connectivity, benefiting fish populations and overall aquatic ecosystems.

Under the proposed scenario where the Shoshone Water Rights are permanently protected as an instream flow water right, habitat suitability and WUA for fish in the Shoshone Reach would be higher annually, providing more habitat for all species over current flows. Based on the analysis, the proposed scenario of permanent protection as an instream flow water right would provide the most habitat on an average annual basis (measured by WUA sq. ft. / 1,000 linear feet (LF) of stream) compared to the other scenarios analyzed. Flow levels would more often remain within an optimal range for extended periods and would provide greater flow during the critical late summer and early fall seasons when temperatures and other stressors are at their peak. Additionally, the seniority and non-consumptive nature of the Shoshone Water Rights would yield a benefit to the Colorado River upstream and downstream, extending these advantages beyond the Shoshone Reach. This assessment's findings indicate that the instream flow use of the Shoshone Water Rights would preserve and improve the natural environment through the Shoshone Reach for all modeled species.

The non-consumptive Shoshone Water Rights, if used for instream flow purposes, would not deplete the river’s water supply but would instead maintain river flows that support instream benefits in the Shoshone Reach. However, if these rights were to be diminished or lost, the river would face increased water quality impacts, and habitat loss. Consequently, the Shoshone Water Rights can serve as a critical instream flow tool for balancing water use with environmental conservation, preserving and improving the natural environment.

1.0 INTRODUCTION

The Shoshone Water Rights are comprised of two rights, a 1905 right for 1,250 cfs, and a 1940 right for 158 cfs. The River District is proposing to purchase and change the Shoshone Water Rights to add instream flow as a beneficial use. The River District will dedicate the use of the rights to the Colorado Water Conservation Board (CWCB) for instream flow use to preserve and improve the natural environment of the Shoshone Reach. The CWCB has the authority to acquire water rights, or interests in water, in such amount as the CWCB determines is appropriate for streamflows or for natural surface water levels or volumes for natural lakes to preserve or improve the natural environment to a reasonable degree.

This assessment has been produced to describe conditions and assess the habitat and hydraulic benefits of various flow scenarios in the Shoshone Reach. Using the Instream Flow Incremental Methodology (IFIM), the assessment evaluates the current aquatic ecosystem and evaluates three flow scenarios for the Shoshone Reach: (1) Baseline – representing flows in the Shoshone Reach under existing conditions; (2) Baseline with permanency – representing a future condition where the Shoshone Power Plant is no longer operating and the Shoshone Water Rights are used for instream flow purposes in the Shoshone Reach; and (3) No Permanency – representing a future condition where the Shoshone Power Plant is no longer operating and the Shoshone Water Rights are no longer exercised. The evaluation also considers the potential effects of a broader range of flow conditions, from very low (50 cfs) to 3,000 cfs, to provide a more comprehensive understanding of how varying flows may preserve and improve the natural environment through the Shoshone Reach. These flow levels were selected to reflect both the low and high flow conditions that may occur seasonally or as part of flow management strategies.

This assessment builds on a recently completed instream flow analysis of the reach performed by Dr. William Miller (2024 Miller Report). In the 2024 Miller Report, one study site was selected for modeling based on habitat characteristics that are generally representative of the Shoshone Reach. The study site included multiple habitat types including riffle, pool, and run habitats. The 2024 Miller Report modeled seven discharge flow scenarios, focusing on four species of fish, and utilizing habitat suitability curves for the adult life stages of each species. This assessment retains several features from the 2024 Miller Report and adds a second study site and increases the number of discharge scenarios for both sites. This assessment includes the four fish species and uses the adult life stage HHS curves for each species utilized in the 2024 Miller Report.

The addition of the second study site (i.e., Site 2) doubles the total modeled assessment area for the Shoshone Reach, thus enhancing the spatial representation of the habitat suitability assessment. Overall, this assessment includes two study sites, four fish species, and twelve flow scenarios, leading to a total of 96 HHS results along with wetted available area results for each flow at both study sites.

Glenwood Canyon and Shoshone Reach

The Colorado River flows west-southwest through Glenwood Canyon for approximately 18 miles, from west of Dotsero to Glenwood Springs, Colorado (Figure 1). The river is confined by a narrow limestone canyon and further constrained by a four-lane highway, a railroad, and a bike path. Notable infrastructure includes power lines, Colorado Department of Transportation (CDOT) rest areas, the Shoshone Power Plant and Dam, and the small community of No Name located downstream of the Shoshone Reach. Several tributaries known to contain spawning habitat for Rainbow Trout, Brown Trout, Mountain Whitefish, and other fish species flow into the Colorado River below the Shoshone Reach, notably Grizzly Creek and No Name Creek. The 2020 Grizzly

Creek Fire burned through the canyon, leading to debris flows that significantly impacted the river, highway, and power plant.

Despite human modifications, Glenwood Canyon is ecologically significant, supporting native and sportfish populations, Rocky Mountain bighorn sheep, and unique plant communities. CPW monitors fish and big game in the area, though studies on non-game species are limited. Most of the canyon is managed by the White River National Forest (WRNF) in partnership with CDOT, while the Bureau of Land Management (BLM) oversees smaller sections. Together, these agencies focus on managing recreation while maintaining ecological integrity.

The Shoshone Power Plant has operated for over a century and holds senior water rights in the watershed, ensuring stream flows during priority calls. The operation consists of the Shoshone Dam and a gravity-fed tunnel leading to two penstocks supplying water to two turbines at the Shoshone Power Plant, which can call for the two Shoshone Water Rights. The river in Glenwood Canyon can be divided into three reaches (Figure 1) by Shoshone Power Plant facilities:

1. *Immediately Upstream of the Shoshone Dam*: The impounded water substantially reduces water velocities in this reach. The reduced flow velocity and increased sedimentation within this reach limits aquatic habitat diversity while the dam fragments fish movement upstream and downstream.
2. *Shoshone Reach:* The Shoshone Reach encompasses approximately 2.4 miles of river between the Shoshone Dam and the Shoshone Power Plant return flow outlet. During seasonal low flow periods the reach is dewatered when the plant is operating, though habitat in the Shoshone Reach is connected by small inflows of groundwater and tributary streams that fill pools and flow through the large boulder and rock substrate. This reach contains both the lower and higher gradient sections that provide a complexity of habitat. Habitat persists even during low flow periods, though wetted area in the stream channel is substantially reduced; however, habitat becomes fragmented for upstream fish movement at low flows.
3. *Downstream of the Shoshone Power Plant*: At this point river flows return, stream gradient gradually decreases, enhancing channel complexity and biodiversity. The river regains its natural character with a mix of riffle, run, and deep pool habitats that all contribute to increased habitat diversity in the mainstem. Two tributaries, Grizzly Creek and No Name Creek, provide important spawning habitat for Rainbow Trout, Brown Trout, and Mountain Whitefish resident to the Colorado River, as reproductive habitat is limited by the geofluvial morphology in the mainstem river in Glenwood Canyon. These tributaries also contribute coldwater inputs as their headwaters originate at elevations well over 10,000 feet in the Flat Tops that encompass the northern edge of Glenwood Canyon.

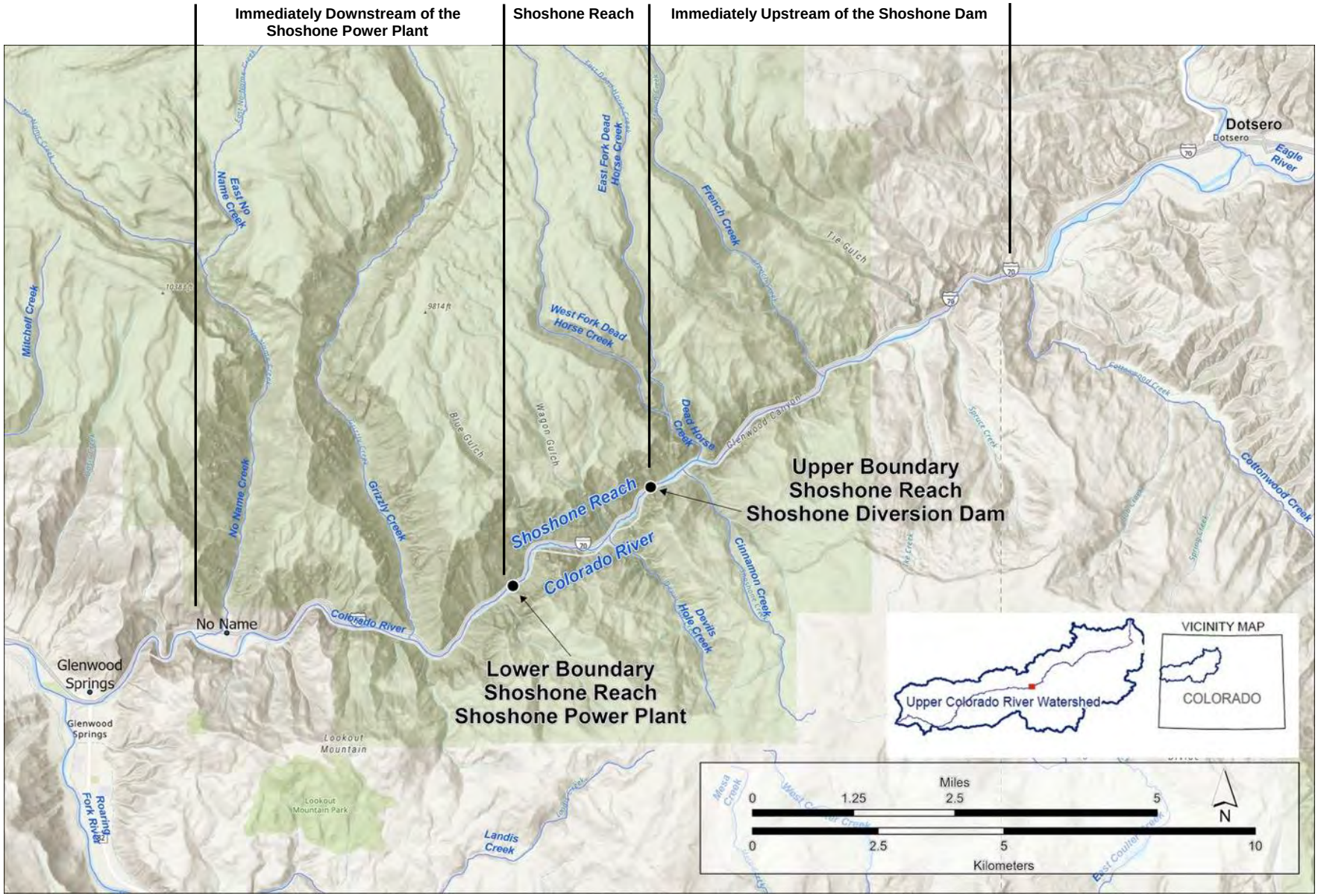


Figure 1: Map of Glenwood Canyon and Location of Shoshone Reach

2.0 SETTING AND CONTEXT

The Colorado Basin is an important watershed in Colorado, extending from the high altitudes of Rocky Mountain National Park to the Utah state line. Covering approximately 9,830 square miles, this basin is vital for both the environment and the economy of the region as stated in the Colorado Water Plan, 2023.

The Colorado Basin features diverse terrains, starting with mountainous areas that are the source of major snowpack, which contribute to the basin's primary water supply, flowing downstream to the dry desert climates of the Colorado Plateau. These snowpacks are crucial resources for water users on both sides of the Continental Divide. Snowmelt, particularly in spring, serves as a key source of water for the basin's tributaries, providing critical seasonal runoff. Geothermal springs in Glenwood Canyon introduce naturally heated water into the Colorado River. While these springs contribute warm water, their effect on the river's overall temperature is relatively localized and minimal due to the river's substantial flow rate. However, during periods of low flow, the influence of these geothermal inputs can become more pronounced, and even lethal, as fish kills have been documented for both Trout and Sculpin below the Shoshone Reach when the river flow was constrained at the dam (CPW, personal communication, 2024).

Nearly three million acres of land in the basin are federally owned. The U.S. Forest Service (USFS) manages the largest share, while the BLM oversees significant rangelands. These public lands serve various purposes. In the upper counties of the basin—such as Grand, Eagle, Summit, and Pitkin—tourism is a dominant industry. Attractions like ski resorts, state and national parks, scenic rivers, and world-class fishing substantially contribute to the local economy. The region also has deep agricultural roots, with ranching and livestock production common in the upper reaches, while the Grand Valley is well-known for its agriculture and cultivation.

The Colorado River Basin encompasses a variety of ecosystems, ranging from alpine environments in the headwaters to desert landscapes in the lowlands. It supports diverse wildlife species and plant communities, many of which depend on the available water from the basin. Maintaining the flow and quality of water in the basin is essential for the health of these ecosystems.

Most of the Colorado's precipitation falls on the western slope of the state. However, most of the population lives on the eastern, front range of the state. This requires up to 50% of the water used in the front range to be transferred from the Colorado Basin in the state's western slope. Transbasin diversions transport water from one geographically distinct river basin to another via pipeline or other engineered methods. The transfer of water out of the Colorado Basin plays a critical role, with considerable amounts of water being exported annually to other basins like the South Platte and Arkansas for agricultural and municipal uses on Colorado's eastern slope. Not only are the Colorado River flows reduced by extensive transbasin diversions throughout its headwaters, like much of the western United States, the river is experiencing the impacts of climate change, including reduced snowpack, earlier spring runoff, and longer, more frequent severe droughts. These changes threaten the predictability of water availability and exacerbate tensions among water users. Key challenges include balancing water usage with the needs of river ecosystem function.

2.1 SHOSHONE WATER RIGHTS

The Shoshone Water Rights were established in the early 20th century, during a significant period of expansion for irrigation and hydropower infrastructure in the western United States. The

Shoshone Power Plant, originally constructed in 1909 and still operational today, was one of the first large-scale hydropower facilities in the region. At the time of its establishment, the water rights associated with the plant were among the earliest granted within the Colorado River watershed. These more senior Shoshone Water Rights (decreed for 1,250 cfs) is consistently one of the foremost calling water rights on the mainstem of the Colorado River, making it extraordinarily important to the flow regime, especially considering the ongoing pressures from increased demand and climate variability within the basin.

The Shoshone Water Rights include two separate absolute water rights associated with the Shoshone Power Plant. The more senior, original Shoshone Water Right was decreed for 1,250 cfs with a priority date of December 5, 1905. The junior Shoshone Water Right was decreed for 158 cfs and is administered with a priority date of May 31, 1940. Together, these water rights total 1,408 cfs. The Shoshone Power Plant operates year-round and when in operation it can lead to dewatering of the 2.4-mile Shoshone Reach shown in Figure 2.



Figure 2: Shoshone Reach - Location of Dam, Intake and Power Plant / Return

The Shoshone Water Rights ensure a consistent flow of water in the Colorado River outside the Shoshone Reach, resulting in positive ecological outcomes, such as maintaining water quality, and flow regimes essential for the resiliency of fish and other aquatic life. If the State of Colorado were to acquire the right to use the Shoshone Water Rights for instream flow purposes, these current benefits would be preserved and the Shoshone Reach itself would experience higher flows and the associated environmental benefits.

Additionally, the Shoshone Water Rights support numerous recreational activities in the region. The steady flow of water in the Colorado River, facilitated by these rights, enables activities like rafting, kayaking, and fishing, which are vital for tourism and local economies. These recreational pursuits rely on reliable water flows to ensure safe and enjoyable conditions for participants.

2.2 INSTREAM FLOW ACQUISITIONS TO PRESERVE AND IMPROVE

The Shoshone Water Rights, under a dedicated instream flow scenario, would play a vital ecological role in preserving and improving the natural environment of the Colorado River. As shown in this assessment, the Shoshone Water Rights would help to preserve and improve habitat for aquatic species, including parts of the natural flow regime which supports the river's ecological functions within the Shoshone Reach. The CWCB may:

> *Acquire, by grant, purchase, donation, bequest, devise, lease, exchange, or other contractual agreement, from or with any person, including any governmental entity, such water, water rights, or interests in water that are not on the division engineer's abandonment list in such amount as the board determines is appropriate for streamflows or for natural surface water levels or volumes for natural lakes to preserve or improve the natural environment to a reasonable degree. CRS 37-92-102(3).*

The concept of environmental or instream flow water rights has gained importance across the western United States, with Colorado leading efforts to protect and restore river ecosystems through recognized water law. This legal framework is crucial in addressing concerns regarding the depletion of freshwater resources and balancing ecological sustainability with development needs. In this way, water law reforms in Colorado, such as the CWCB's Instream Flow Program, have been recognized as successful models for integrating environmental concerns into water management systems.

Under a dedicated instream flow scenario, the Shoshone Water Rights would play a crucial role in ensuring adequate flows are preserved within the Shoshone Reach of the Colorado River at times when the Shoshone Power Plant is not operating. The flow of water that would be provided by instream flow use of the Shoshone Water Rights under these conditions would be essential for preserving and connecting habitats for fish and aquatic invertebrates in the Shoshone Reach, preventing the formation of dry sections in the river that disrupt these ecosystems as discussed further in Section 3.0.

Preserving reliable water flow through Shoshone Water Rights can greatly benefit fish species by keeping water levels and temperatures within the ranges necessary for survival, spawning, and thriving. Healthy stream flows are essential for creating and maintaining a diversity of habitats for reproduction, recruitment, and seasonal needs of fish, ensuring resiliency in a dynamic environment.

2.3 SHOSHONE REACH HISTORICAL CONDITIONS, HYDROLOGY, AND HABITAT

The Shoshone Reach has undergone significant ecological and hydrological changes due to the development of hydropower infrastructure, and water diversions. Before significant changes were made to the Colorado River system, including the construction and operation of the Shoshone Power Plant in 1909 and other water management structures (such as irrigation development, transmountain diversions, and upstream reservoirs), the river's flow was characterized by natural seasonal fluctuations caused by snowmelt in the Rocky Mountains. Without physical barriers and with higher natural water flow, the Shoshone Reach would connect fluvial habitats throughout the entire reach, including high-gradient sections.

Historically, the Shoshone Reach was a confined, high-gradient segment of the Colorado River, that has been further constrained by the construction of an interstate highway and railroads. The natural hydrology and geomorphology of this reach plays a crucial role in shaping habitat availability and aquatic species dynamics. The Colorado River experiences annual high flows driven by snowmelt. Annual spring runoff maintained diverse habitats, such as riffles, pools, and

runs, which allowed a wide range of fish species to thrive. The riparian zones, though limited in extent within the Shoshone Reach, likely provided important habitats for fish refuge, insect populations, and wildlife. These zones supported various plant species adapted to the river's seasonal flooding, contributing to the ecological richness of the area. Additionally, natural thermal gradients in the river created different thermal habitats for cold-water species. The cooler waters from spring snowmelt and the warmer conditions in summer and fall supported the reproduction and growth of fish species. The high-gradient nature of the reach contributes to increased oxygenation of the water, which is beneficial for aquatic life. Large pools within the reach may have offered velocity refuges and important holding habitats for fish during periods of elevated flow.

2.3.1 Changes After the Shoshone Power Plant and Other Water Diversions

The construction of the Shoshone Power Plant, along with other water management projects (such as upstream irrigation, reservoirs, and transmountain diversions), significantly changed the hydrology of the Colorado River, particularly in the Shoshone Reach. These developments altered both the flow patterns and the aquatic habitats of the river.

The Shoshone Reach is impacted by the hydropower operations at the Shoshone Power Plant via reduced and highly variable flows depending on the plant’s operational status. Within the Shoshone Reach, when the plant is fully operating (i.e., when water is diverted into the tunnels and penstocks, bypassing the natural channel), and during natural seasonal low flow periods, sediment transport is inhibited, wetted habitat is reduced, and longitudinal channel/flow connectivity is impaired. The intermittency and loss of wetted habitat limits aquatic invertebrate productivity, the primary food source for resident fish. At low flows, the Shoshone Reach becomes fragmented due to large bed drops in the high-gradient cascade and rapid sections. Additionally, the Shoshone Dam acts as a barrier to upstream fish movement.

Natural high-flow events that once cleared sediment and created essential habitats for native species have declined. Regulated river flows have stabilized riverbed features, altered sediment transport, and reduced ecosystem dynamism. These changes affect spawning habitats and biodiversity. The regulation of the Colorado River and its tributaries has also led to water quality challenges, including temperature fluctuations which impact aquatic ecosystems. Altered flow regimes and habitat modifications have influenced sediment deposition, nutrient cycling, and habitat availability for both native and non-native species (Van Streeter and Pitlick, 1998).

3.0 SHOSHONE INSTREAM FLOW USE BENEFITS

Instream flows are a critical topic in water management, driven by concerns over ecological preservation and improvement. In the 1970s, the CWCB was authorized to appropriate water for instream flow purposes, marking a significant shift in water management that recognizes the importance of healthy river ecosystems. Research shows that maintaining adequate instream flows is crucial for the health of riverine ecosystems, as it supports biodiversity and the overall ecological function of rivers (Rushforth et al., 2022; Martin et al., 2015; Poff et al., 2009).

3.1 WATERSHED BENEFITS

The Shoshone Water Rights are a crucial legal and ecological asset for both the upstream and downstream reaches of the Colorado River. While the Shoshone Water Rights are used for hydroelectric power production, the water rights also play a significant, though indirect, role in maintaining the health and functioning of the ecosystems along the Colorado River.

3.1.1 Upstream Reaches

The Shoshone Water Rights are one of the primary means of controlling water flow in this region. By maintaining reliable flows that stabilize upstream low flow conditions and support vital ecosystem functions.

Wild and Scenic Rivers Management: BLM and WRNF amended their respective resource management and forest plans to incorporate management prescriptions for Wild and Scenic Rivers in Glenwood Canyon and segments of the Colorado River from Dotsero to Kremmling. The agencies identified that these river segments support Outstandingly Remarkable Values (ORVs), which are unique or exemplary river-related values within the region. As a result, the agencies concluded that four river segments are eligible for inclusion in the National Wild and Scenic Rivers System.

During the evaluation of whether the river segments are suitable for this designation, the agencies received an alternative management plan proposal from the Upper Colorado River Wild and Scenic Stakeholder Group.

The BLM and WRNF plan specifically focuses on protecting and enhancing the ORVs that are most dependent on flow conditions. The intent behind adopting this plan is to ensure it is consistent with BLM and WRNF land use authorities and decisions, thereby enabling the federal agencies to better fulfill their management obligations under the Wild and Scenic Rivers Act. The plan includes monitoring streamflow through the Wild and Scenic segments, supplemented by coordinated, cooperative, and voluntary water deliveries when available. This approach aims to balance the permanent protection of ORVs with the needs of stakeholders, the yield of water projects, and the flexibility required by water users.

It is important to note that the plan relies on the existing water rights of the Shoshone Power Plant as a primary long-term protection measure:

> *Existing senior water rights: The Shoshone and Cameo groups of senior water rights generally control the administrative call within the Colorado River Basin. These water rights are located downstream of the subject stream reaches; therefore, an administrative call during dry or average conditions by these water rights can curtail diversions from upstream junior water rights or require the release of water from storage to replace those junior diversions. This administrative call generally results in stream*

flow through the subject stream segments in amounts greater than would exist in the absence of the administrative call.[1]

Aquatic Habitat Health in the Upper Colorado River: The health of aquatic habitats upstream of the Shoshone Reach significantly depends on consistent water flow. Species such as the Colorado River Cutthroat Trout, Rainbow Trout, and various macroinvertebrates rely on reliable flow conditions for survival. The Shoshone Water Rights call down water to the Shoshone Reach (whether through releases from reservoirs or curtailment of junior rights). The Shoshone Water Rights are instrumental in ensuring reliable flows, thus preventing conditions that could threaten these species. Reliable flows promote the development of proper habitats within the river channel and adjacent riparian zones, providing aquatic species with access to food, refuge shelter, and spawning areas. By facilitating regular releases from upstream reservoirs and providing reliable flow, the Shoshone Water Rights helps support the necessary hydrological conditions for a diverse range of plant and animal species to exist. Without these steady water releases, upstream habitats could become vulnerable to drying out, especially during droughts, leading to habitat loss for aquatic species.

Low Water Flow Periods: The Shoshone Water Rights seniority allows them to call for a significant portion of natural flow in the basin up to their combined flow rate, meeting minimum flows during dry years and periods of low flow as feasible. Essentially, the Shoshone Water Rights act as a buffer against extreme hydrological events (such as droughts), contributing to more sustainable flows in upstream reaches. The increasing severity of debris flows associated with intense rainfalls and fire scars, and sediment flows after rain events, can be further mitigated by Shoshone flows. In winter the flows brought downstream by the Shoshone Water Rights also help reduce formation of anchor ice and provide habitat during seasonally low flow periods.

Riparian and Wetland Ecosystems: The riparian areas and wetlands along the Colorado River and upstream of the Shoshone Power Plant respond to fluctuations in river flow. Riparian and floodplain habitats provide essential ecological services but differ in location and function. Riparian habitats, located along riverbanks, feature plants like willows and cottonwoods. They stabilize streambanks, filter pollutants, and regulate water temperatures. These zones are crucial for juvenile fish, providing refuge shelter and abundant food sources, and serve as refuges during high-flow events, protecting fish from strong currents.

Without consistent water curtailment or replacement made in response to the Shoshone Water Rights, riparian vegetation may suffer from reduced water availability, leading to the degradation of wetland ecosystems that support many plants, animals, and migratory bird species.

3.1.2 Downstream Reaches

The Shoshone Water Rights are important for maintaining the ecological health of downstream areas, including important habitats such as wetlands and riparian zones. These habitats are vital for a wide range of species, including fish, amphibians, and waterfowl.

The area immediately downstream of the Shoshone Power Plant (Figure 1) supports a healthy sportfish population consisting of Brown Trout, Rainbow Trout, and Mountain Whitefish. Despite the challenges posed by invasive fish species, native species such as the Flannelmouth Sucker and Bluehead Sucker are frequently found in the Colorado River, particularly in and around Glenwood Canyon. Other native fish in this area include the Bluehead Sucker, Roundtail Chub, Sculpin, and Dace. The Shoshone Power Plant return flows help maintain riffle, run, and pool

[1] https://www.upcowildandscenic.com/uploads/1/3/5/3/135388668/amended_and_restated_sg_plan_july_2024.pdf

habitats. The resilience of the aquatic ecosystem is bolstered by the greater availability of riffle habitats, which enhances the productivity of macroinvertebrates and resident fish.

Water Quality Protection: Downstream water quality is significantly influenced by flow conditions. The Shoshone Water Rights help regulate the amount of water flowing through the system, preventing sudden drops in flow that could degrade water quality. For instance, low flows can increase water temperature and decrease dissolved oxygen levels, both of which are harmful to aquatic species. By maintaining reliable flows, the Shoshone Water Rights support good water quality, particularly temperature, for both aquatic life and human use.

Recreation and Tourism: The Colorado River downstream of the Shoshone Power Plant, particularly through Glenwood Canyon, is a popular recreational area for activities such as rafting, kayaking, fishing, and wildlife watching. Maintaining a reliable flow helps preserve these recreational opportunities by ensuring consistent river conditions, making the river more useable for river enthusiasts. Additionally, the recreation industry is vital to the local economy, and the Shoshone Water Rights contribute directly to the sustainability of this sector.

3.1.3 Shoshone Water Rights and Federally Listed Fish Species

The Shoshone Water Rights are important not only for the local fish community but also may have downstream benefits for four federally listed fish species under the Endangered Species Act (ESA): Bonytail, Colorado Pikeminnow, Humpback Chub, and Razorback Sucker. A consistent Shoshone Call supports the availability of water that may be used to support important habitats in the "15-Mile Reach" of the Colorado River, which extends from the Town of Palisade to the confluence with the Gunnison River in Grand Junction. This area is particularly susceptible to very low water flows because significant water withdrawals occur just upstream of Palisade for agricultural and other purposes. These ESA species are highly sensitive to changes in water flow, temperature, and habitat conditions.

Federally Listed Fish Species in the Colorado River Basin

The Colorado River and its tributaries are home to several ESA-listed fish species that have suffered significant declines due to habitat degradation, water diversions, and invasive species. The four Colorado River endangered fish species are:

- Colorado River Pikeminnow (*Ptychocheilus lucius*) – a large predatory fish historically abundant in the Colorado River but now listed as endangered.
- Bonytail *(Gila elegans)* – a species of riverine fish endemic to the Colorado River system, listed as endangered.
- Razorback Sucker (*Xyrauchen texanus*) – another Endangered species (currently proposed for downlisting to Threatened) that once thrived in the Colorado River but is now restricted to isolated populations.
- Humpback Chub (*Gila cypha*) – a species of riverine fish endemic to the Colorado River system, listed as threatened.

Critical habitat for the four endangered fishes in Colorado River is designated downstream of Glenwood Canyon beginning near Rifle, Colorado, and extends into the lower Colorado River basin. Colorado Pikeminnow and Razorback Sucker Critical Habitat starts at the Highway 13 bridge and includes the 15-Mile Reach identified as crucial to their recovery by the Upper Colorado River Recovery Program. The upstream extent of Bonytail and Humpback Chub Critical Habitat begins below the 15-Mile Reach, approximately 5 miles upstream of the Utah border.

The Colorado River's endangered fish species are highly dependent on specific flow regimes, water temperatures, and habitat conditions that are often disrupted by human activities, including damming, diversion, and water withdrawals. The U.S. Fish and Wildlife Service (USFWS) and other regulatory agencies have developed recovery plans for ESA-listed species in the Colorado River basin. These plans outline specific flow regimes and habitat conditions necessary for the survival and recovery of species.

3.2 SHOSHONE REACH BENEFITS

Permanently protecting the Shoshone Water Rights by adding an instream flow use is a future benefit that would preserve and improve aquatic habitat supporting fish populations, maintain stream health, and ensure ecological integrity within the Shoshone Reach. This section of the river supports a diverse array of species, including Rainbow Trout, Brown Trout, Mountain Whitefish, and Flannelmouth Suckers, and a robust population of macroinvertebrates. The survival of these species relies on adequate water flow conditions, which influence critical factors such as habitat availability, water temperature, oxygen levels, sedimentation, and food resources.

3.2.1 Fishery and Aquatic Habitat Conditions

The Shoshone Reach of the Colorado River plays a role in sustaining aquatic ecosystems, particularly for fish populations that rely on its diverse habitat throughout the year. When the Shoshone Reach is dewatered during plant operations, these valuable functions are impacted.

This section of the river provides important refugia and habitat complexity, ensuring fish have access to a variety of depth zones and structural features. The rough and diverse streambed—composed of boulders, cobbles, and gravels—provides interstitial habitats with numerous small pockets and spaces that fish can utilize for shelter and feeding. These microhabitats remain available even at high flows, providing refuge offering stability during fluctuating conditions.

Fish access the Shoshone Reach when feasible, utilizing available habitat for multiple life-cycle processes, including spawning, rearing, migration, foraging, and refuge. Even during periods of low flow, this reach remains viable for fish populations as it is sustained by spring and small tributary flows that allow downstream connectivity and fragmented connectivity within the reach. Lower flows prevent upstream fish passage in cascade and rapid sections where large bed drops and boulder pour-overs are barriers to fish that either cannot make the extensive jump or cannot swim through the fast laminar flows.

During low flow conditions, the channel functions more like a small stream and currently provides some spawning opportunities to fall spawners (e.g., Brown Trout and Mountain Whitefish) that would otherwise be washed out in higher native flows. The shallower stream-like habitat also offers refuge for juvenile fishes from larger predatory trout. Habitat for macroinvertebrates in the lesser stream channel supports an abundance of EPT Taxa (Ephemoroptera Plecoptera and Tricoptera Taxa) that indicate good water quality functions despite the reduced amount of available wetted habitat. Wetted areas retained during low flows offer connectivity downstream to other parts of the river and sustain juvenile fish that depend on its habitat (CPW personal communication, 2024).

The Shoshone Reach features both high-gradient and low-gradient areas, allowing fish to move between different habitat types based on their needs. This natural variation supports movement between the foraging, resting, and spawning areas that fish need to complete their life cycle.

The Shoshone Reach, when sufficient flow is available, provides important ecological benefits that support fish populations, enhance habitat connectivity, and sustain wildlife. Adding an instream flow use to the Shoshone Water Rights establishes a legal framework that will noticeably preserve and improve the Shoshone Reach, safeguarding long-term ecological balance, fish passage, and habitat resilience across seasons.

3.2.2 Macroinvertebrates

Aquatic macroinvertebrates play a crucial role in maintaining the health and balance of both aquatic and terrestrial ecosystems. Macroinvertebrates, particularly aquatic insects, are essential components of the Colorado River aquatic food webs, serving as primary consumers that feed on organic matter and algae and as prey for fish, amphibians, and birds. By breaking down organic material, they facilitate nutrient cycling, contributing to the decomposition process and improving water quality. Macroinvertebrates also serve as indicators of ecosystem health, as their presence and diversity reflect water quality and habitat conditions. Beyond the water, they are a vital food source for terrestrial insects, bats, and birds, creating a bridge between aquatic and terrestrial ecosystems. For example, emergent aquatic insects like mayflies and caddisflies provide essential energy and nutrients to riparian predators such as birds, bats, and spiders. This can be particularly true in river reaches with confined or limited riparian areas, like that exhibited in the Shoshone Reach. This interconnectedness underscores aquatic macroinvertebrate ecological significance, highlighting the need for their conservation to sustain biodiversity and ecosystem functions across landscapes.

The availability and quality of streamflows play a pivotal role in shaping aquatic ecosystems, directly influencing macroinvertebrate abundance and composition. Macroinvertebrates rely on specific habitat conditions, such as substrate composition, flow velocity, and water quality, to thrive. Adequate flow ensures that these conditions are met, creating diverse and stable habitats that support a wide variety of macroinvertebrate species. These organisms, in turn, serve as a critical food source for fish, forming a foundational link in aquatic food webs. Conversely, insufficient flow can degrade habitat quality, leading to higher water temperatures, lower dissolved oxygen levels, and increased sedimentation—all of which can stress or eliminate sensitive macroinvertebrate species. Such changes not only reduce the diversity and abundance of macroinvertebrates but also negatively affect fish populations that depend on them.

The interconnectedness between flow, habitat, water quality, and macroinvertebrates underscores the cascading effects that flow alterations can have on river ecosystems. When flow levels are reduced, the resulting environmental changes can disrupt the balance needed for a healthy ecosystem. Higher temperatures and lower oxygen levels can create inhospitable conditions for both fish and macroinvertebrates, while excessive sedimentation can smother benthic habitats critical for macroinvertebrate survival. On the other hand, maintaining adequate flow supports optimal conditions, including stable temperatures, high oxygen levels, and balanced sediment transport. These factors promote the health of macroinvertebrate communities, promoting a robust food supply for fish and fostering a resilient aquatic ecosystem. Protecting and restoring natural flow regimes is central to sustaining the intricate relationships that underpin ecosystem resilience and biodiversity.

4.0 INSTREAM FLOW ASSESSMENT OF THE SHOSHONE REACH

4.1 SHOSHONE REACH HYDROLOGY

The hydrologic time series data for the Shoshone Reach, derived from the StateMod modeling tool, were used to assess various flow scenarios. StateMod utilizes USGS flow records along with diversion records from the State of Colorado. This assessment incorporated a new StateMod daily model, the Upper Colorado River Basin Model (2024 UCRM), with modeling results evaluated at the Dotsero Gage (water years 1988-2003) as performed and documented by Hydros (Hydros, 2024). Because of the importance of Shoshone Reach flows for fish habitat in dry years, the StateMod model outputs were focused on dry years for which the record was complete during late summer and early fall (calendar years 1989, 1990, 2001 and 2002) consistent with overlapping dry years utilized by Hydros.

Flows at the Dotsero Gage may exceed the Shoshone Water Rights call for 1,408 cfs due to the administrative practice of shepherding by state water officials in Colorado, or due to snowmelt runoff. Bypassed flows, also known as shepherded releases, refer to water that is released from upstream reservoirs for delivery to downstream users beyond the natural levels expected at those locations. For example, these releases may benefit irrigators or provide environmental flows to the 15-Mile Reach in the Grand Valley.

The Dotsero Gage (USGS 09070500) serves as an administrative point used by the Colorado Division of Water Resources (DWR) to measure and administer streamflow for water rights, including for the Shoshone Water Rights. DWR accounts for two types of measured flow at the Dotsero Gage: (1) the amount of undepleted natural flow; and (2) the amount of shepherded bypassed flow. “Undepleted natural flow” refers to the volume of water that can be diverted under the Shoshone Water Rights when those rights are in priority, excluding any releases from upstream reservoirs that are shepherded for downstream use below the Shoshone Reach.

4.1.1 Shoshone Reach Flow Scenarios

- For this assessment, the River District evaluated and provided three flow scenarios for the Shoshone Reach (Hydros, 2024). Recent disruptions to the traditional flow regime—caused by wildfires, debris flows, and power plant maintenance—indicate that the most representative period of record is from the beginning of the 2024 UCRM model period Water Year 1988 (beginning October 1, 1987) through Water Year 2003. The analysis focused on consecutive months with lower water flows and higher temperatures that stress fish and affect habitat quality, specifically from August to October. This late summer to early fall period is critical for the relationship between water flow, temperature, and fish habitat. During this time, unfavorable habitat conditions for fish have resulted in voluntary fishing closures in the Shoshone Reach (CPW personal communication, 2025).
- Each of the time-series scenarios is an output from StateMod using the daily timeseries in the 2024 UCRM, a water rights administration model developed by the State of Colorado. The three scenarios, illustrated in Figure 3, are as follows:
    - **Scenario 1 (Baseline)**: Represents flows in the Shoshone Reach under existing conditions (Figure 3). This scenario is modeled as the flow at the Dotsero Gage minus the Shoshone Power Plant’s diversions, which is defined as the “Baseline” scenario in the 2024 UCRM and by Hydros (Hydros, 2024). The Shoshone Reach operates like an intermittent stream channel with high flows during runoff and little to no flow in seasonally low water periods, when the entire river flow is often diverted for hydropower production

at the Shoshone Power Plant and the Shoshone Reach flows like a small stream supplied by intervening small springs and tributary inputs.

- **Scenario 2 (Future with Permanency):** Represents a future condition with additional Colorado River build-out demand (Hydros, 2024) in which the Shoshone Power Plant no longer operates, and the Shoshone Water Rights (as defined by the Shoshone Baseline demands) are permanently protected as an instream flow water right (Figures 3). This scenario assumes all flows remain in the Shoshone Reach, corresponding to the Baseline Future model output at the Dotsero Gage (Hydros, 2024).
- **Scenario 3 (Future without Permanency):** Represents a future condition where the Shoshone Power Plant no longer operates, and the Shoshone Water Rights are no longer maintained or able to call (Figures 3) (Hydros, 2024).

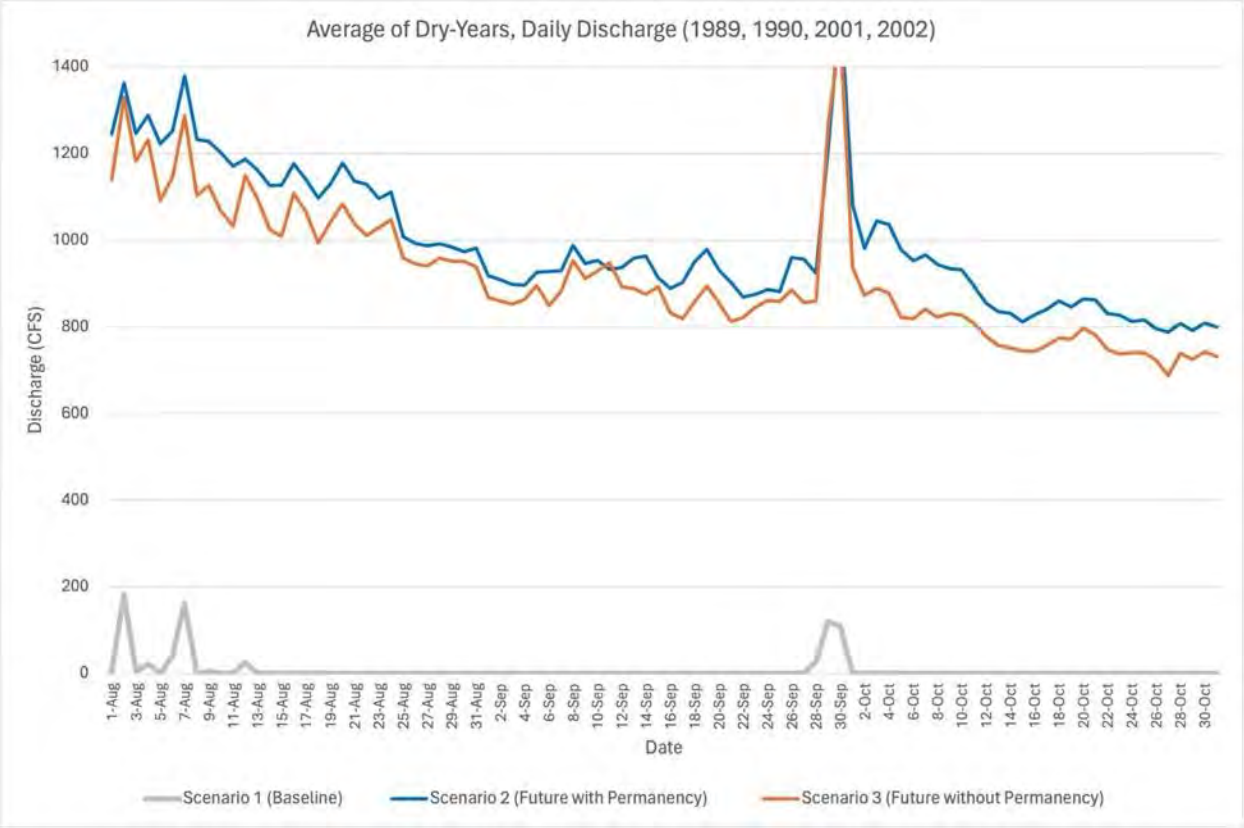


Figure 3: Shoshone Reach Mean Daily Discharge during low flow years 1989, 1990, 2001, and 2002, for each of the three Scenarios.[2]

The analysis indicates that both Scenario 2 (Future with Permanency) and Scenario 3 (Future without Permanency) will result in increased flows within the Shoshone Reach under all conditions, effectively eliminating days with flows below 700 cfs. Scenario 1 would have the most days/year (most frequency) of modeled flows of 250 cfs or less; Scenario 3 would have the most days/year (most frequency) of flows at 700 cfs and 1,020 cfs; Scenario 2 would have the most

[2] Note that the isolated spike in flows observed near the end of September in Figure 3 is attributable to modeled reservoir release operations at the end of the water year that resulted in the 2024 UCRM. These processes, operations, and trends have not occurred historically in September for all years and are unlikely to occur in the future as presented in Figure 3.

days/year (most frequency) of flows at 1,250 cfs, 1,400 cfs, 1,500 cfs, and 1,750 cfs. Differences in frequency of predicted discharges above 2,000 cfs between Scenarios 2 and 3 are nominal, but more frequent than Scenario 1. This informs the interpretation of the hydraulic habitat modeling; the Shoshone Reach is more likely to have flows between 1,250 cfs and 1,750 cfs and less likely to have flows between 700 cfs and 1,250 cfs with Future with Permanency (Scenario 2) than the Future without Permanency.

The analysis of median monthly flows for the entire period of record highlights a significant advantage of Scenario 2 (Future with Permanency), particularly during late-summer months (August–October) when ambient temperatures are still high, demand on storage water is at or near its peak, and cold-water species—primarily Brown Trout and Mountain Whitefish—are spawning (Figure 3).

In Scenario 2, late-summer discharge shows notable increases compared to Scenario 3, with median flow differences of:

- +144 cfs (+11.7%) in August
- +221 cfs (+20%) in September
- +26.9 cfs (+2.8%) in October

These increases provide up to 221 cfs more flow during this critical period, supporting spawning habitat, and aquatic ecosystem health.

The predicted frequency the Shoshone Reach will experience each flow informs the interpretation of the habitat suitability results and when reaches upstream and downstream of the Shoshone Reach will have changes in flow associated with each scenario. The modeled flow scenarios demonstrate that fish and other aquatic biota and other resources (such as recreation), would benefit from higher flows during seasons where they are most in need of those flows (Figure 3).

4.2 EVALUATION OF INSTREAM FLOWS

This section documents the evaluation of instream flows using the IFIM process. The IFIM was used to explore the relationship between various flow scenarios and the hydraulic suitability of flows for focal fish species within the Shoshone Reach of the Colorado River. The study area spans from the point of diversion for the Shoshone Water Rights at the Shoshone Diversion Dam to the outfall of the Shoshone Power Plant. The objectives of this evaluation were to assess the current state of the aquatic habitat to predict expected changes due to potential hydrologic alterations resulting from the proposed change of use of the Shoshone Water Rights. The proposed hydrologic change would involve dedicating the full 1,408 cfs of flow, when available in priority to an alternate use for instream flow purposes, meaning that the otherwise diverted water would remain in the river to support aquatic habitat when the Shoshone Power Plant is not operating.

IFIM is a widely recognized method for assessing the relationship between streamflow and habitat quality for aquatic species. Developed by Bovee (1982), the IFIM uses habitat suitability curves and flow-habitat relationships to model how changes in streamflow affect the availability of suitable habitat for target species (Bovee, 1982; Stalnaker et al., 1995).

HHS is used to quantify the suitability of different habitats for various aquatic species under different flow conditions (Bovee, 1982). Habitat suitability curves were developed based on empirical data and expert judgment, relating the availability of habitat to streamflow parameters such as depth and velocity. The habitat suitability criteria for the fish species examined under this

IFIM were recommended by CPW and Dr. Miller (Miller 2024, Final Report), as habitat suitability curves from the published literature. No changes to the habitat suitability curves were made for this analysis (Appendix B).

Habitat availability was assessed by calculating the effect different flow levels have on the extent and quality of habitat within the study area. This is typically done using hydraulic models and habitat-suitability relationships to predict how different flows influence the quantity and quality of habitat. By simulating a wide range of flows, the evaluation examines how habitat availability for target species changes across different flow regimes (Poff et al., 1997; Bovee, 1982).

Study Sites

Site 1 is 1,854 ft. in length (River Restoration, 2023). The wetted area at 1,400 cfs is 6.1 acres (266,456 sq. ft.) and is representative of 14.4% of the total Shoshone Reach.

Site 2 is 1,830 ft. in length (River Restoration, 2025). The wetted area at 1,400 cfs is 5.9 acres (255,436 sq. ft.) and is representative of 14.2% of the total Shoshone Reach.

Combined, Sites 1 and 2 are representative of 28.6% of the Shoshone Reach (Figure 4).

4.2.1 Objectives

The primary objective was to evaluate the potential changes to aquatic hydraulic habitat (depth and velocity) resulting from incremental changes in flow. The analysis examines a range of flows, which include 50, 250, 700, 1,020, 1,250, 1,400, 1,500, 1,750, 2,000, 2,250, 2,500, and 3,000 cfs. The range of modeled flows allows quantification of how these flow changes influence aquatic species, and habitat availability. The range of flows were selected due to their likelihood of occurring in the reach based on the three scenarios provided (see section 2.6.1).

4.2.2 Discharge Flows Modeled

Currently, the Shoshone Water Rights divert up to 1,408 cfs from the Colorado River for power generation at the Shoshone Power Plant. The proposed change of the Shoshone Water Rights would allow the CWCB to exercise the Shoshone Water Rights, when not being used for hydropower generation, in a manner that would cause the decreed amount of water available to the water rights to remain in the Shoshone Reach to support aquatic ecosystems instead (CWCB, 2021). In addition to evaluating the effect of the proposed new use of the Shoshone Water Rights for instream flow purposes on flow conditions within the Shoshone Reach, the evaluation also considers the potential effects of a broader range of flow conditions, from 50 cfs to 3,000 cfs, to provide a more comprehensive understanding of how the flow changes may affect the Shoshone Reach's aquatic habitat.

The three flow scenarios (1-Baseline, 2-Future with Permanency, 3-Future without Permanency) were analyzed in flow increments to explore the effects of both reduced and increased flows on habitat availability. Flow levels from 50 cfs to 3,000 cfs represent potential hydrologic conditions under current management practices and the proposed instream flow use.

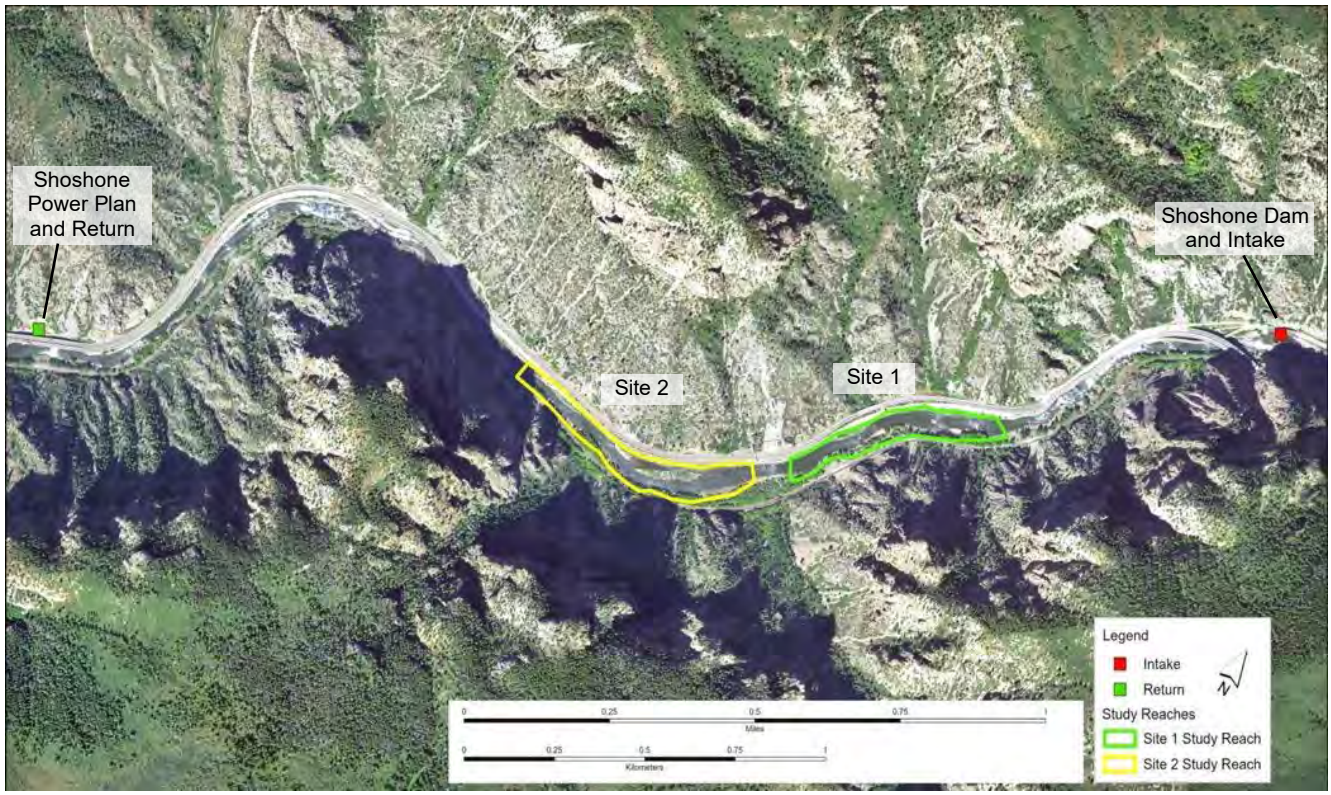


Figure 4: Shoshone Reach - Sites 1 and 2

4.3 METHODS

A two-dimensional habitat suitability model was created for two sites within the Shoshone Reach of the Colorado River (Figure 4). One suitability model was created for the two sites; meaning the same Hydraulic Habitat Suitability (HHS) criteria (velocity, and depth suitability curves) and equation were used for both sites. The two sites were assessed independently from one another. The HHS models were not combined into one continuous reach.

The following sections describe the development and application techniques used to create the two-dimensional model. The model was employed to derive the extent and quality, or suitability, of fish habitat within the two sites over a range of flows. Weighted Usable Area (WUA) is the measure of suitable habitat per species per flow per site and is calculated by multiplying an areas (pixel or polygon) suitability score by that areal extent to determine the actual measure of habitat available to each species at each flow. The extent and quality of suitable habitat is derived for adult Brown and Rainbow Trout, adult Flannelmouth Sucker, and adult Mountain Whitefish. The two-dimensional model examines depth and velocity to identify habitat suitability for each species. Environmental Systems Research Institute's (ESRI) ArcGIS Professional (ArcPro) was used to create and run the two-dimensional model. ArcPro is a Geographic Information System (GIS) platform. Accordingly, all data were converted (e.g., depth, velocity, suitability curves) to GIS consumable data and analyzed in ArcPro. Only the HHS model was run in ArcPro.

The topography (digital elevation model [DEM]) and hydraulic modelling was performed by River Restoration. These reports can be found in Appendix D which provide an in-depth description of the topographic data collection, topographic grid creation and the hydraulic modelling (Appendix D). The results of this work included depth and velocity grids (GIS data) for each modeled flow (e.g., 50, 250, 700, 1,020, 1,250, 1,400, 1,500, 1,750, 2,000, 2,250, 2,500, 3,000 cfs). These datasets were employed to derive the HHS for each species per flow.

4.3.1 Two-Dimensional Habitat Modeling—General Approach

There is considerable research on two-dimensional habitat suitability modeling for fish species. The methods used, computations, and the interpretation of results have been studied and deliberated (Austin 2002, Jowett and Davey 2011, Payne 2020). This research has led to a simple conclusion: that the methods employed to obtain results, and the interpretation of those results, should be dictated by the goals of the project (Austin 2002). The goal of this project, and the two-dimensional model used for the assessment, is to examine the impact that incremental flow changes would have on the extent and quality of habitat for four adult fish species (e.g., Brown and Rainbow Trout, Flannelmouth Sucker and Mountain Whitefish). This assessment evaluates a high gradient, confined canyon reach of river that does not provide optimal habitat for all life stages and species of fish. Therefore, the goal of this assessment is expressly to look at the extent and quality of each adult fish species' habitat, and how that habitat is affected by depth and velocity changes over a range of flows. Furthermore, this assessment is not intended to evaluate permanency of the Shoshone Water Right, rather it is to evaluate HHS benefits of the water right should it be converted to an instream flow beneficial use. Therefore, when the Shoshone Power Plant is not diverting, the flows can be put to beneficial use for the environment.

An additive model was chosen to derive HHS in the Shoshone Reach. The equation for habitat suitability for each species in the Shoshone Reach is:

Fish Species HHS per flow = Depth HHS + Velocity HHS

Additive models resolve some of the criticisms that have been made of conventional habitat suitability criteria and habitat suitability modeling (Jowett and Davey, 2007). The main rationale for employing an additive model rather than a computation including multiplication is to address the depth-averaged velocity issue in high gradient and deeper rivers, such as the Colorado River Shoshone Reach. Depth-averaged velocity output from hydraulic models, which gives one velocity value for the entire water column, often does not account for lower and likely suitable velocities that can occur along the streambed and adjacent to roughness elements that create a hydraulic shadow. In large rivers with boulder substrates, such as the Colorado River through the Shoshone Reach, suitable velocities could be found along the bed in locations where the depth-average velocity would be considered too high. In which case, using a traditional approach of multiplying the depth and velocity suitability to obtain a composite suitability may underestimate the true amount of suitable habitat.

The additive model improves, or overcomes, the depth-averaged velocity because it does not constrain suitable habitat predictions in deep, fast-flowing areas where few data were collected, and where velocity is not consistent throughout the water column (Jowett and Davey, 2007). Large bed material, such as what exists throughout the Shoshone Reach, provides velocity breaks for fish, and enable movement even at high flows, where velocities are extreme. Thus, velocity is not consistent in the water column, and depth-averaged velocities used in 2-D models may not be biologically informative.

Sampling deep and/or fast-flowing habitat types presents significant challenges. These habitat features are common in the Colorado River Shoshone Reach. Field researchers and biologists have reduced capture efficiency when sampling areas with deep and/or swift currents. Species suitability curves are largely based on where humans are able to observe fish species. This bias, resulting from the lack of observations in deep, fast-flowing waters, typically leads to a pronounced negative interaction between velocity and depth in rivers such as the Colorado River Shoshone Reach. The negative velocity-depth interaction means that high average velocity values (e.g., HHS_{vel} > 6.0 feet per second = 0) often exclude potential habitat because the velocity suitability score is zero (Jowett and Davey, 2007). In traditional HHS models, velocity suitability is multiplied by depth suitability (HHS = D*V) to determine an overall suitability metric. Anywhere that velocity suitability is zero is deemed as non-habitat. This velocity-depth interaction has been shown to be a poor predictor of species occurrence in deep fast flowing rivers (Jowett and Davey, 2007). Therefore, the simplified additive model was used for this assessment. Additive models provide a more biologically realistic results and have been shown to be a better predictor of species occurrence than multiplicative models (Jowett and Davey, 2007).

4.3.2 Habitat Suitability Curves

The Habitat Suitability Curves were recommended in the 2024 Miller Report with feedback provided by CPW, and based on local expertise and professional judgement:

> *Habitat data for the species of interest came from several sources and have been used in previous studies on the Colorado River (Miller and Swaim 2011). The data for adult trout was collected by direct observation at several locations in rivers in Colorado. The data was collected by personnel from the Colorado Division of Wildlife (now CPW) and US Fish and Wildlife Service in 1988 and 1989 (Colorado Division of Wildlife 1989). Those observations were used to develop habitat preference suitability indices for depth and velocity and corrected for habitat presence (Wilding 2012)*. (Miller 2024).

Additionally, the 2024 Miller Report provides that:

> *Criteria for Mountain Whitefish used for this analysis came from Bovee (1978). The criteria for adult Flannelmouth Sucker were updated in early 2024 from a combination of data from radio telemetry studies on the Colorado River near Grand Junction, existing data from a range of rivers and literature review of habitat and population studies (Miller 2024). Additional habitat criteria for Flannelmouth Sucker were incorporated into the final suitability criteria as documented by Miller (2024).*

The suitability curves for all species are shown in Appendix B. The numeric suitability curves (Excel files) for each fish species were imported into ArcPro and converted to a GIS table.

4.3.4 Application in Geographic Information System (GIS)

As mentioned above, the habitat suitability modeling used ESRI's ArcPro. Four species were modeled at two sites within the Shoshone Reach of Colorado River. Twelve flow rates were modeled. A total of 96 HHS scenarios were modelled to document the change in extent and quality of habitat for the four fish species in the Shoshone Reach.

Figure 5 below demonstrates the simplified process of taking raw depth and velocity grids, provided by the hydraulic modeling (River Restoration 2023, 2025, Appendix D), and then converted each into a suitable habitat layer for each species. The initial step in the process is to import the depth and velocity grids to ArcPro. The next step is to apply the suitable habitat criteria (HHS Table) to the raw depth and velocity grids using a tool called "Reclass by Table." This step

converts the depth and velocity grids to a suitable habitat layer, based on the suitability curves, with values ranging from 0 to 1. The next step is to add the depth and velocity grids (i.e., additive model) together to create an overall HHS score (additive model maximum = 2) for each species at each flow (Figures A1-A18, Appendix A). Habitat selection by fish often appears to have thresholds. For example, many fish species will use a wide range of depths once the depth has exceeded some critical minimum value (Bovee et al. 1998). For this assessment, the critical minimum HHS depth value for all species was identified as 0.5 feet (CPW Personnel Communication, 2025). Areas of each site where depths were less 0.5 feet were given an overall score of 0 regardless of velocity. HHS values ranged from 0 to 2. A score of zero indicates no habitat. Low HHS values (<0.2) indicate marginal habitat, whereas high or maximum HHS values (2.0) indicate optimal habitat.

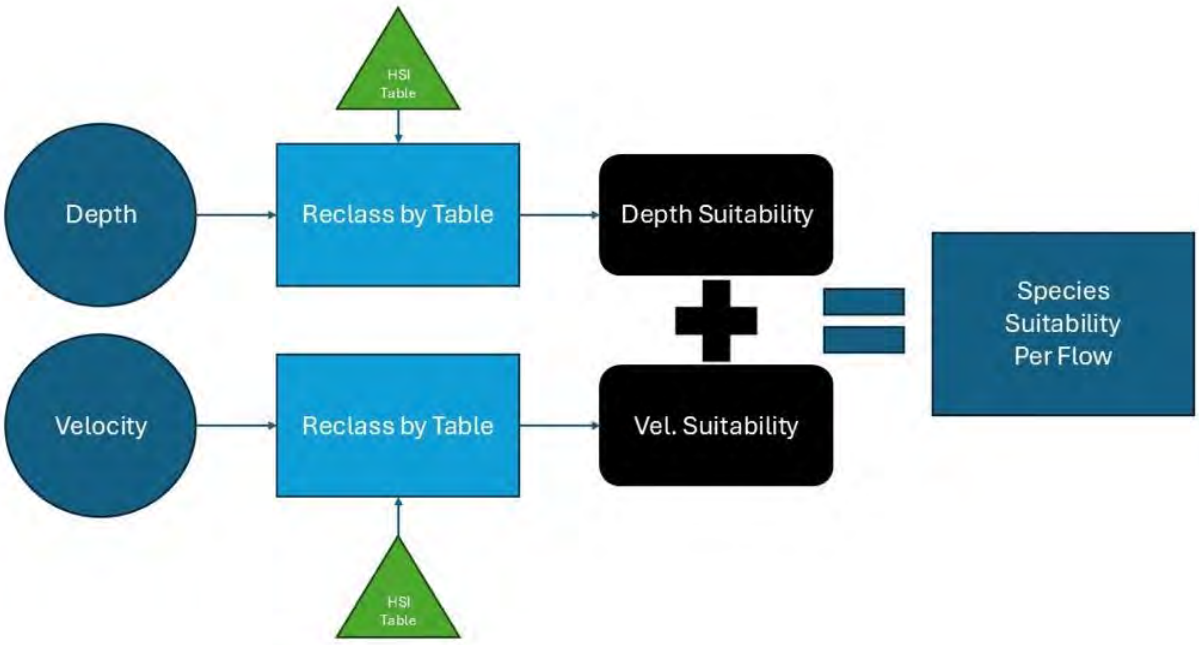


Figure 5. Simplified Process of Creating HHS Layers in ArcPro.

Results discussed below are expressed as Weighted Usable Area (WUA) per species per flow per site. WUA is derived by multiplying each modeled pixel's area by that pixel's HHS (WUA_{pixel} = Pixel * HHS). Effectively, if the additive model (depth HHS + velocity HHS) pixel sum is greater than zero, the pixel offers suitable habitat and the WUA is equal to the pixel area multiplied by the HHS. For the WUA calculation, additive HHS values were converted to a 0 to 1 scale by dividing the additive HHS by 2 (e.g., Additive HHS = 1.4, [1.4/2 = 0.7], WUA = 0.7 * Pixel Area). WUA is further calculated as a linear measurement, where overall WUA per species per flow is divided by the length of the study site to determine square feet of habitat per 1,000 ft of stream. Thus, the WUA figures per site and per species depict square feet of habitat per 1,000 ft of stream length.

4.4 RESULTS

The results presented in this assessment are organized by study site. For each site, results for wetted area per flow (depth >0.1ft) and HHS per species and per flow are presented and described. Minimum suitable depths were based on communication with CPW and set as 0.5 feet

for all species (CPW personnel communication, 2025). HHS results are presented as WUA per species, per flow, and per site.

The two study sites, when viewed together, present a mosaic of instream habitat characteristics that represent the overall Shoshone Reach. Site 1 is 1,854 feet in length (River Restoration 2023). Site 2 is 1,830 feet in length (River Restoration 2025). The combined study sites' total length is 3,684 feet. Together, the study sites comprise 28.6% of the total Shoshone Reach.

4.4.1 Site 1

Site 1 is located roughly ½ mile downstream of the Shoshone Diversion Dam (Figure 4). Site 1 is discernable by two large pools divided by a riffle in the center of the site. Site 1 is narrower (e.g., floodplain width) than Site 2, with a defined channel flowing through the middle of the site. There is limited off-channel areas at Site 1. The two pools within Site 1 provide significant habitat for all species modeled, dependant on discharge and depth.

Site 1 Wetted Area

Wetted area increases with flow at Site 1. Minimum wet area within Site 1 occurs at a discharge flow of 50 cfs, with over 118,000 sq. ft. of linear wetted area per 1,000 ft. of stream (Figure 6). Maximum hydraulic modeled wetted area occurs at the highest flow, 3,000 cfs, and includes over 152,000 sq. ft. of wetted area per 1,000 ft. of stream (Figure 6). Although the adult fish species modeled do not use the entire wetted area, based on HHS criteria, wetted area below the adult species minimum suitability criteria provides food base (e.g., macro-invertebrate habitat when inundated for sufficient duration for colonization) and habitat for non-modeled life stages (e.g., juvenile). Wetted area extent is an important indicator of the overall stream habitat available to modeled species, potential habitat for non-modeled life stages, and stream life-cycle dynamics.

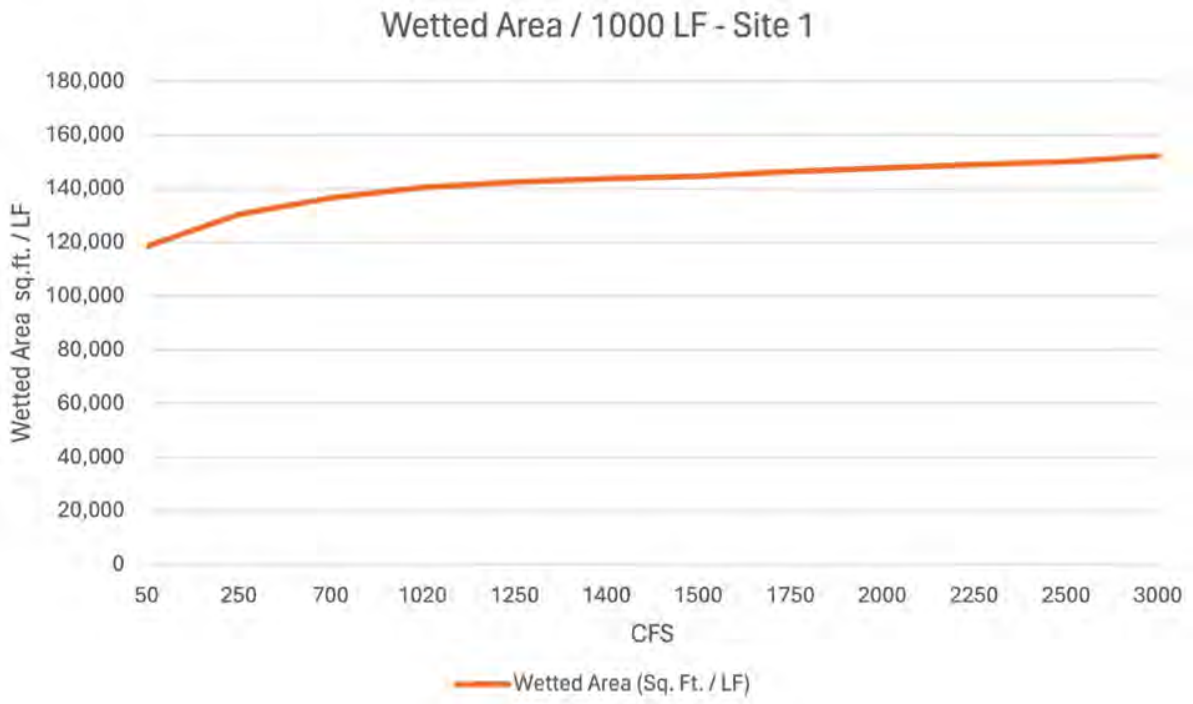


Figure 6. Site 1 Wetted Area Results, all Discharge (cfs) per 1,000 linear feet.

Site 1 WUA Results Per Species

The extent of suitable habitat per 1,000 feet of stream, per adult species modeled, defined as WUA, generally increases with flow at Site 1 (Figures 7, 8, 9, 10). Maximum WUA for Brown and Rainbow Trout occurs at 2,250 cfs (Figure 7 and Figure 8, respectively). As flow increases above 2,250 cfs the suitability of the habitat within the Shoshone Reach for trout species begins to plateau and slightly decline, thus slightly reducing the overall WUA. Adult Flannelmouth Sucker WUA increases from 50 cfs to 1,500 cfs (Figure 9). Above 1,500 cfs, habitat quality (HHS) begins to plateau and then decline as velocity and depth thresholds for the species reach maximum values. Mountain Whitefish maximum WUA occurs at 2,000 cfs at Site 1. Above 2,000 cfs, Mountain Whitefish habitat quality begins to plateau and then slightly decline, thus reducing the extent of WUA for the species (Figure 10). In summary, at Site 1, the extent of adult fish species suitable habitat generally increases with flow, even up to the higher discharges modeled for some species, while others experience a plateau and slight decline.

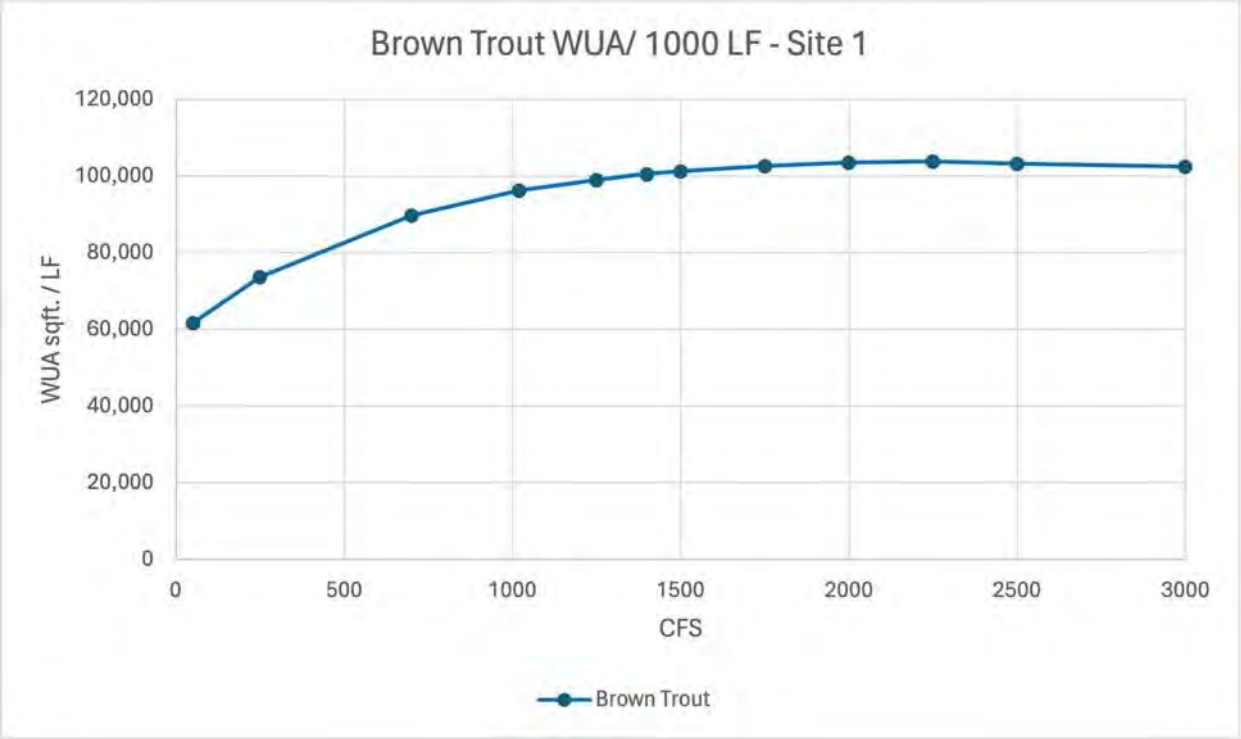


Figure 7. Weighted Usable Area per discharge flow (cfs) for Brown Trout at Site 1.

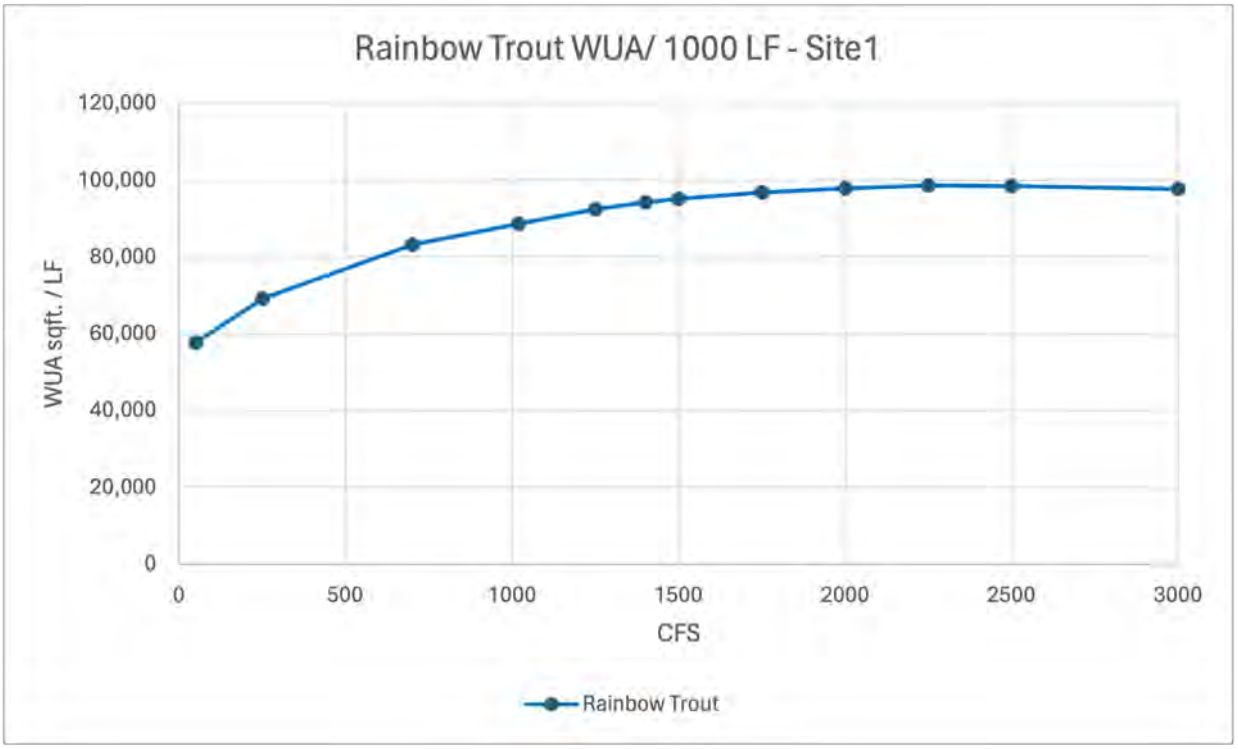


Figure 8. Weighted Usable Area per discharge flow (cfs) for Rainbow Trout at Site 1.

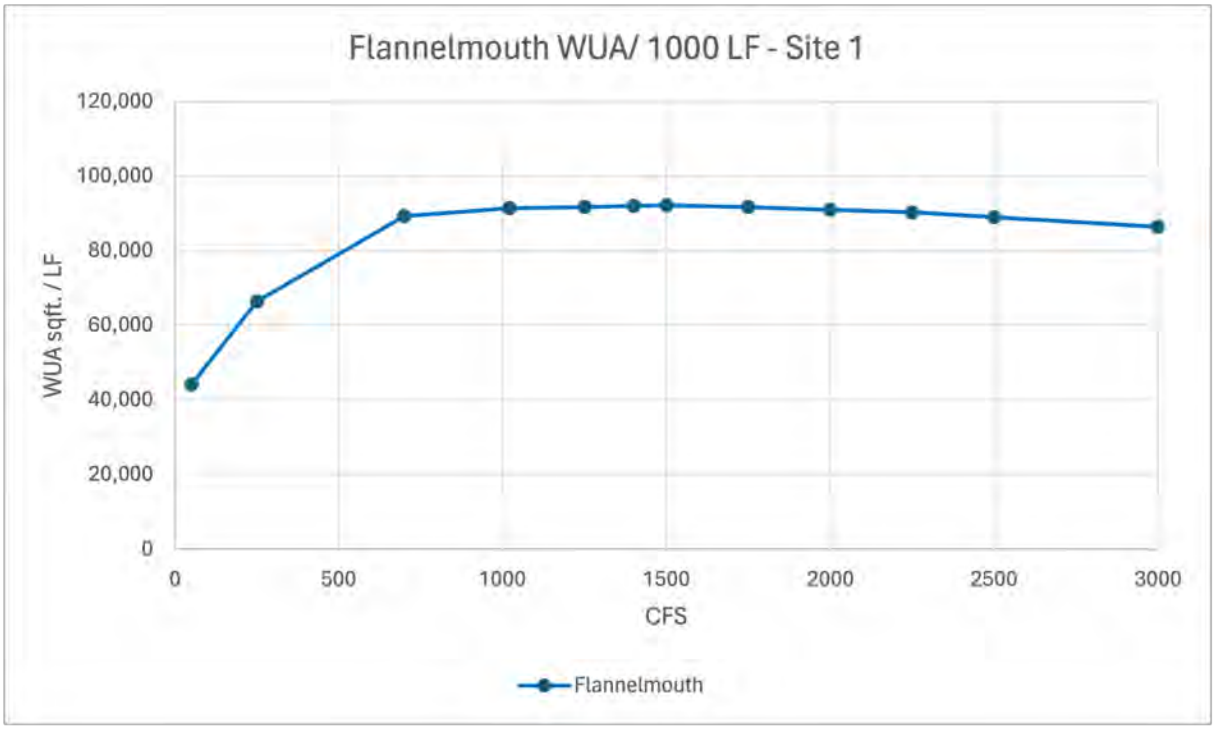


Figure 9. Weighted Usable Area per discharge flow (cfs) for Flannelmouth Sucker at Site 1.

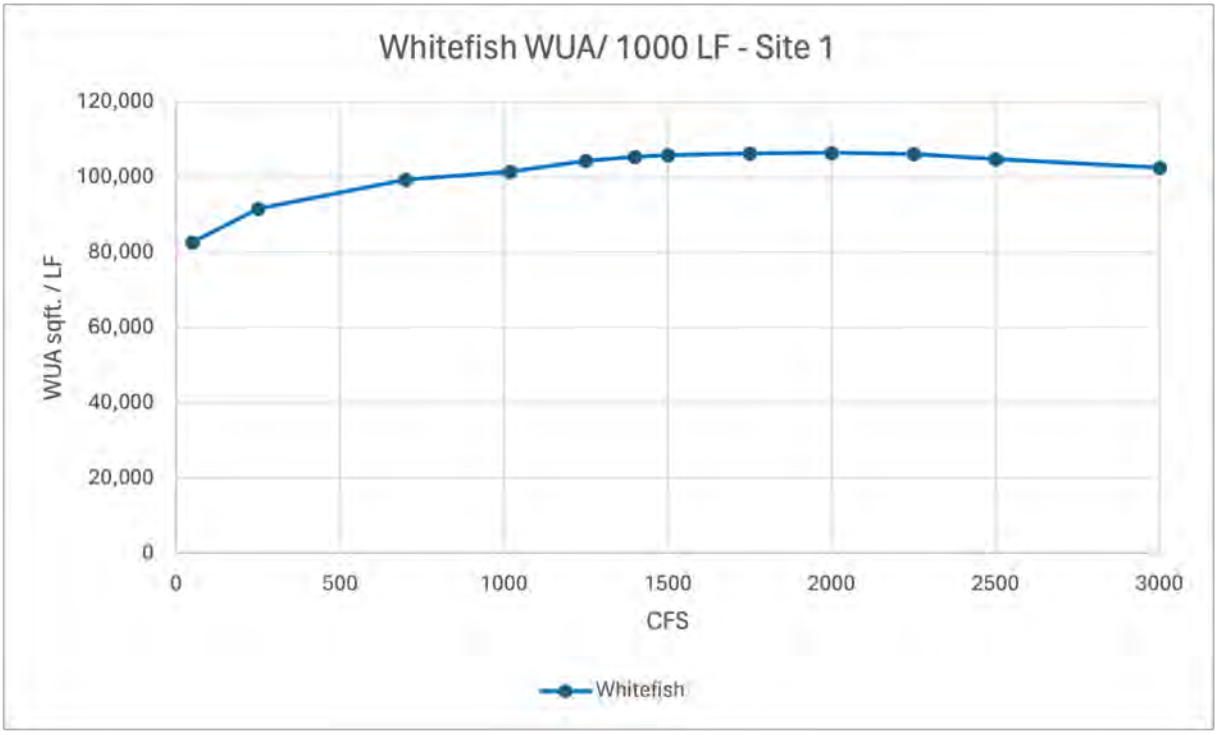


Figure 10. Weighted Usable Area per discharge flow (cfs) for Mountain Whitefish at Site 1.

4.4.2 Site 2

Site 2's floodplain is wider than Site 1's floodplain and provides a notable difference in overall riverine complexity. Site 2 includes two large islands that create a complex channel environment. Portions of the complex channel are wetted at different flows, creating a dynamic environment in which flow volume increases and previously dry areas (e.g., off-channel areas) become wetted and provide accessible habitat. This complexity offers different habitat availability for the four modeled species and demonstrates a diverse habitat (extent and quality) response to increased flows.

Site 2 Wetted Area

In Site 2, wetted area increases with increasing flow volume, like Site 1. However, the increase in wetted area is not as linear as at Site 1. For example, Site 2 wetted area increases significantly from 50 cfs to 250 cfs (Figure 11). Another significant wetted area increase occurs from 250 cfs to 700 cfs of discharge at Site 2 (Figure 11). Above 700 cfs, wetted area increases are similar to Site 1, with varying increases of generally less than 10,000 sq. ft. per 1,000 ft of stream occurring from 1,020 cfs to 3,000 cfs. The greatest wetted extent at Site 2 occurs at 3,000 cfs, with just over 160,000 sq ft of wetted area per 1,000 ft of stream (Figure 11). This is likely the result of high-flow channels being wetted.

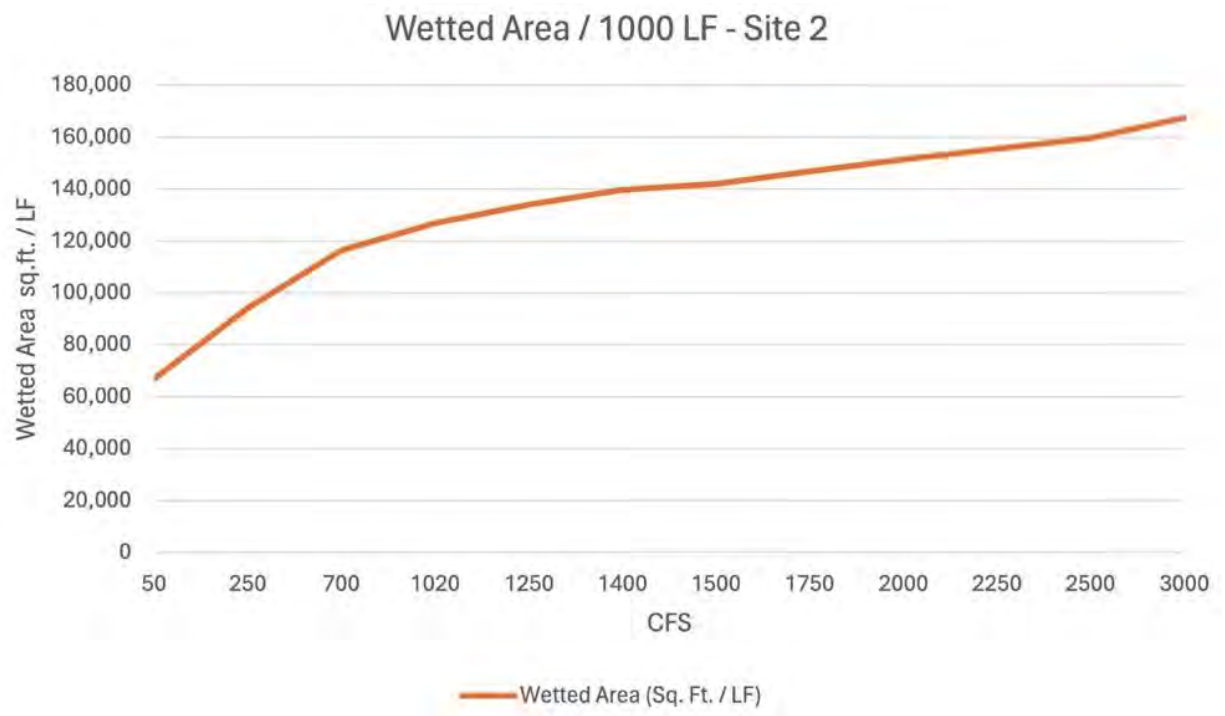


Figure 11. Site 2 Wetted Area Results, all Discharge (cfs) per 1,000 linear feet

Site 2 WUA Results Per Species

The extent of WUA per 1,000 feet of stream, per adult species modeled, increases with discharge flows at site 2 (Figures 12, 13, 14, 15). Noticeably, a large increase in WUA occurs for all species from 50 cfs to 700 cfs. Maximum WUA for Brown and Rainbow Trout occurs at 3,000 cfs (Figure 12 and Figure 13). There is a noticeable increase in WUA between 2,500 cfs and 3,000 cfs for Brown and Rainbow Trout at Site 2. While not modeled, this trend likely indicates that Trout species WUA would continue to increase at flows above 3,000 cfs (Figures 12 and 13).

Flannelmouth Sucker WUA at Site 2 increases up to 2,250 cfs, and plateaus as flows increase towards 3,000 cfs (Figure 14). Mountain Whitefish WUA over the range of flows modeled exhibits a similar curve as the trout species, with gains as flows increase (Figure 15). However, the slope of the Mountain Whitefish WUA curve, between 2,500 cfs and 3,000 cfs begins to plateau and levels off.

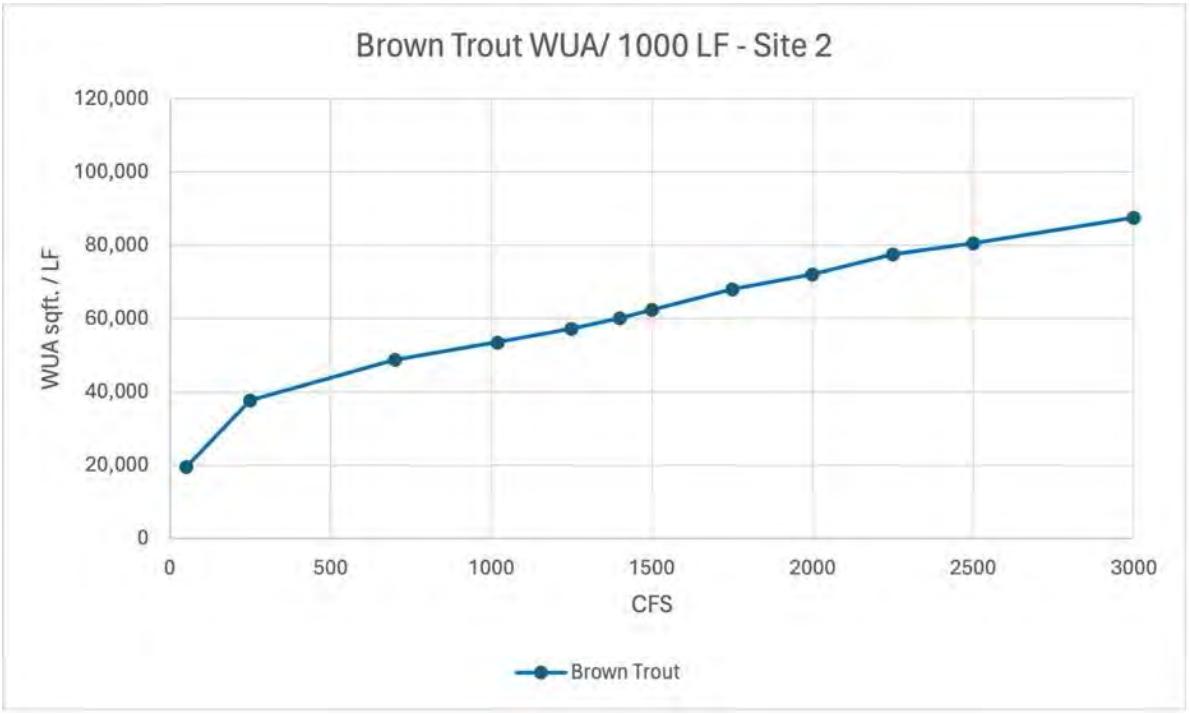


Figure 12. Weighted Usable Area per discharge flow (cfs) for Brown Trout at Site 2.

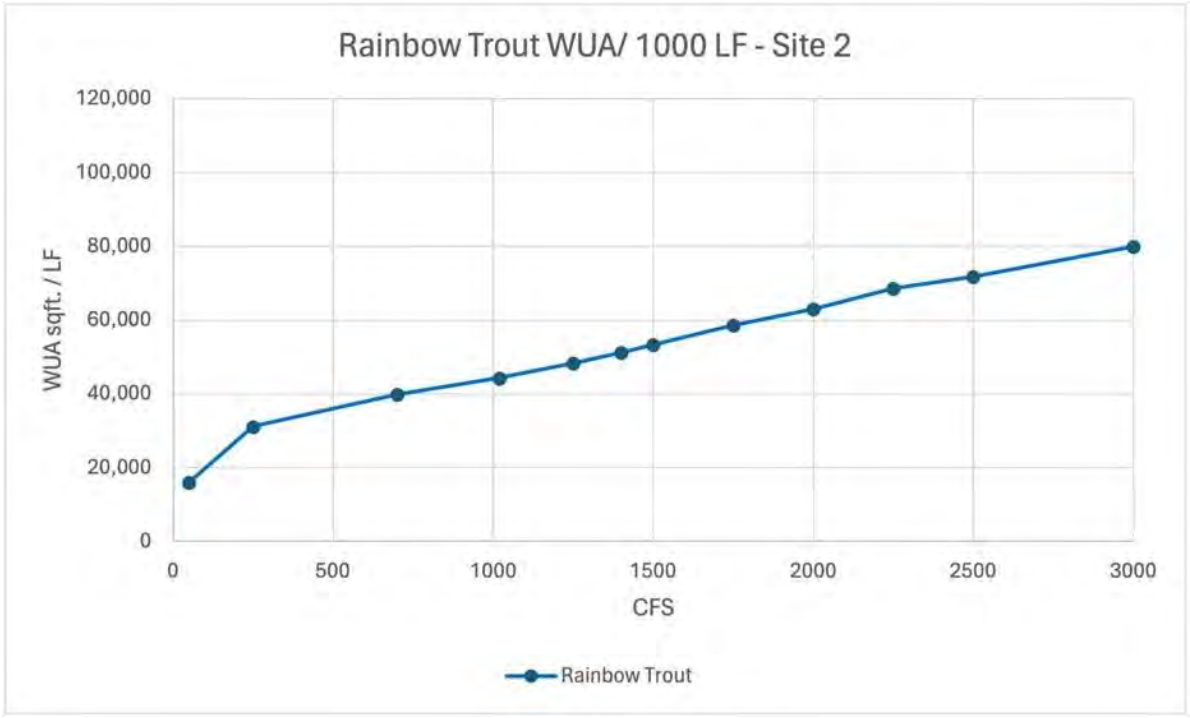


Figure 13. Weighted Usable Area per discharge flow (cfs) for Rainbow Trout at Site 2.

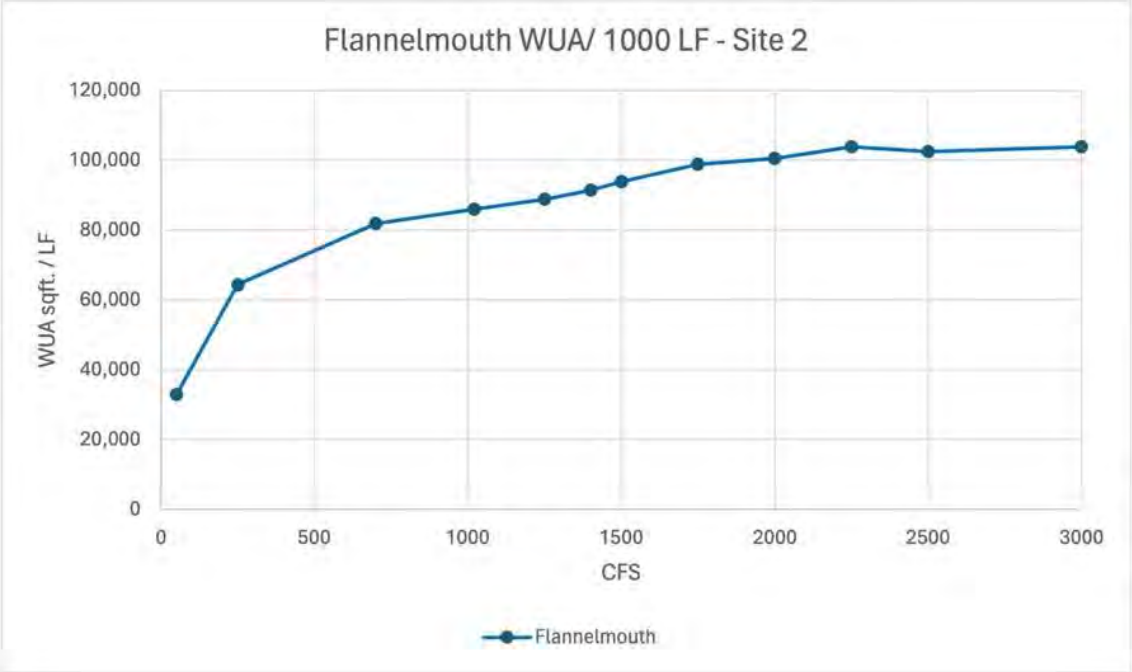


Figure 14. Weighted Usable Area per discharge flow (cfs) for Flannelmouth Sucker at Site 1.

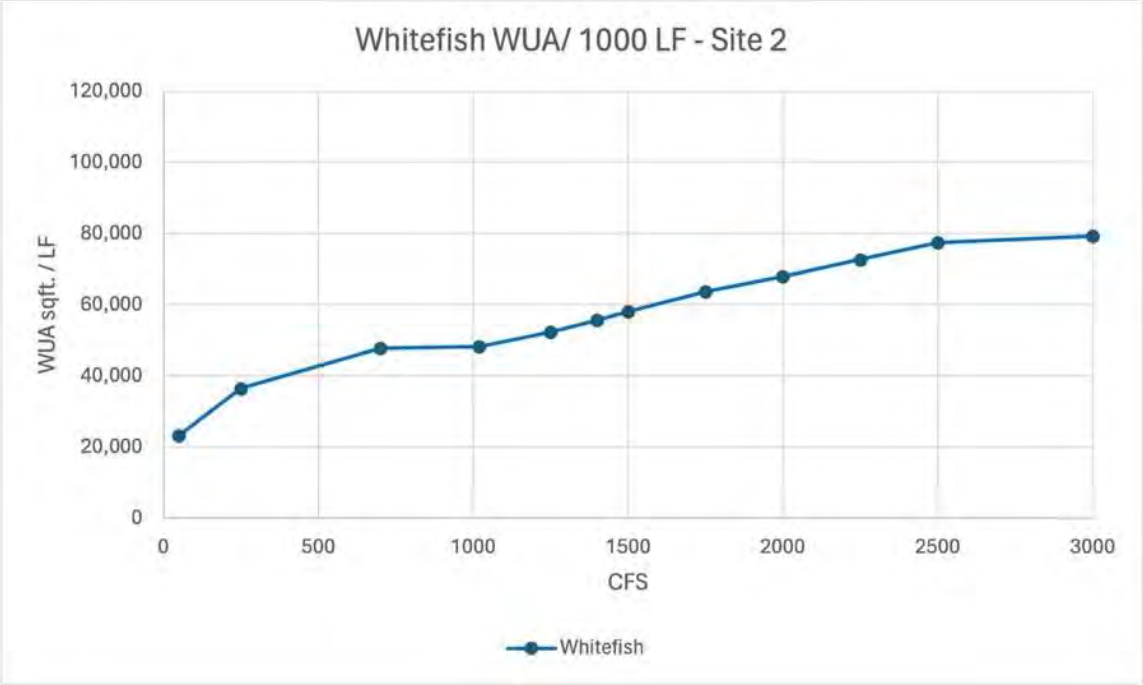


Figure 15. Weighted Usable Area per discharge flow (cfs) for Mountain Whitefish at Site 2.

Visual HHS Results Site 1 and Site 2

Appendix A includes visual layouts of results for each study site reach with flow model and WUA charts (Figures A1-A18, Appendix A).

5.0 DISCUSSION AND CONCLUSION

5.1 DISCUSSION

Hydraulic Habitat Suitability and Wetted Area

The hydraulic suitability results from the expanded IFIM analysis provide useful insights into how varying flow regimes influence habitat quality and availability within the Shoshone Reach of the Colorado River. At Site 1, WUA generally increases with flow, peaking at approximately 2,000 cfs, dependent on species. Beyond this range, suitability scores plateau and slightly decline at maximum discharge flows, primarily due to reductions in velocity suitability. Despite this plateau or slight decline in suitability scores at the highest discharge flows, the wetted area continues to increase, providing additional habitat that helps offset minor reductions in overall hydraulic habitat suitability that is observed beyond and at the higher range of discharge flows. Additionally, the two large pools at Site 1 provide quality habitat for all fish species.

In comparison, WUA at Site 2 continues to improve as flows increase through higher discharge flow scenarios up to the highest modeled flow of 3,000 cfs. This outcome is likely due to the greater habitat complexity at Site 2, which provides a diverse array of hydraulic conditions and microhabitats throughout all flows. For example, wetted area at Site 2 almost doubles from 50 to 700 cfs and continues to increase steadily up to the highest flow modeled. Features such as large boulders, cobble substrates, an island complex, and deep pools contribute to a wider range of depth and velocity conditions, as compared to Site 1, that remain suitable for fish across a broader range of flows. These instream structural attributes not only enhance habitat suitability but also provide critical velocity refuges and feeding zones during high flows in high gradient reaches, further supporting both the modeled and other aquatic species. For example, Brown and Rainbow trout WUA continues to increase at the highest modeled flows (e.g., 2,500 and 3,000 cfs), while Mountain Whitefish and Flannelmouth Sucker WUA plateaus at similar modeled discharges.

The geomorphic characteristics of Site 2 also play a significant role in shaping the hydraulic responses to increasing flows. Site 2's physical diversity promotes steady increase in WUA as flows increase, avoiding the leveling off and slight declines in velocity suitability observed at Site 1. This enhanced connectivity between habitats allows fish to exploit newly wetted areas that are unavailable under lower flow conditions. The expansion of wetted area at higher flows further supports primary (e.g., algae) and secondary (e.g., aquatic macroinvertebrate) production, both of which form the foundation of the river's food web.

The site-specific differences observed in the analysis illustrate the critical role of local channel morphology in shaping hydraulic conditions and habitat availability. These results highlight the ecological benefits of the Shoshone Reach's physical heterogeneity in supporting a range of flows for multiple species.

Although hydraulic suitability scores are a valuable tool for evaluating relative habitat quality, they likely underrepresent the ecological benefits of increased flows for fish and other aquatic species within high gradient, confined canyon reaches like the Shoshone Reach. The abundant velocity refuges created by large boulders and cobble substrates provide microhabitats that are not fully captured in the two-dimensional hydraulic model. These microhabitat pockets, located behind large boulders and cobble substrate, offer shelter for fish, particularly during high flows, reducing the energetic costs of maintaining instream position while also providing foraging opportunities along velocity seams. While the hydraulic model used in this assessment effectively quantifies depth and velocity relationships, it does not account for the influence of substrate and cover

features on microhabitat diversity, or geomorphic benefits of higher flows including flushing fine sediment, maintaining habitat diversity, and recruitment of wood and organics.

The HHS results emphasize the ecological benefits of higher flows within the Shoshone Reach. While flows in the range of 1,500 to 2,250 cfs maximize hydraulic habitat suitability for modeled species at Site 1, the continued increase in wetted area at higher flows supports expanded habitat availability and off-channel (not wetted at lower flows [e.g., under 700 cfs]) connectivity, particularly in reaches with greater habitat complexity, such as Site 2. Higher flow conditions, particularly at Site 2, benefit fish populations and broader aquatic ecosystems by enhancing habitat diversity (e.g., wetting off-channel areas with higher flows) and supporting critical ecological processes.

Microhabitat Features and Interstitial Space

Fish microhabitat use involves interactions of habitat features, behavior, and ecology. Trout benefit from large substrates like boulders and cobbles, which provide shelter, foraging opportunities, and refuge from strong currents. Trout prefer lower flow areas but utilize faster currents as needed. Riffles are essential for food production. Species like Brown and Rainbow Trout favor complex substrates in high-gradient streams for predator evasion and efficient feeding. They seek refuge in areas with slower water and adjust their positions based on flow conditions. The riverbed's stability during high flows can influence available trout refuges.

The influence of hydraulic conditions on habitat selection is significant. Studies have shown that adult Brown Trout can occupy microhabitats with relatively high stream velocities, although juveniles typically favor lower velocities (Raleigh et al., 1984 & 1986). Additionally, the availability of cover, such as woody debris and boulders, plays a critical role in habitat selection, providing both protection from predators and a reliable environment for feeding and growth (Ayllón et al., 2008). The interaction between flow regimes and habitat use is essential for understanding trout behavior in high-velocity rivers. Research indicates that trout from rivers with highly irregular flow patterns are more adaptable and willing to shift habitats compared to those in stable environments (Ayllón et al., 2013). This adaptability is vital for their resilience in fluctuating habitats, allowing them to exploit spatially distinct refugia during periods of high flow (Ayllón et al., 2013). The presence of these substrates can significantly influence the distribution and abundance of trout populations. For example, studies have shown that juvenile trout often seek shelter in boulder-sheltered positions, while older individuals may prefer visually isolated areas along river margins (Ayllón et al., 2008; Ayllón et al., 2010). This behavior is particularly pronounced in high-velocity environments, where the risk of displacement is greater, and the availability of refuge is critical for survival.

The instream microhabitat use by trout in high-velocity rivers is shaped by a multitude of factors, including physical habitat characteristics, hydraulic conditions, behavioral adaptations, and ecological interactions. The presence of interstitial spaces and large substrates plays a pivotal role in providing refuge and foraging opportunities.

Aquatic Invertebrates

A variety of macroinvertebrate species inhabit the Glenwood Canyon. These and other aquatic invertebrates provide important high value food sources for resident fish, birds, and bats and are an important component of the riverscape food web. Flow management is a critical determinant of macroinvertebrate community health. Research shows that reductions in instream flow can lead to increased sedimentation, elevated water temperatures, and lower dissolved oxygen levels, all of which can stress or exclude sensitive taxa like EPT (Poff et al., 1997; Biaou et al., 2024). Conversely, restoring and maintaining adequate instream flows and natural hydrograph

characteristics can enhance habitat conditions, water quality, and promote macroinvertebrate production. Scenario 2, Future with Permanency, would provide reliable flows that support a healthy macroinvertebrate community within the Shoshone Reach. Reliable annual flow would not only enhance the Shoshone Reach's overall ecological value, but potentially support a fishery on par with other world-renowned fisheries. Reliable annual flow volumes, like those proposed in Scenario 2, Future with Permanency, would promote resilient macroinvertebrate communities, supporting a thriving aquatic food web, and improve the Shoshone Reach capacity to function as a healthy fishery.

Fishery

Fish access the Shoshone Reach for seasonal movements, foraging, reproduction, and refuge. Its complex streambed creates microhabitats that provide shelter and feeding opportunities. The reach features both high-gradient and low-gradient areas, allowing fish to move between different velocity zones, enhancing passage and supporting various species.

In flow Scenario 2 (Future with Permanency), the habitat suitability in the Shoshone Reach is higher more often compared to Scenario 1 (Baseline) and Scenario 3 (Future without Permanency). This is because the water flows in this reach would more frequently fall within a higher HHS range for longer durations particularly in the later summer to fall period. The reliable annual flows provided under Scenario 2 (Future with Permanency) would also alleviate the stresses associated with habitat fragmentation that occurs at low flows and when water is diverted to support hydropower operations. Habitat fragmentation occurs when flow is insufficient to provide the depth required for fish species to be able to migrate between habitats. Habitat fragmentation is a common occurrence under existing conditions and can lead to fish kills (personal communication CPW, 2025). If fish get stranded in pools and air temperature and stream temperatures are elevated fish become stressed. This condition has led to CPW calling for salvage operations in the Shoshone Reach (personal communication CPW, 2025). Under Scenario 2 (Future with Permanency) salvage operations in the Shoshone Reach would be unlikely.

Summer Stream Temperatures & Winter Habitat

Preserving and improving the natural environment in the Shoshone Reach by providing reliable instream flow is likely to help regulate water temperatures, particularly during the summer months and early fall when ambient air temperatures are high, and warm spring inputs have the potential to elevate water temperatures. This reach of the Colorado River is listed as impaired for temperature under Section 303(d) of the Clean Water Act, suggesting that elevated temperatures may be affecting aquatic life. Higher flows can help buffer temperature fluctuations by increasing thermal mass and promoting greater mixing, potentially reducing the likelihood of localized thermal spikes. Additionally, increased flow volumes are likely to mitigate the influence of warm groundwater or thermal hot spring inputs by dispersing heat more effectively throughout the water column. Temperature regulation is particularly important for cold-water species such as Mountain Whitefish, Rainbow Trout, and Brown Trout, which are sensitive to thermal stress. Sustaining higher flows through the Shoshone Reach provides important thermal refugia for fish and other aquatic organisms, supporting overall ecosystem health and resilience in the face of warming trends and increasing climatic variability. Based on the three flow scenarios, Scenario 2 (Future with Permanency) would result in increased flows during these critical months compared to Scenarios 1 or 3. Critical flow periods in the Shoshone Reach are late summer (August) through fall (October), when stream flow is often low and ambient air temperatures and solar input is high.

Instream flows during the winter months could improve habitat conditions by increasing wetted area and enhancing holding and foraging opportunities for fish. At unnaturally low winter flows

when most, if not all, of the river flow is diverted through the penstocks, habitat availability can become significantly constrained, limiting the space available for fish to occupy and potentially increasing competition for resources. Additional flow would provide greater access to deep pools, velocity refuges, and complex habitat features, which are critical for fish survival during winter when metabolic rates are lower, and energy conservation is essential. By maintaining even modest instream flows (greater than 1,020cfs), the Shoshone Reach may support habitat complexity and improve overwinter survival rates, contributing to overall fish population stability and resilience.

5.2 CONCLUSION

The instream flow use of the Shoshone Water Rights will preserve and improve flow conditions through the Shoshone Reach and would provide direct ecological benefits by increasing aquatic habitat, fostering connectivity, and supporting primary and secondary production. The proposed instream flow uses within this reach would help regulate stream temperatures, maintain habitat complexity, and enhance the availability of critical refuges for fish, particularly during seasonal low-flow periods.

The assessment's key conclusion, which is the Shoshone Water Rights applied as an instream use would preserve and improve the ecological condition of the Shoshone Reach, is backed by habitat modeling results from two sites in the Shoshone Reach. HHS scores, WUA, and wetted area increase with flow. The complexity of the habitat—featuring boulders, cobble substrates, islands, and deeper pools—creates diverse conditions that support fish habitat for all species at various flow levels, providing critical refuges and feeding zones. The trends of the two sites differ in overall habitat suitability due to their physical diversity. However, both sites provide suitable habitat for all species upwards of 1,500 cfs and above, underscoring the ecological benefits of permanent instream flows in the Shoshone Reach. The velocity refuges formed by boulders and cobble, which are often underrepresented in habitat suitability curves, provides essential microhabitats for several the fish species modeled. Indeed, higher flows enhance availability of wetted area and habitat connectivity (Site 2 specifically), benefiting fish populations and aquatic ecosystems overall.

Although HHS scores are useful in characterizing immediate and direct benefits to fish, they do not evaluate the ecological advantages of increased flows to habitat maintenance and water quality. The reliable annual flows provided by the Shoshone Water Rights, applied to instream use, would provide channel forming and water quality (primarily temperature) benefits that are not being realized under current conditions.

Under the proposed permanent instream flow scenario (Scenario 2, Future with Permanency) with preservation of the Shoshone Water Rights, HHS for fish in the Shoshone Reach would be higher more frequently (and therefore a greater WUA sq. ft./1,000 LF). Flow levels would more often remain within a high suitability range for extended periods and would provide greater flow during the critical late summer and early fall seasons when temperatures and other stressors are at their peak. The assessment's findings indicate that the use of the Shoshone Water Rights for instream flow would preserve and improve the natural environment of the Shoshone Reach up to the highest evaluated discharge of 3,000 cfs. This is demonstrated by Scenario 2 (Future with Permanency) as it would provide the most habitat on an average annual basis when compared to Scenario 1 (Baseline) or Scenario 3 (Future without Permanency). Further, Scenario 2 (Future with Permanency) would provide added habitat during critical late summer and early fall time periods when fish are more likely to be stressed by low flows and elevated temperatures.

The two study sites cover a mosaic of instream habitat characteristics that represent the overall Shoshone Reach. The diverse geomorphic features of both locations create a variety of flow conditions, which enhance habitat complexity, an essential factor for fish survival. The hydraulic connectivity between the sites enables fish to access newly wetted areas and different habitats under varying flow conditions.

At the same time, the Shoshone Water Rights provide benefits that extend beyond their immediate area. The Shoshone Water Rights would preserve flows necessary to support upstream and downstream ecosystems and will improve conditions dramatically within the Shoshone Reach. The Shoshone Water Rights strengthen regional economies by supporting outdoor recreation and tourism, while also playing a role in securing downstream water deliveries. As competition for water resources in the Colorado River Basin continues to intensify, the preservation of the Shoshone Reach Water Rights is a key strategy for balancing environmental and economic needs across the region while also maintaining the ecological integrity of the Shoshone Reach itself.

These water rights, if made permanent through the introduction of an alternate use for instream flow purposes, would preserve and improve the Shoshone Reach's natural environment. Without them, the river could experience rising temperatures, habitat degradation, and declining fish populations. The Shoshone Water Rights are an important factor for the survival and resilience of fish populations, the integrity of aquatic and terrestrial (i.e., riparian) habitats, and the long-term health of the Colorado River. A vital component of all aquatic systems is a connection to requisite resources throughout the year that supports all life-stages and strategy needs (food, clean water, velocity break, feeding zones, spawning habitat, etc.). The Shoshone Water Rights employed for in-stream use would provide a reliable and ecologically meaningful year-round flow that would support all aquatic species in the Shoshone Reach.

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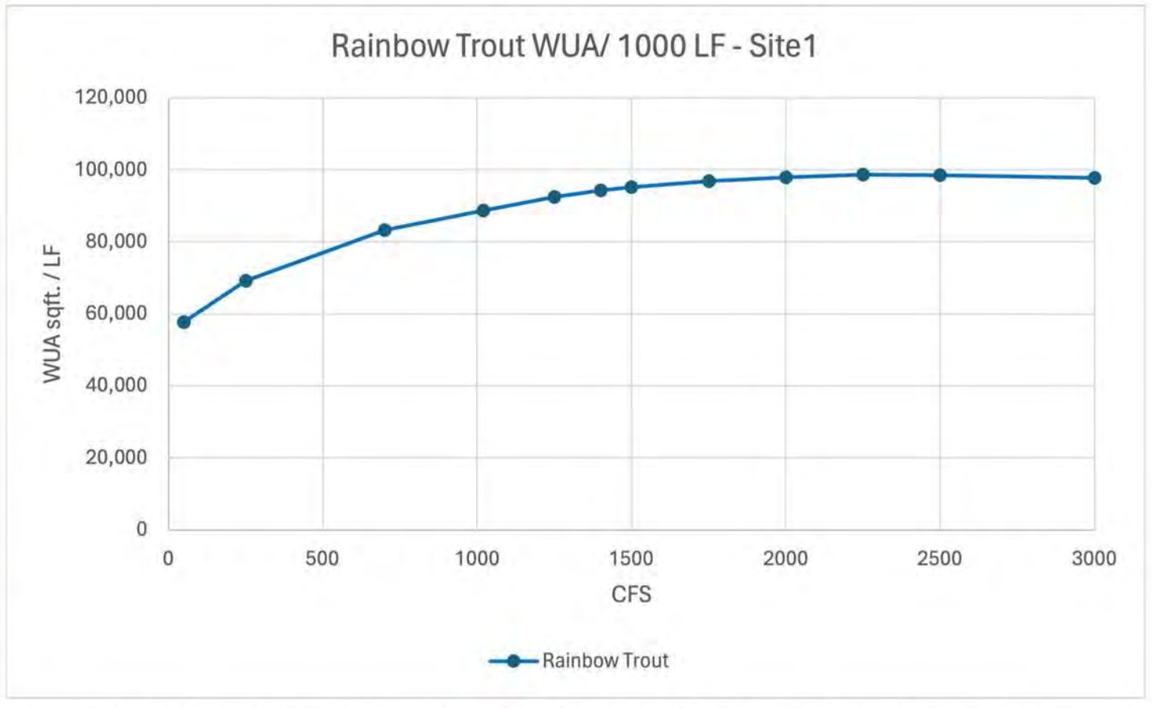
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APPENDIX A - Hydraulic Habitat Suitability Results, Maps and Weighted Useable Area Graph





Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Rainbow Trout at Site 1 per Discharge (cfs).

Figure A-1: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Rainbow Trout

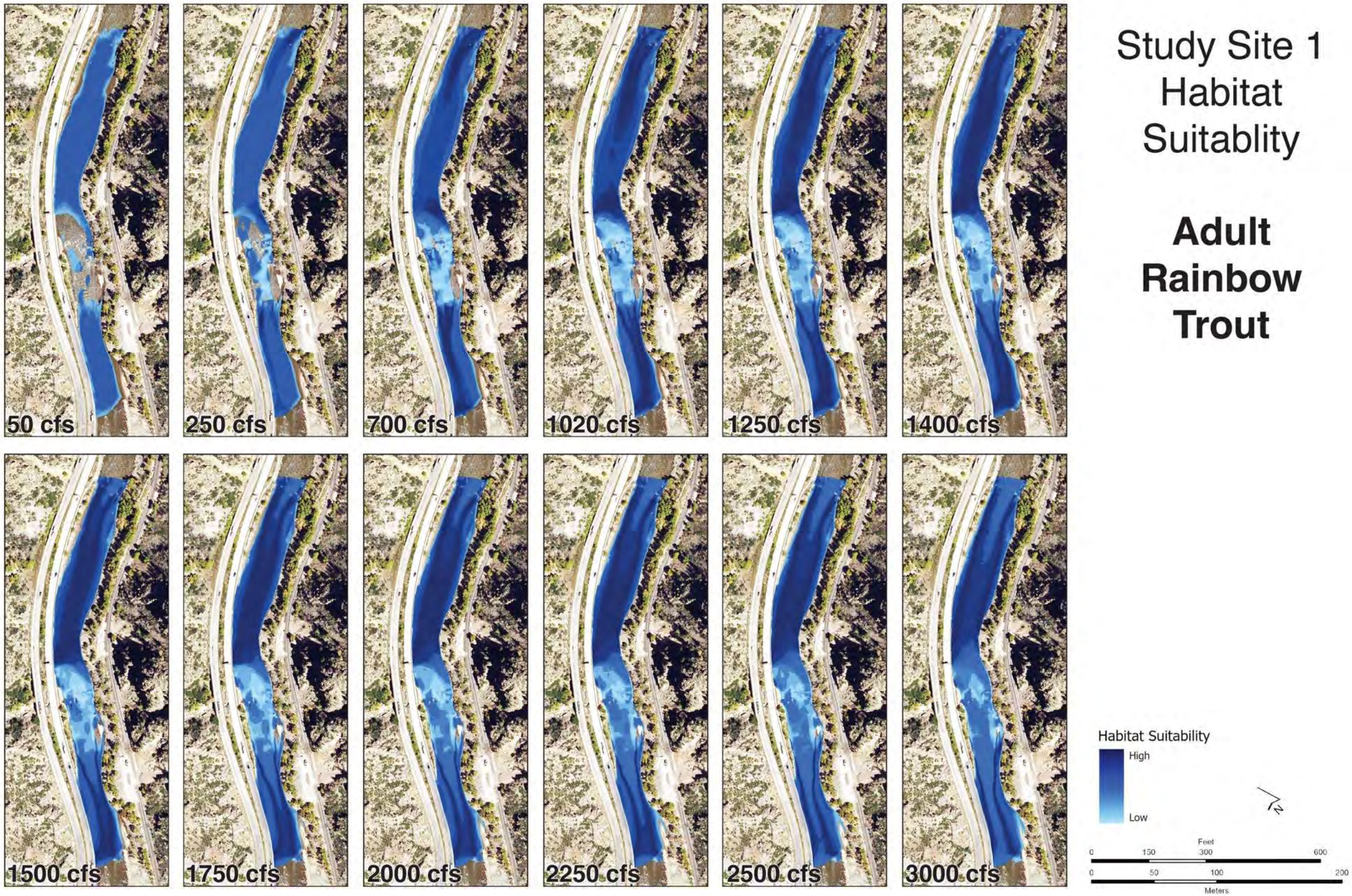
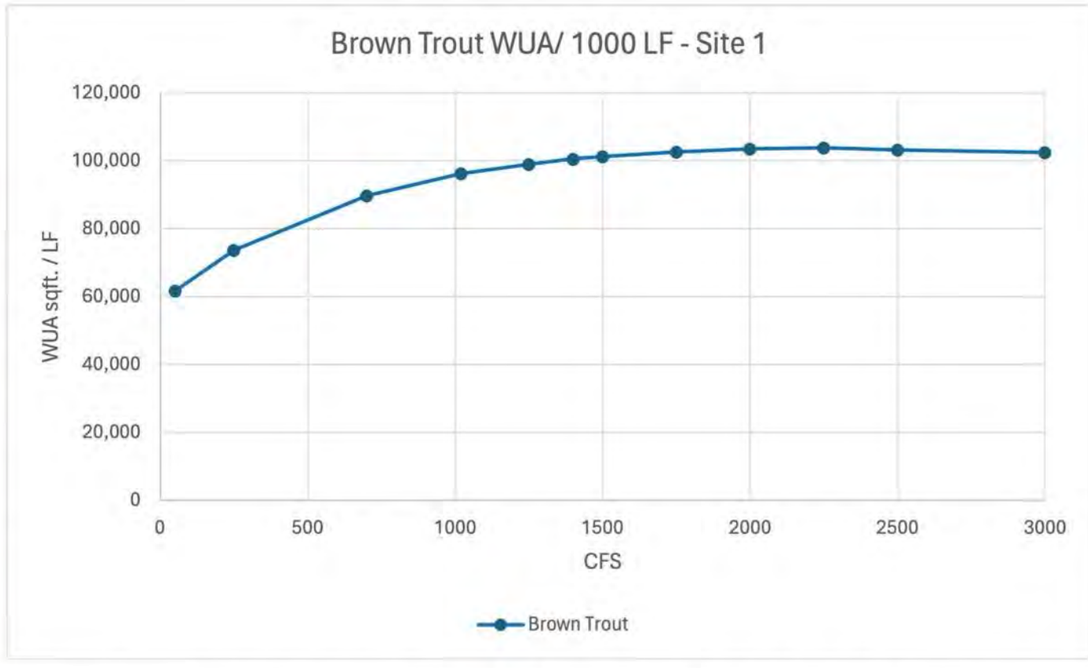


Figure A-2: Study Site 1 - Adult Rainbow Trout HHS Maps per Flow (cfs)





Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Brown Trout at Site 1 per Discharge (cfs).

Figure A-3: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Brown Trout

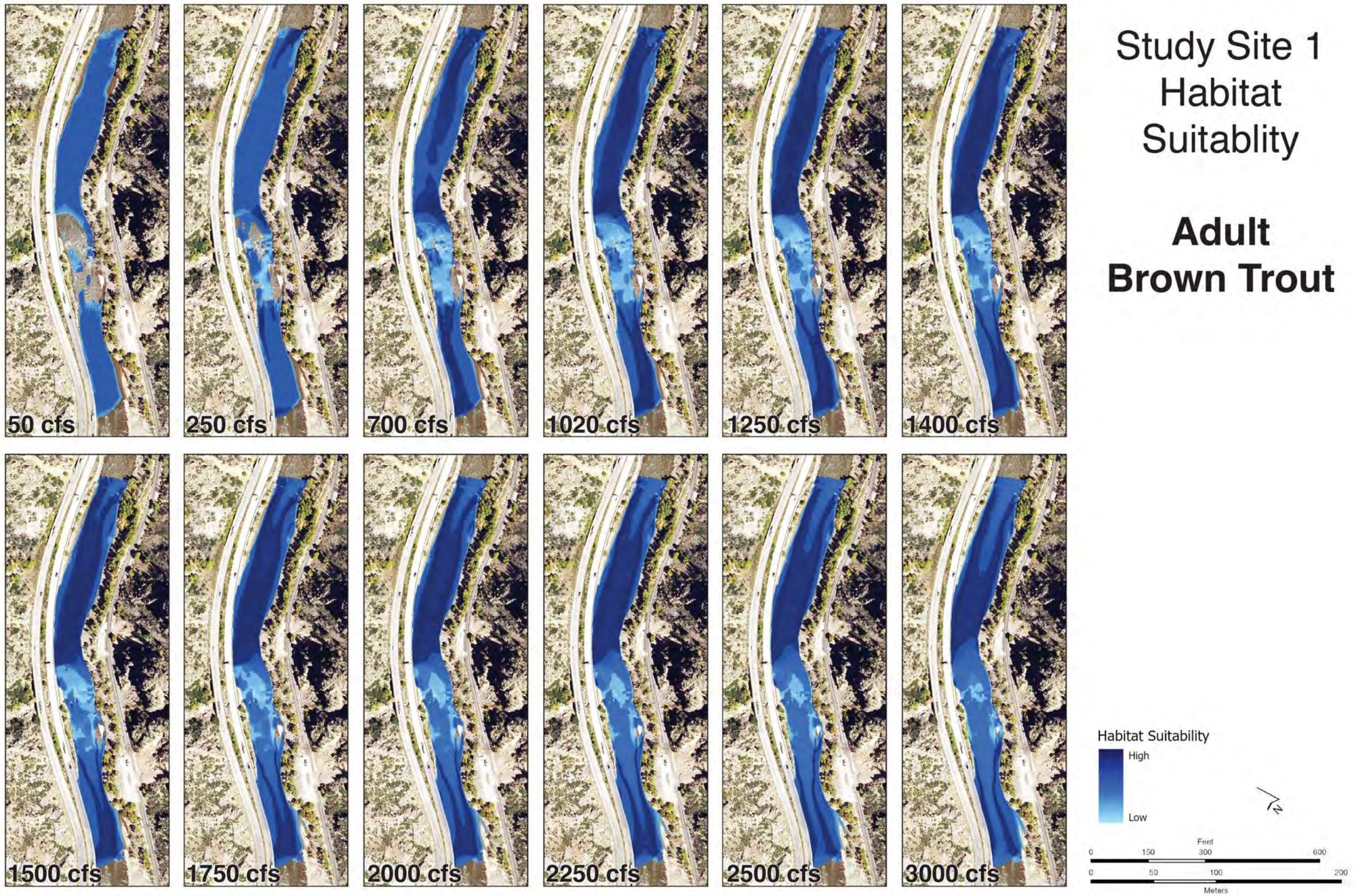
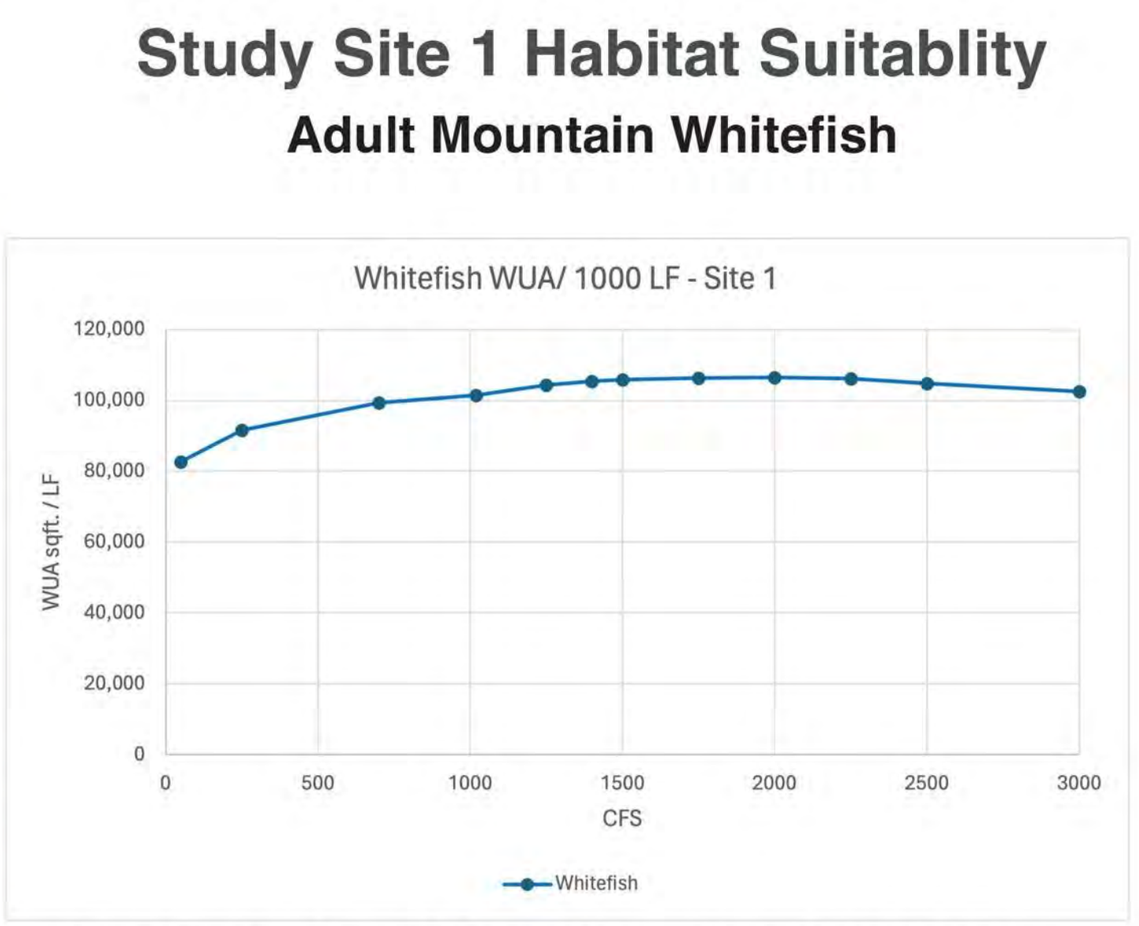


Figure A-4: Study Site 1 - Adult Brown Trout HHS Maps per Flow (cfs)





Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Mountain Whitefish at Site 1 per Discharge (cfs).

Figure A-5: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Mountain Whitefish

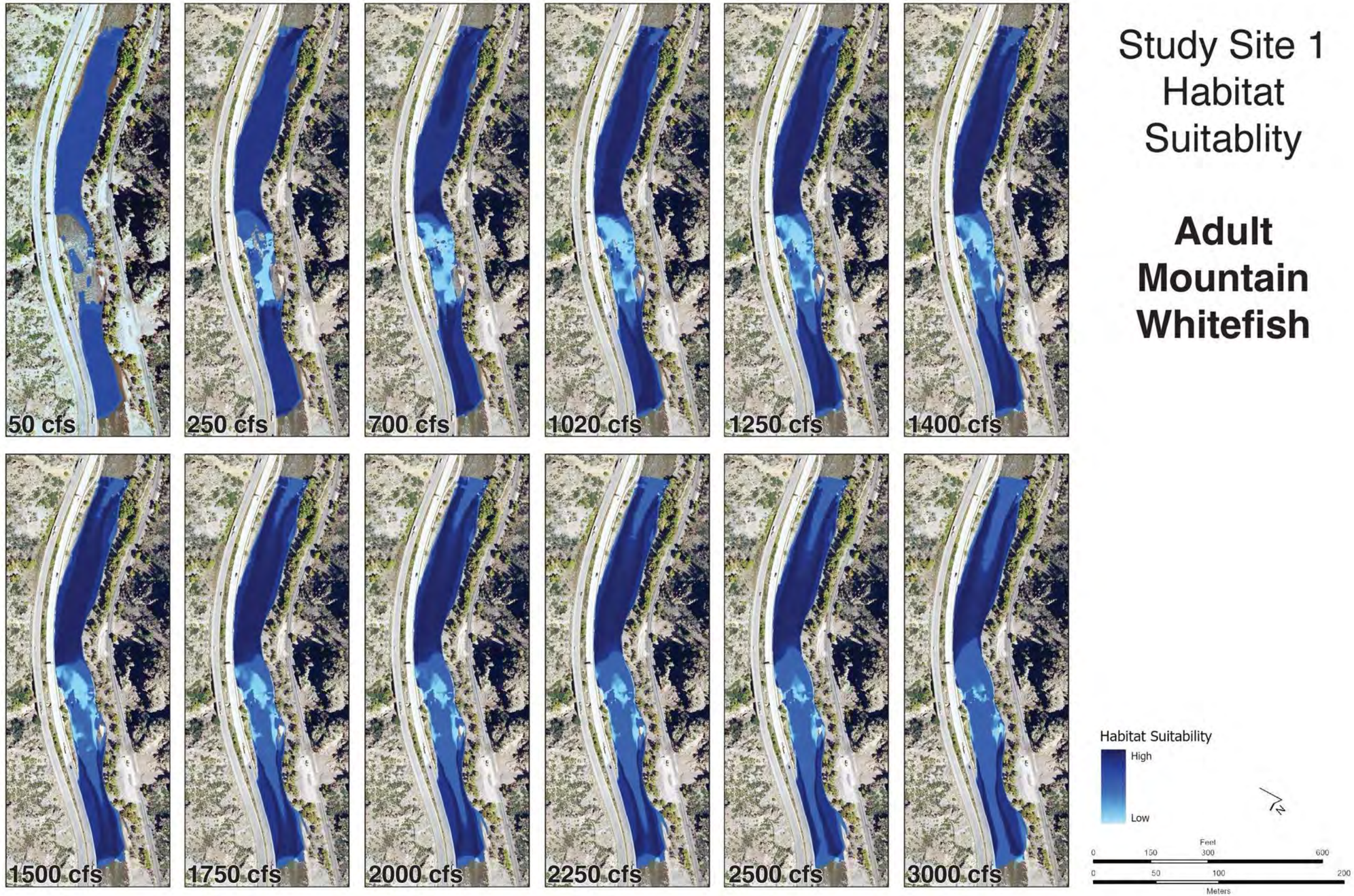
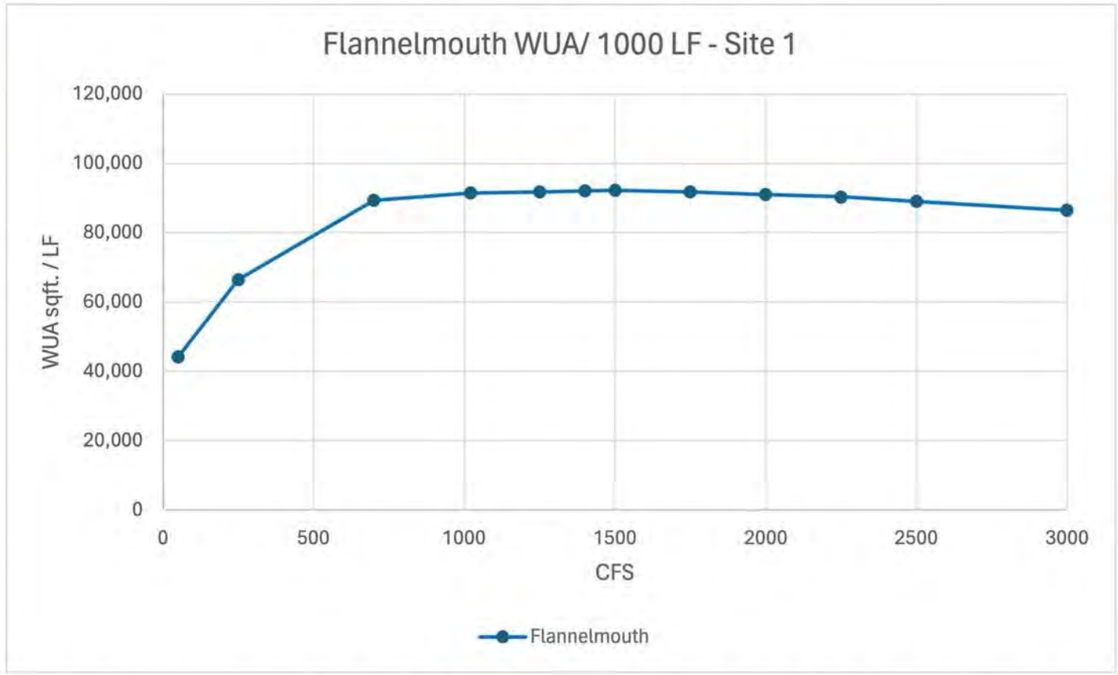


Figure A-6: Study Site 1 - Adult Mountain Whitefish HHS Maps per Flow (cfs)



Study Site 1 Habitat Suitablity

Adult Flannelmouth Sucker



Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Flannelmouth Sucker at Site 1 per Discharge (cfs).

Figure A-7: Study Site 1 - Hydraulic Habitat Suitability and WUA Adult Flannelmouth Sucker

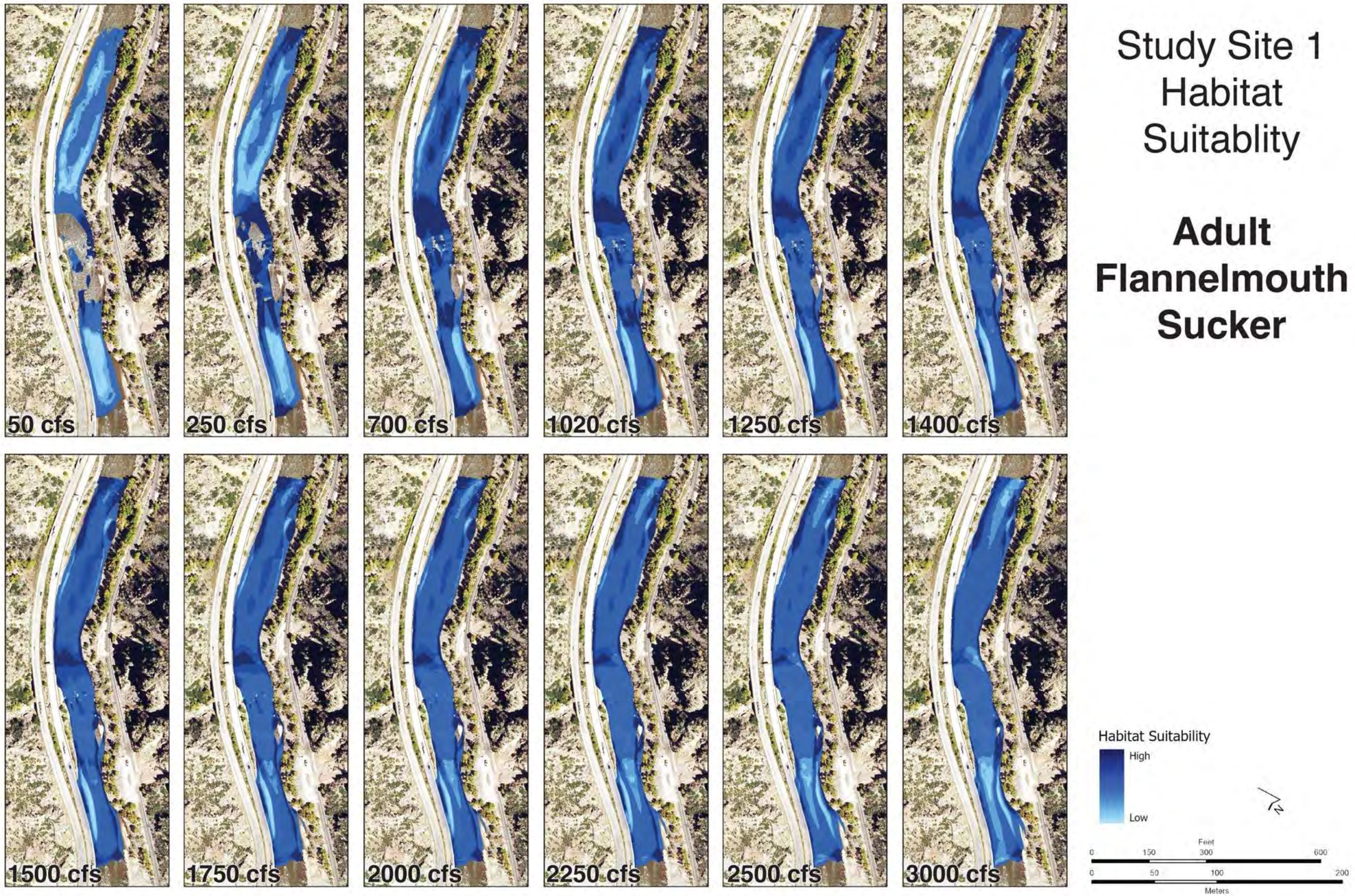
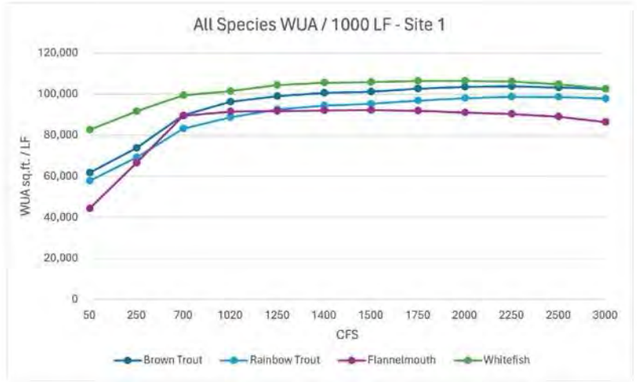
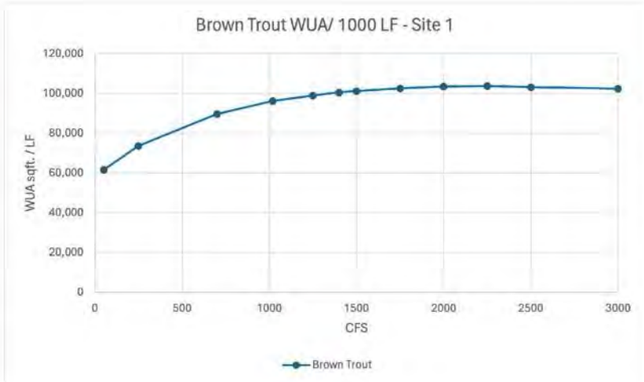
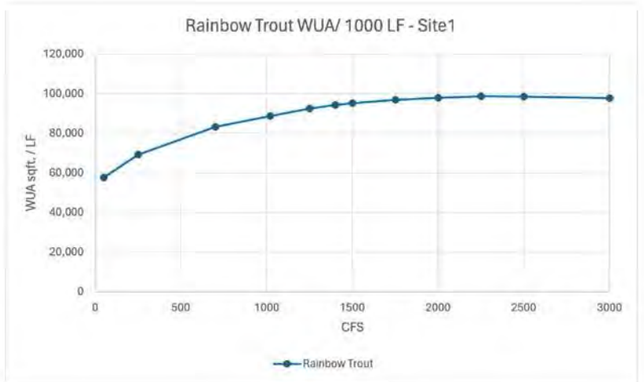


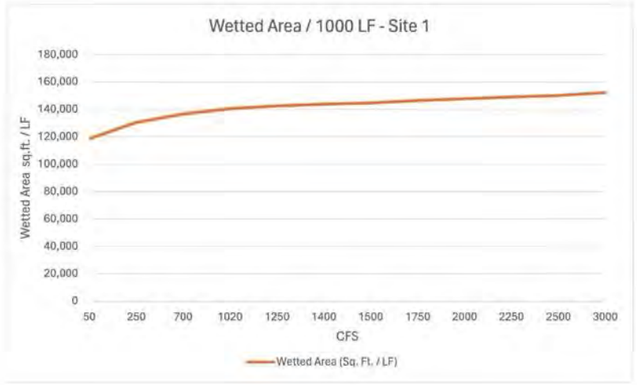
Figure A-8: Study Site 1 - Adult Flannelmouth Sucker HHS Maps per Flow (cfs)

Study Site 1 Habitat Suitablity

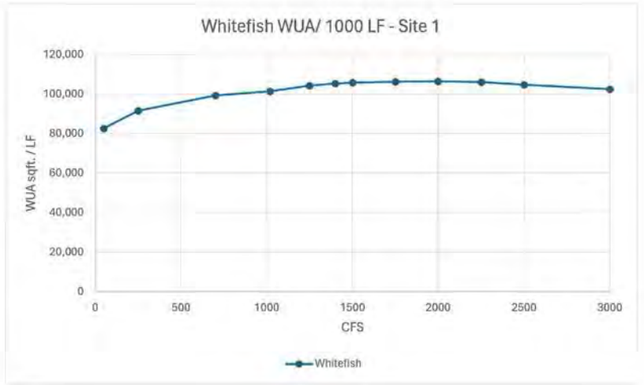








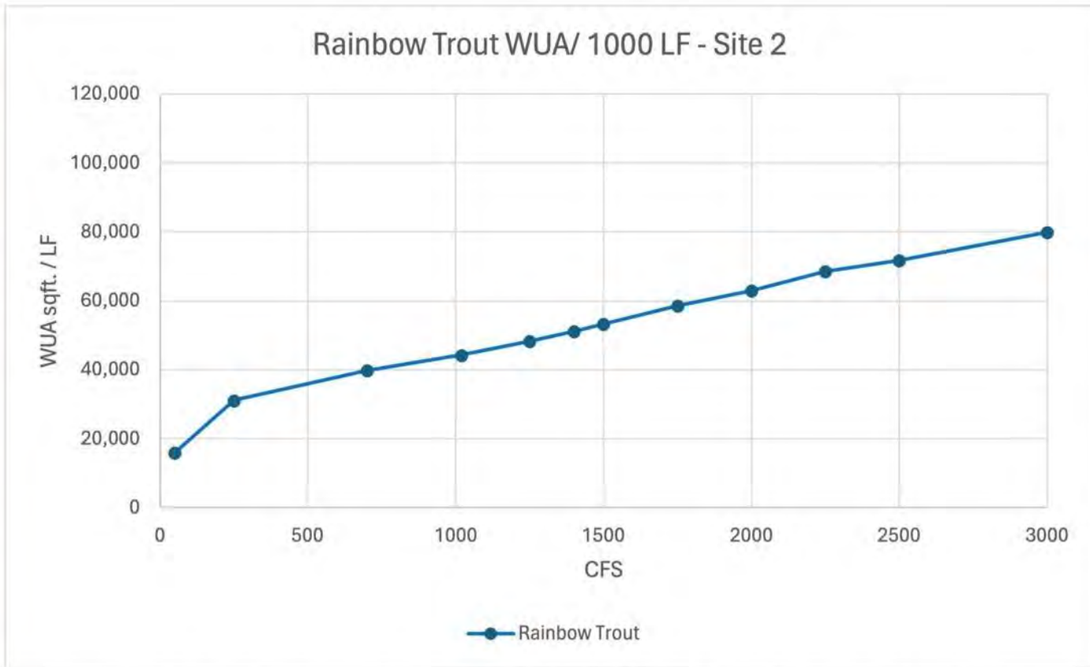




Graphs of Weighted Useable Area (WUA Sq. Ft. / LF.) for all species at Site 1 per Discharge (cfs).

Figure A-9: Study Site 1 - WUA All Species





Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Rainbow Trout at Site 2 per Discharge (cfs).

Figure A-10: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Rainbow Trout

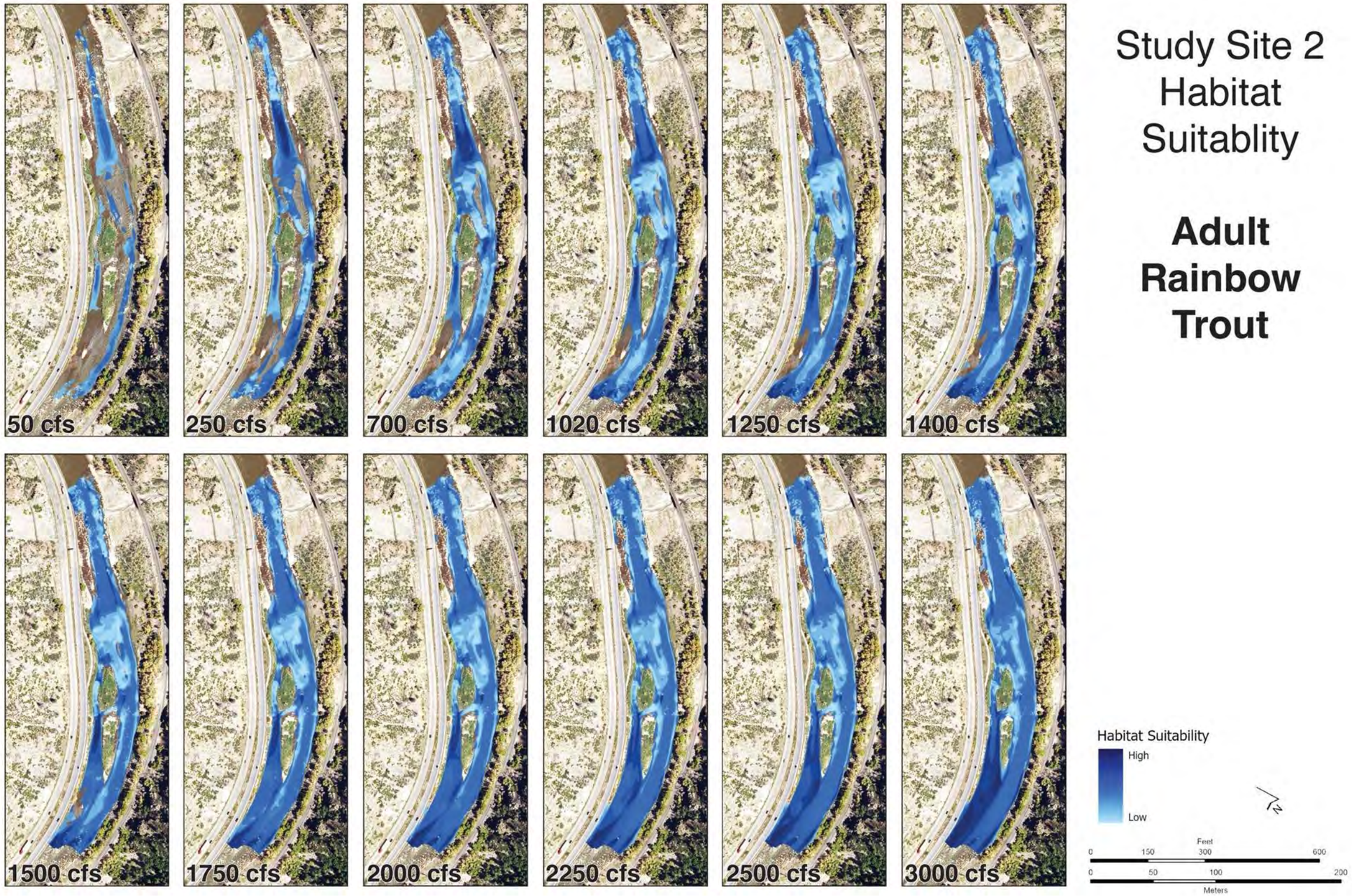
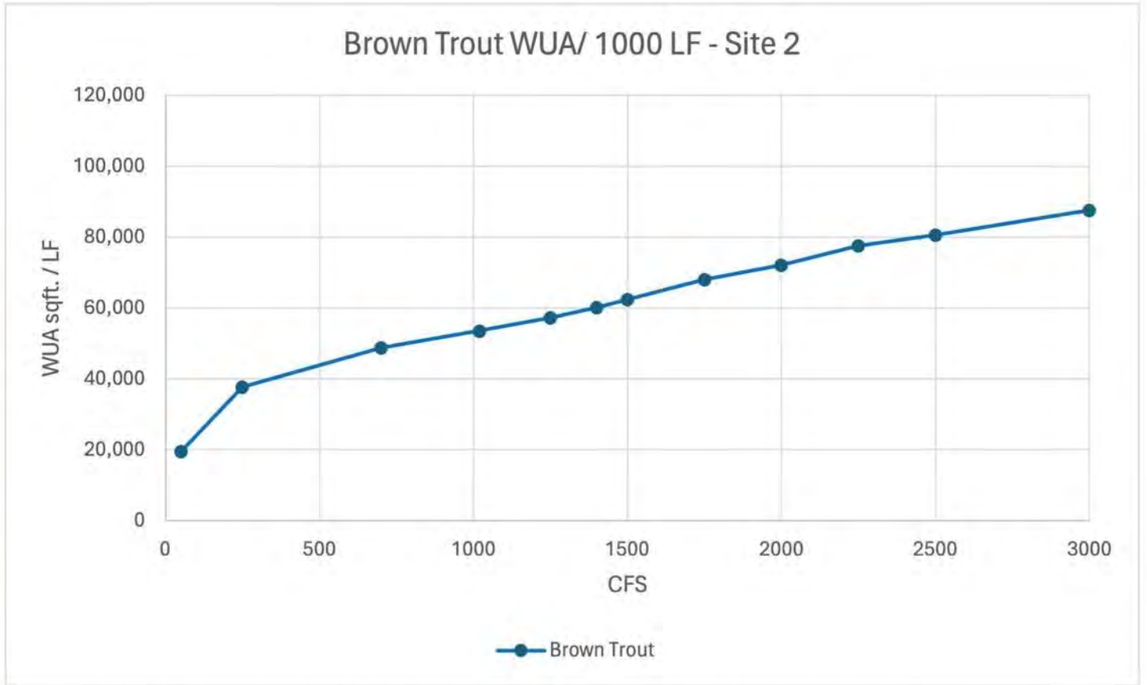


Figure A-11: Study Site 2 - Adult Rainbow Trout HHS Maps per Flow (cfs)



Study Site 2 Habitat Suitablity

Adult Brown Trout



Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Brown Trout at Site 2 per Discharge (cfs).

Figure A-12: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Brown Trout

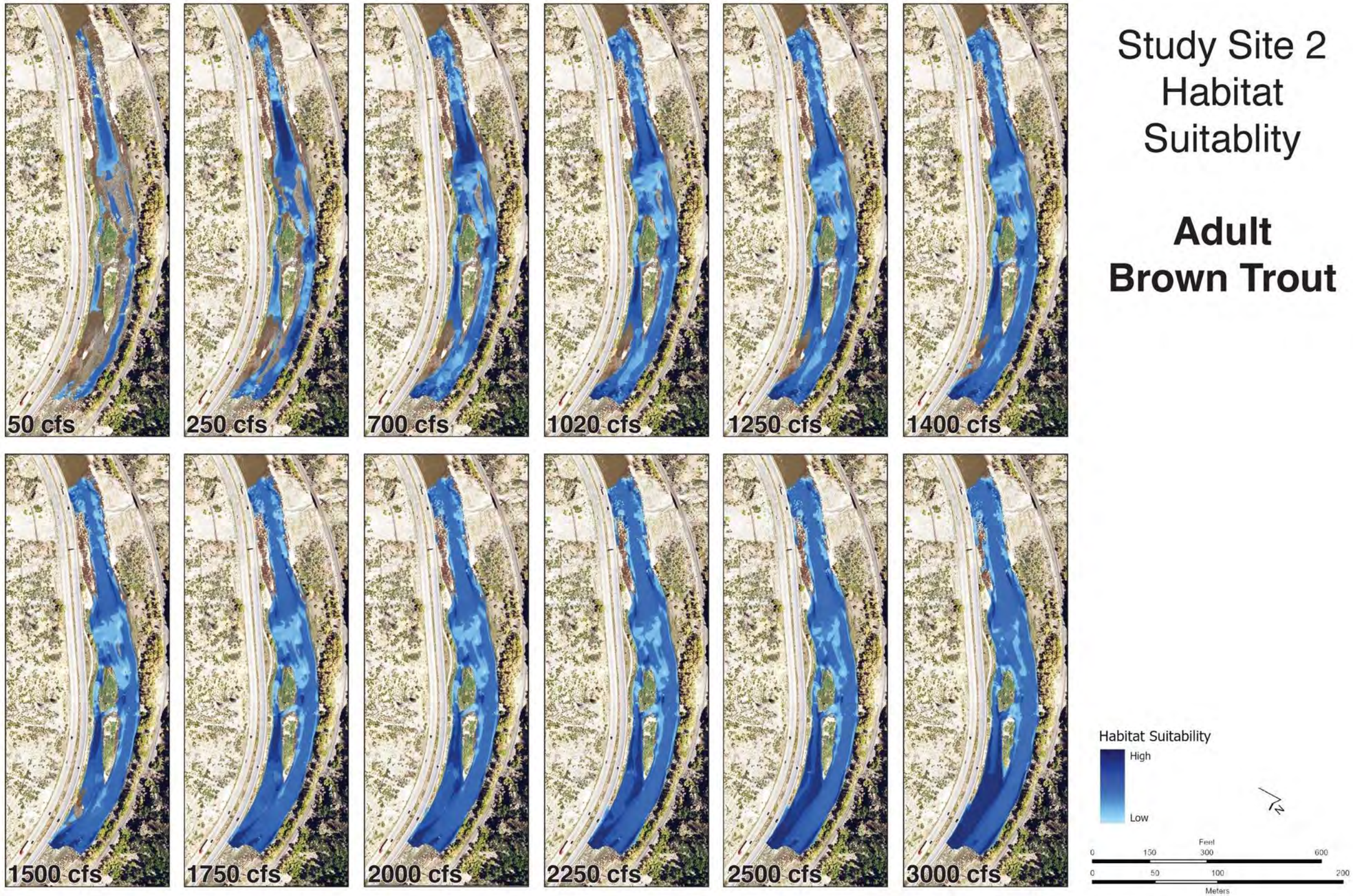
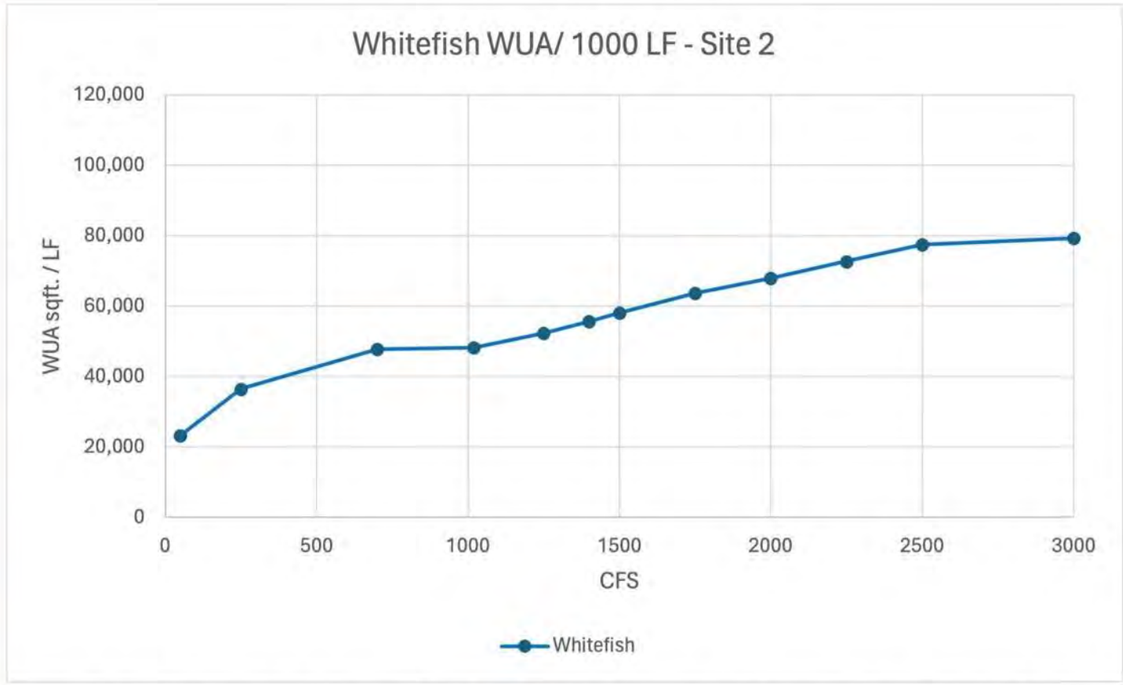


Figure A-13: Study Site 2 - Adult Brown Trout HHS Maps per Flow (cfs)





Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Mountain Whitefish at Site 2 per Discharge (cfs).

Figure A-14: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Mountain Whitefish

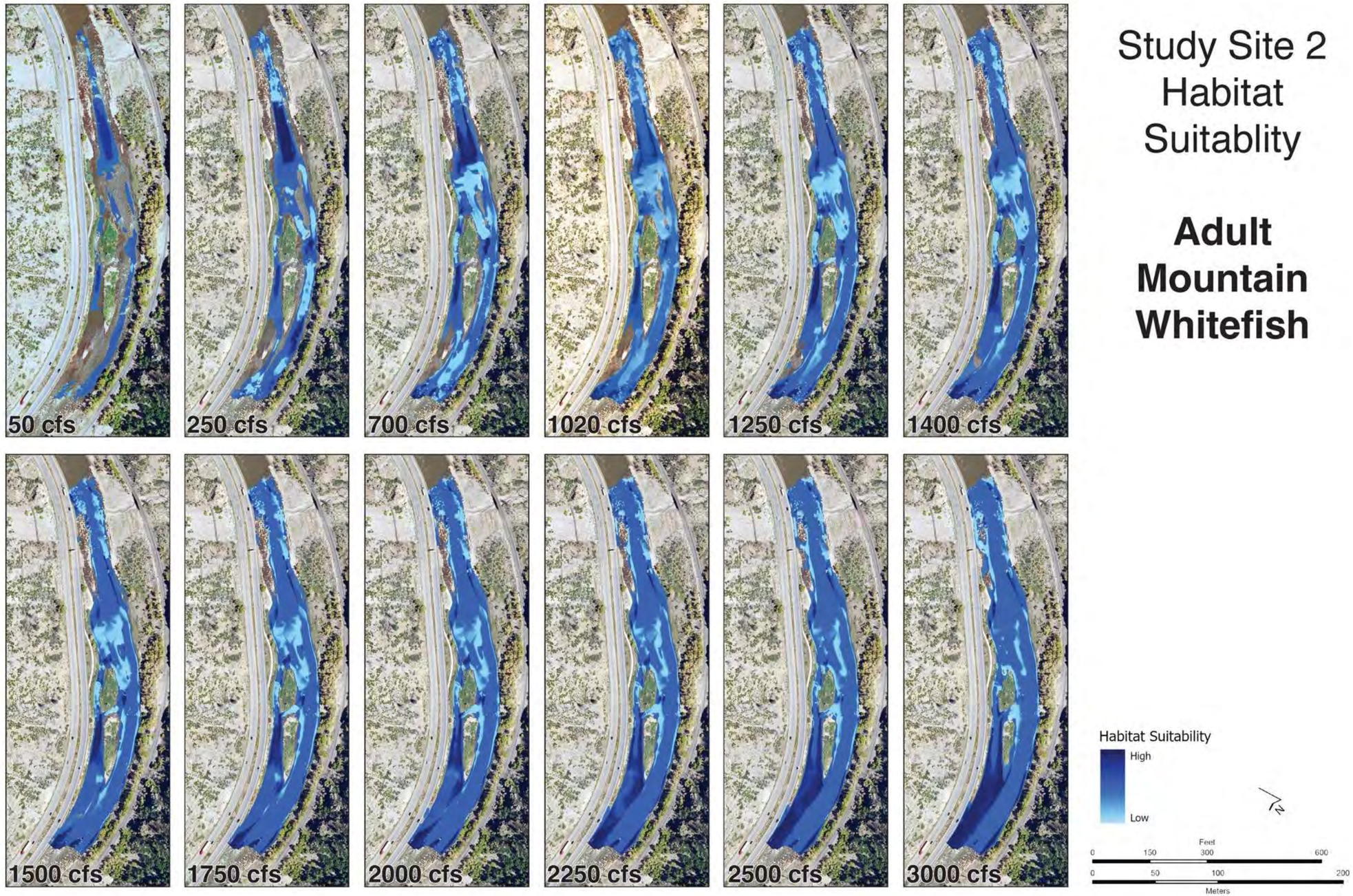
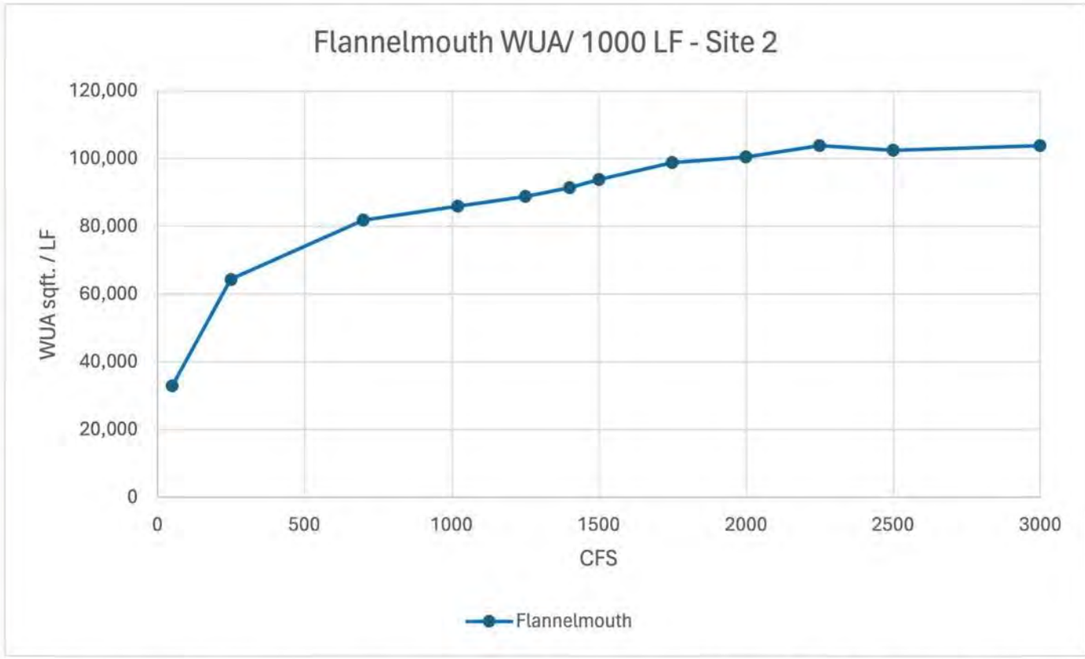


Figure A-15: Study Site 2 - Adult Mountain Whitefish HHS Maps per Flow (cfs)



Study Site 2 Habitat Suitablity

Adult Flannelmouth Sucker



Graph of Weighted Useable Area (WUA Sq. Ft. / LF.) for Adult Flannelmouth Sucker at Site 2 per Discharge (cfs).

Figure A-16: Study Site 2 - Hydraulic Habitat Suitability and WUA Adult Flannelmouth Sucker

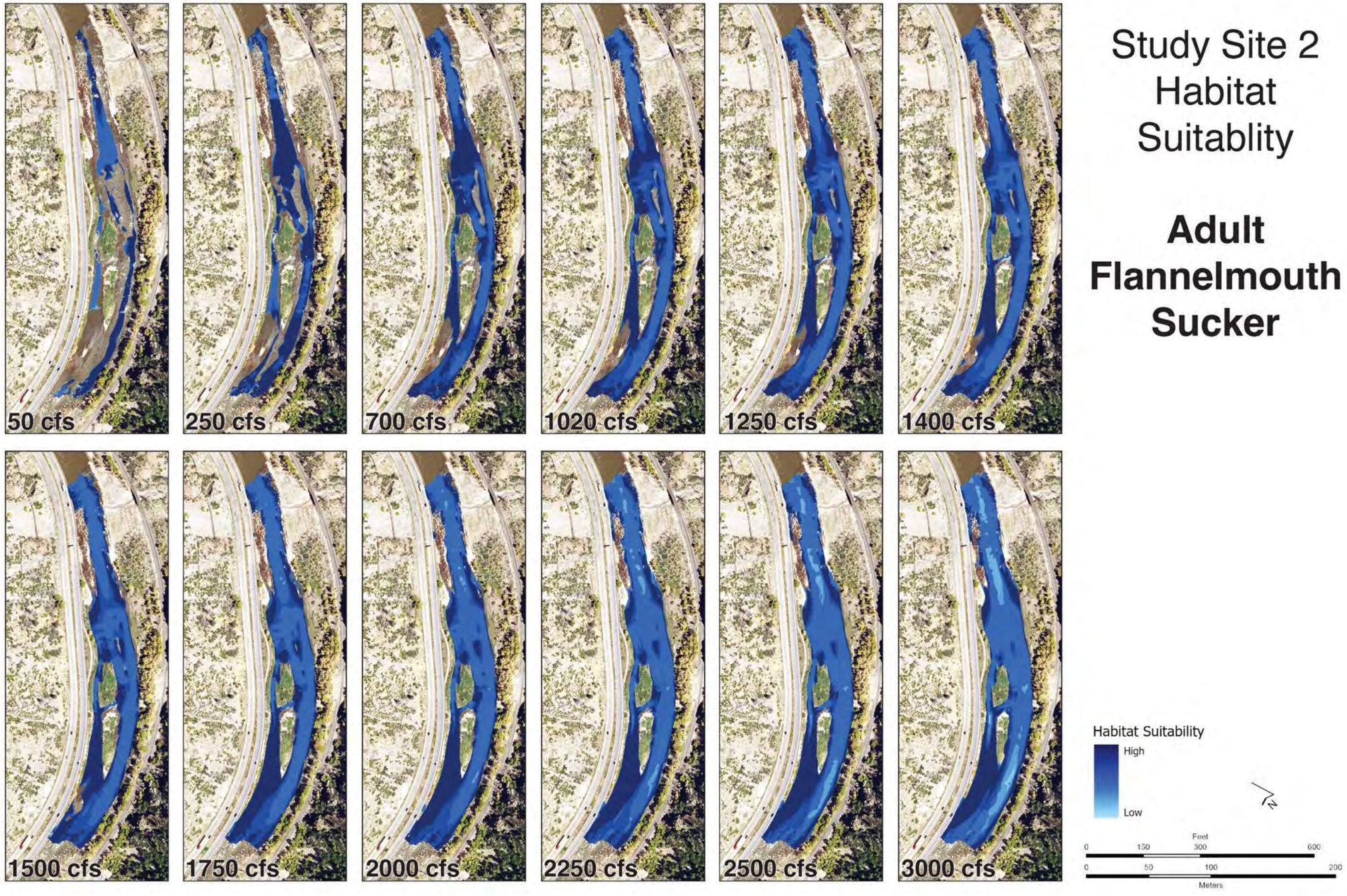
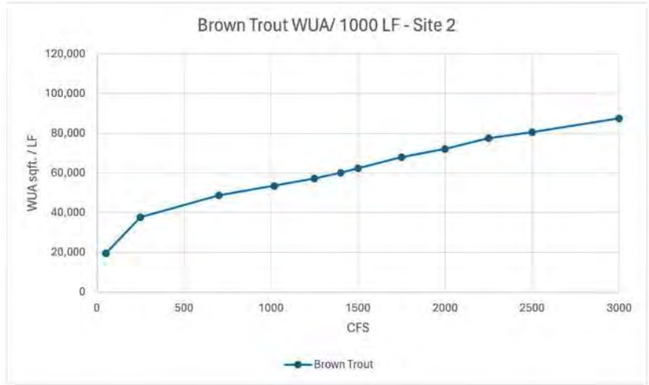
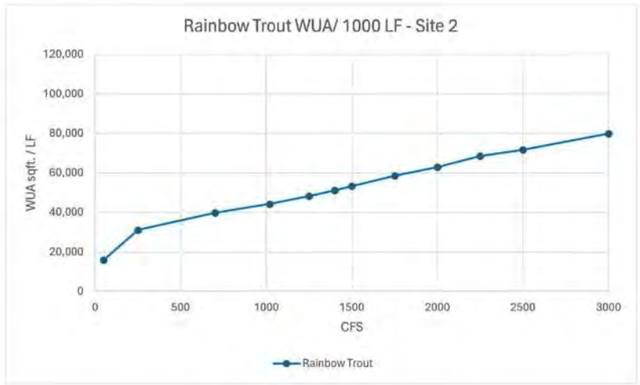


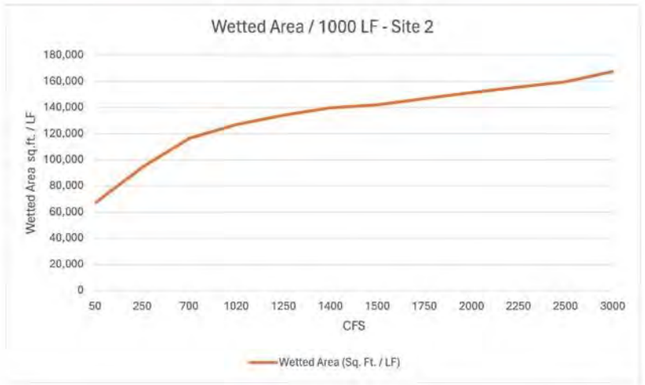
Figure A-17: Study Site 2 - Adult Flannelmouth Sucker HHS Maps per Flow (cfs)

Study Site 2 Habitat Suitablity

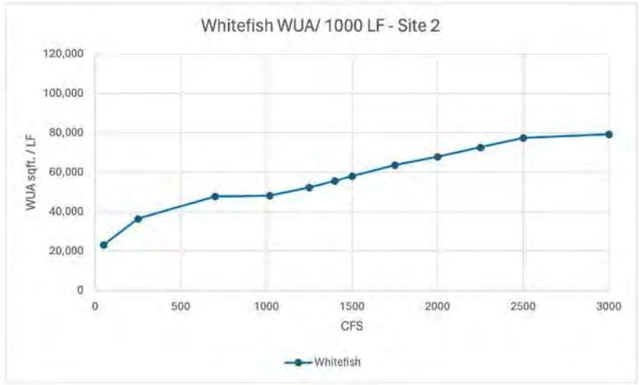








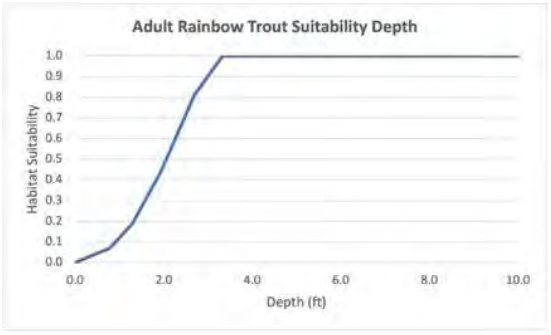




Graphs of Weighted Useable Area (WUA Sq. Ft. / LF.) for all species at Site 2 per Discharge (cfs).

Figure A-18: Study Site 2 - WUA All Species

APPENDIX B – SPECIES Suitability Curves



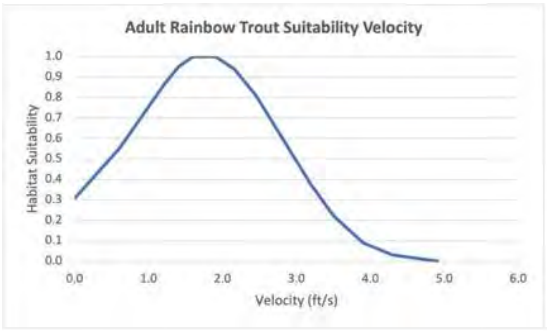
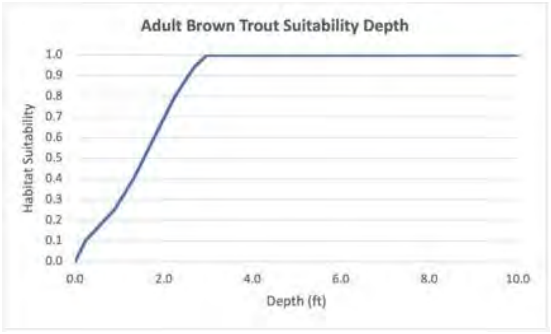


Figure B-1: Adult Rainbow Trout Suitability Curves (Depth and Velocity)



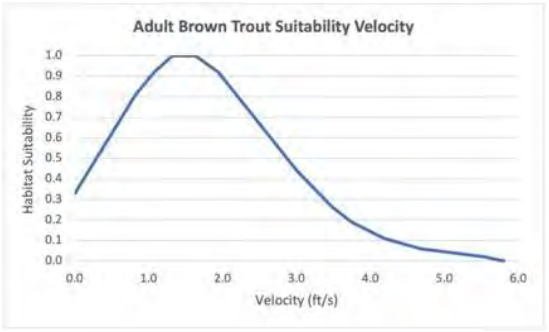
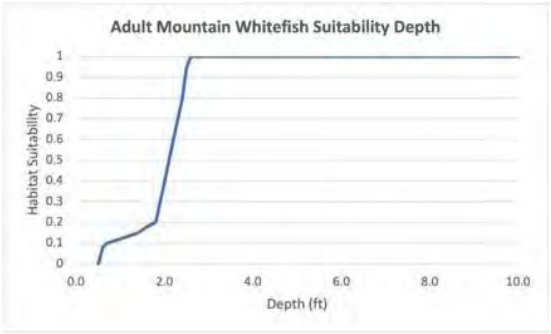


Figure B-2: Adult Brown Trout Suitability Curves (Depth and Velocity)



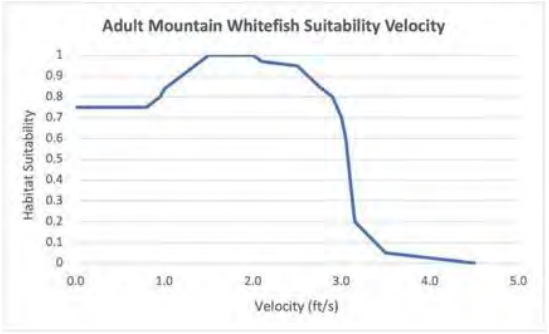
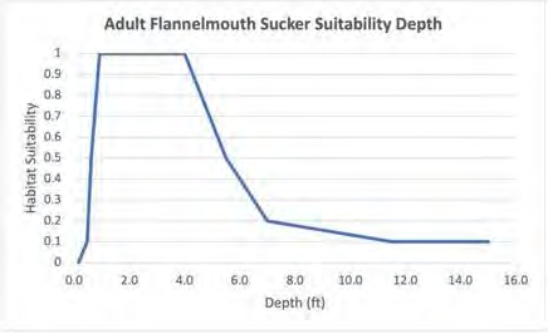


Figure B-3: Adult Mountain Whitefish Suitability Curves (Depth and Velocity)



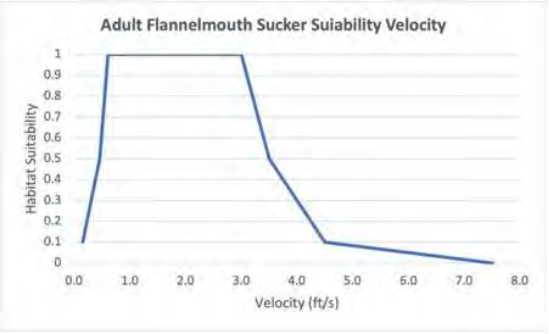


Figure B-4: Adult Flannelmouth Sucker Suitability Curves (Depth and Velocity)

APPENDIX C – HYDRAULIC MODELING AND HYDROGRAPHIC SURVEY REPORTS

Hydraulic Modeling Report – 2023. Prepared by Riverrestoration.org, December 2023.

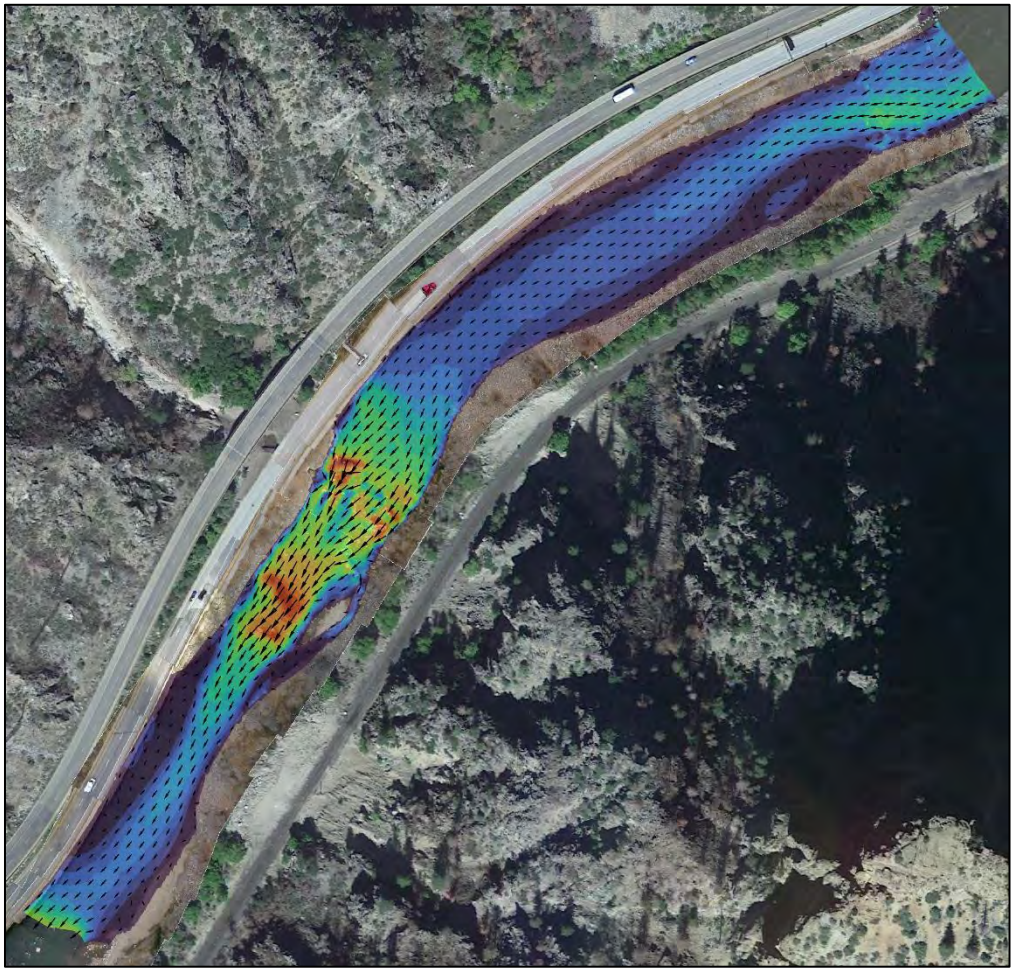
Hydrographic Survey Report – 2023. Prepared by Riverrestoration.org, January 2024.

Hydraulic Modeling Report – 2024. Prepared by Riverrestoration.org, January 2025.

Hydrographic Survey Report – 2024. Prepared by Riverrestoration.org, January 2025.

GLENWOOD CANYON AQUATIC HABITAT STUDY
COLORADO RIVER, COLORADO

HYDRAULIC MODELING REPORT – 2023



PREPARED BY RIVERRESTORATION.ORG, DECEMBER 2023

Corresponding authors: Jason Carey, PE – Project Manager – jason.carey@riverrestoration.org
Russell Bair, PE – River Engineer; russell.bair@riverrestoration.org

TABLE OF CONTENTS

1. Introduction 1
2. Modeling Methodology 1
   2.1. Model Overview 1
   2.2. Model Calibration 2
3. Results 3
   3.1. Model Outputs 3
   3.2. Model Results Discussion 3
4. Summary 5

TABLE OF FIGURES AND TABLES

Figure 1. Glenwood Canyon model domain DEM 1
Figure 2. Final spatially distributed Manning's n values used in the SRH-2D hydraulic model 2
Figure 3. Model Calibration Results 3
Figure 4. Glenwood Canyon model domain 3
Figure 5. Model results showing velocity at the flows of interest 4
Figure 6. Model results showing depth at the flows of interest 5

RESULTS DATA APPENDICES

GlenwoodCanyon_DEM_ft.tif
50cfs_results.xlsx
250cfs_results.xlsx
700cfs_results.xlsx
1020cfs_results.xlsx
1250cfs_results.xlsx
1400cfs_results.xlsx
3000cfs_results.xlsx

1. INTRODUCTION

A 2 dimensional (2D) hydrodynamic model was used to simulate a variety of low flow conditions for a study reach on the Colorado River in Glenwood Canyon. The model was based on a digital elevation model (DEM) developed from hydrographic survey data collected over an 1854 foot reach (Figure 1). The goal was to provide spatially discrete data and weighted values of water depth, velocity, shear stress, and a Froude value for use in a usable habitat analysis.

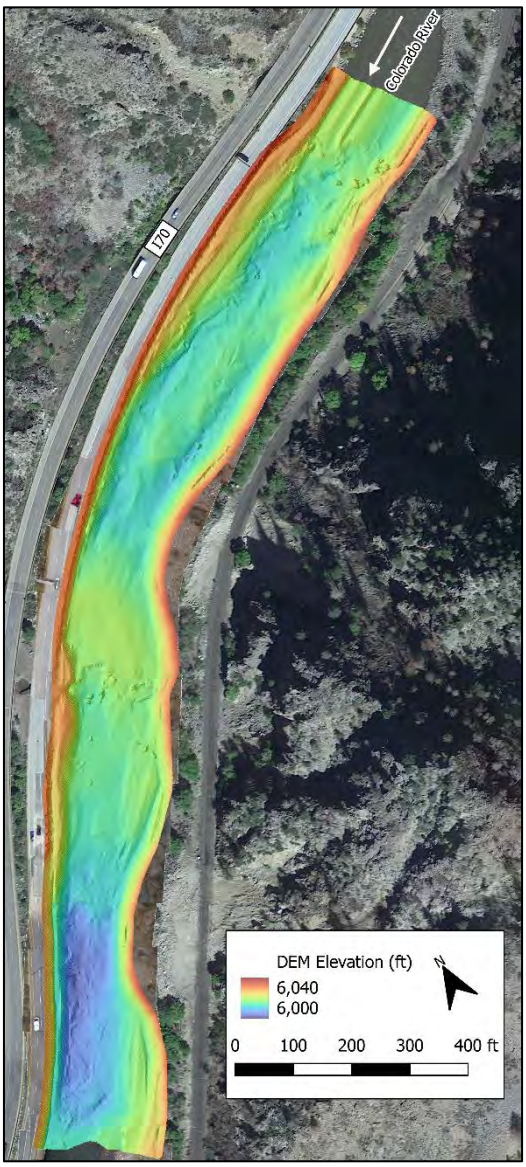


Figure 1. Glenwood Canyon model domain DEM

2. MODELING METHODOLOGY

2.1. Model Overview

Hydrographic survey data (see Glenwood Canyon Survey Report) was used to develop a DEM for the study reach. Point elevations and breaklines were used to characterize bed features like pools, rapids, and individual boulder features. This DEM is available in a geotiff format in the associated data appendices. This DEM was converted into an irregular 2D mesh with a cell sides targeted to a length of 4' within the channel using SMS software. Due to the SMS software interpolating an irregular mesh, a range of cell side lengths were modeled. Both three and 4 sided cells exist in the irregular grid, leading to a range in cell areas. These cells represent the elevations of the bed and provides calculations locations with discrete boundaries for a solver to calculate a depth-averaged result within. Depth-averaged two-dimensional velocity modeling simulates hydraulics in the streamwise and lateral directions, averaging values through the water column in the vertical. SRH-2D is a two-dimensional numerical model widely implemented for hydraulic applications and was used to simulate conditions within the project reach.

The SRH-2D model requires a spatially distributed friction element in addition to elevation for each cell. This can be provided in the form of a Manning's n value layer. For the model, we used spatially discrete Manning's n values based on the bed sediments observed during the survey. The final values for each area can be found in Figure 2, these values were adjusted within a reasonable range during the model calibration process, discussed below.

The upstream end of the 2D mesh was artificially extrapolated 100' upstream. This is visible in Figure 1 where the channel geometry appears stretched. The extra 100' was added to provide an area for the modeled inflow to non-uniformly distribute before entering the area of interest in the model domain. The extrapolated geometry was developed with the upstream cross section of survey data copied to the

upstream location and directly interpolated in between. Results provided from the modeling process used for the habitat analysis excluded all values in this extrapolated area.

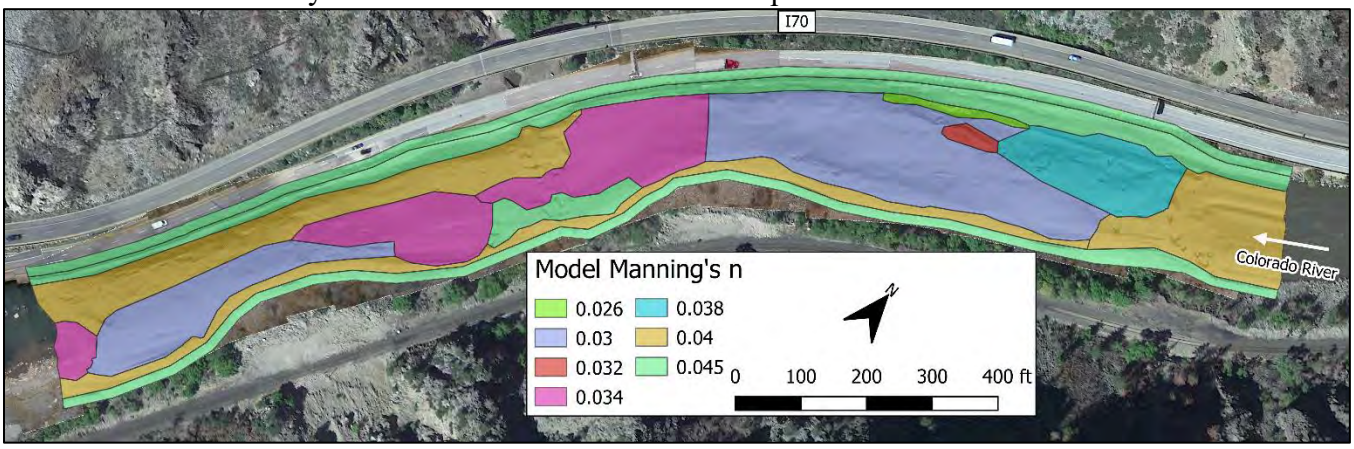


Figure 2. Final spatially distributed Manning's n values used in the SRH-2D hydraulic model

SRH-2D requires an upstream and downstream boundary condition. A steady flow rate was used as the upstream boundary condition for each different flow of interest and the model time was run until a steady state was achieved throughout the model domain. A constant water surface elevation (WSE) was used as the downstream boundary condition for each flow. The downstream boundary in the model domain was set at the crest of a rapid, where the flow exited the pool and passed through the critical state. A known water surface elevation was measured for the survey flow (1020 cfs) and used during the calibration process (discussed below). A 1D critical flow area equation (Eq. 1) based on the geometry of the downstream section of the model was used to calculate the water surface elevation boundary condition for each additional flow of interest. Flows of interest for this study were: 50 cfs, 250 cfs, 700 cfs, 1020 cfs (survey flow), 1250 cfs, 1400 cfs, and 3000 cfs.

Eq. 1 $$Q = \left(\frac{Area^3 * g}{Top\ Width}\right)^{1/2}$$

2.2.Model Calibration

The 2D hydraulic model was calibrated to WSE points captured during the survey flow of 1020 cfs. Calibration consisted of adjusting Manning's n values for different areas of the model within a reasonable range and adjusting the geometry of the DEM at observed control sections that were not sufficiently surveyed for bathymetric data. DEM adjustments were primarily focused on the grade controlling rapid in the middle of the survey area that impacted the large pool upstream and were a challenge to survey in great detail due to safety concerns in the field. The largest adjustment was made on the thalweg on the left side of the channel near the crest of each rapid, where conveyance needed to be increased to match the surveyed upstream water surface slope exiting the pool. After the calibration adjustments were made, the majority of the WSE calibration points were within +/- 0.2' of the model result (Figure 3), which is in line with the expected vertical accuracy of the survey. The majority of the outliers from this range, and the largest outliers, were in the steepest section of the rapid. Here, any given WSE in the model represents a smaller area of the channel. Additionally, less consistent WSE in rapids in the field decreases the accuracy of a given survey value. The large pools and areas of more gradually varying WSE slope all were well matched within the model. Mannings 'n' values were held consistent for all model runs between 50 cfs and 3,000 cfs based on the calibration at 1,020 cfs.

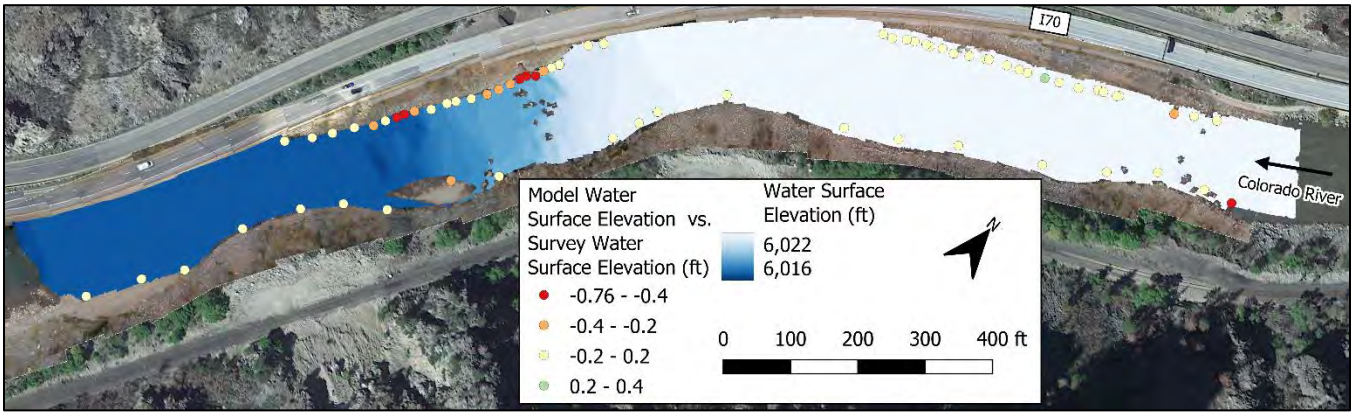


Figure 3. Model Calibration Results

3. RESULTS

3.1. Model Outputs

The model simulations were run until the flowrate into the model came to an equilibrium with the flow rate out of the model and was considered steady state. Results for each were then output for use in the habitat analysis. Results were sampled at the centroid location of each computation cell in the model 2D mesh (Figure 4). These cells represent areas ranging from less than 1 ft^2 to 70 ft^2, with the majority of the cells in the active channel between 5 ft^2 and 15 ft^2. Table 1 lists each of the hydraulic outputs that were sampled at the centroid of each cell.

Table 1. Model Outputs

Output	Unit
Cell Area	ft^2
Centroid X Coordinates	ft
Centroid Y Coordinates	ft
Bed Elevation	ft
Water Surface Elevation	ft
Water Depth	ft
Velocity in X direction	ft/s
Velocity in y direction	ft/s
Velocity Magnitude	ft/s
Froude Number	Dimensionless
Shear Stress	lb./ft^2

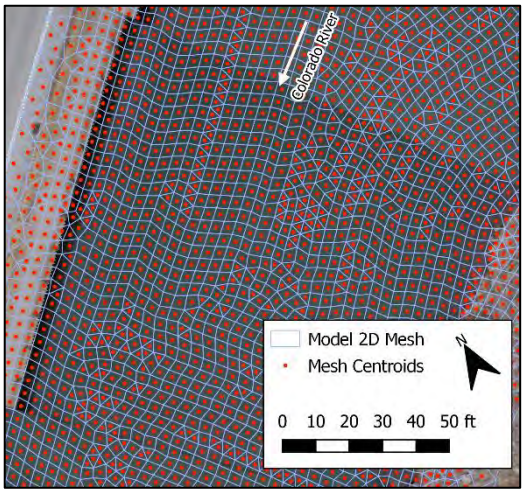


Figure 4. Glenwood Canyon model domain

3.2. Model Results Discussion

The model reach is bound on both sides by steep banks, including areas of vertical concrete in the highway embankment. Across the flow range evaluated the wetted flow area increased 23%. The largest changes in flow area occur around shallow areas of sand deposits near the up and downstream ends of the model as well as in some of the shallow cobble areas of the riffle in the middle of the model. The flow generally increases in velocity and depth as discharge increases (Figure 5). At the lowest modeled flow of 50 cfs

some unwetted areas emerge at the top of the rapid grade control that are larger than just single elevated boulders. At such extreme low flows, it may be reasonable to assume that some of the control section flow would be hyporheic flow between the large bed materials and infiltrate subsurface. The model also represents areas where the channel geometry is overhung by a suspended concrete bike path on the right bank in both pools. The modeled WSE in these areas remains several feet below the path elevations at the highest flow modeled for this analysis, 3000 cfs, but field observations have shown that extreme high flows in the river can reach these vertical obstructions, limiting the applicability of this model to flow levels less than or equal to 3,000 cfs.

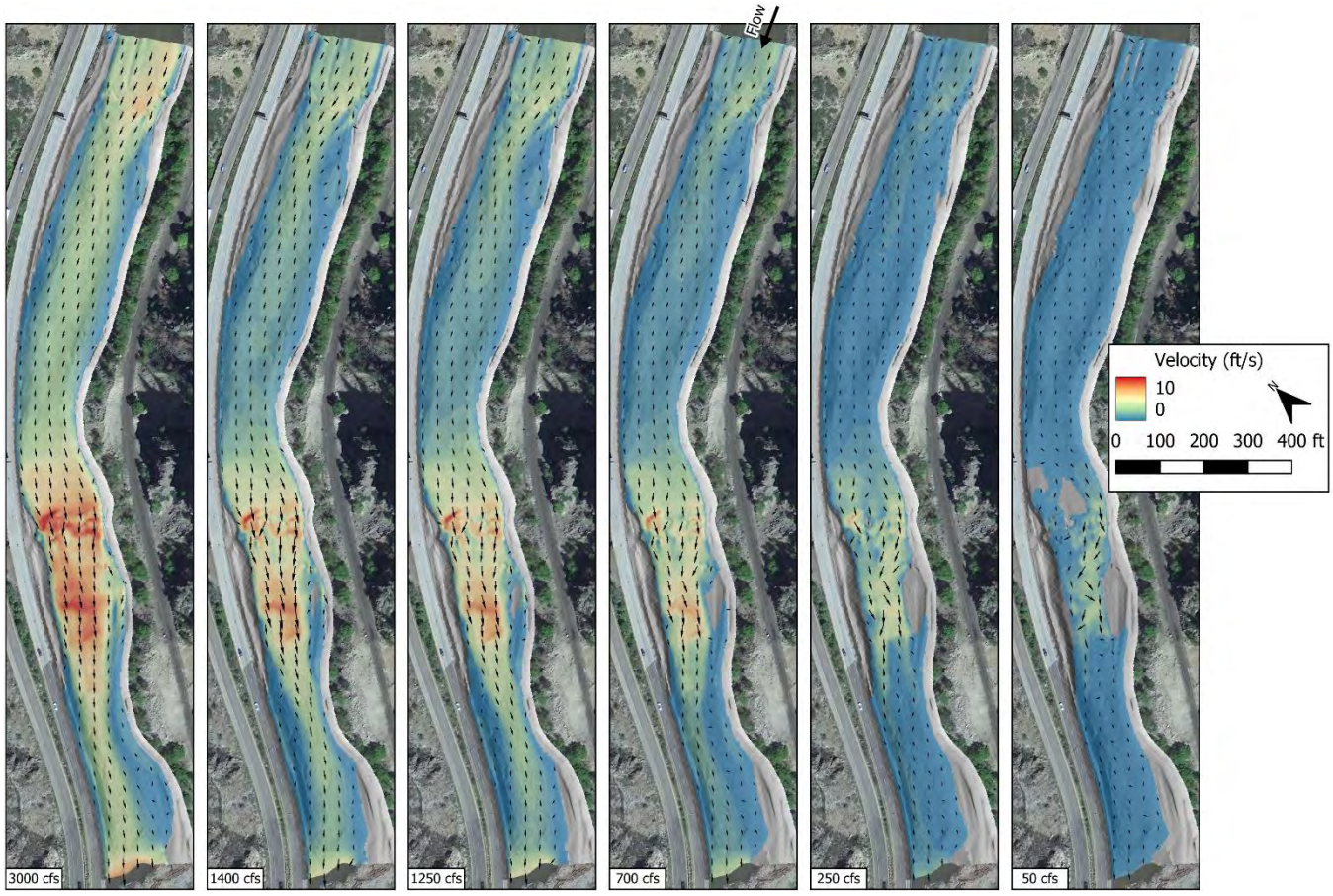


Figure 5. Model results showing velocity at the flows of interest

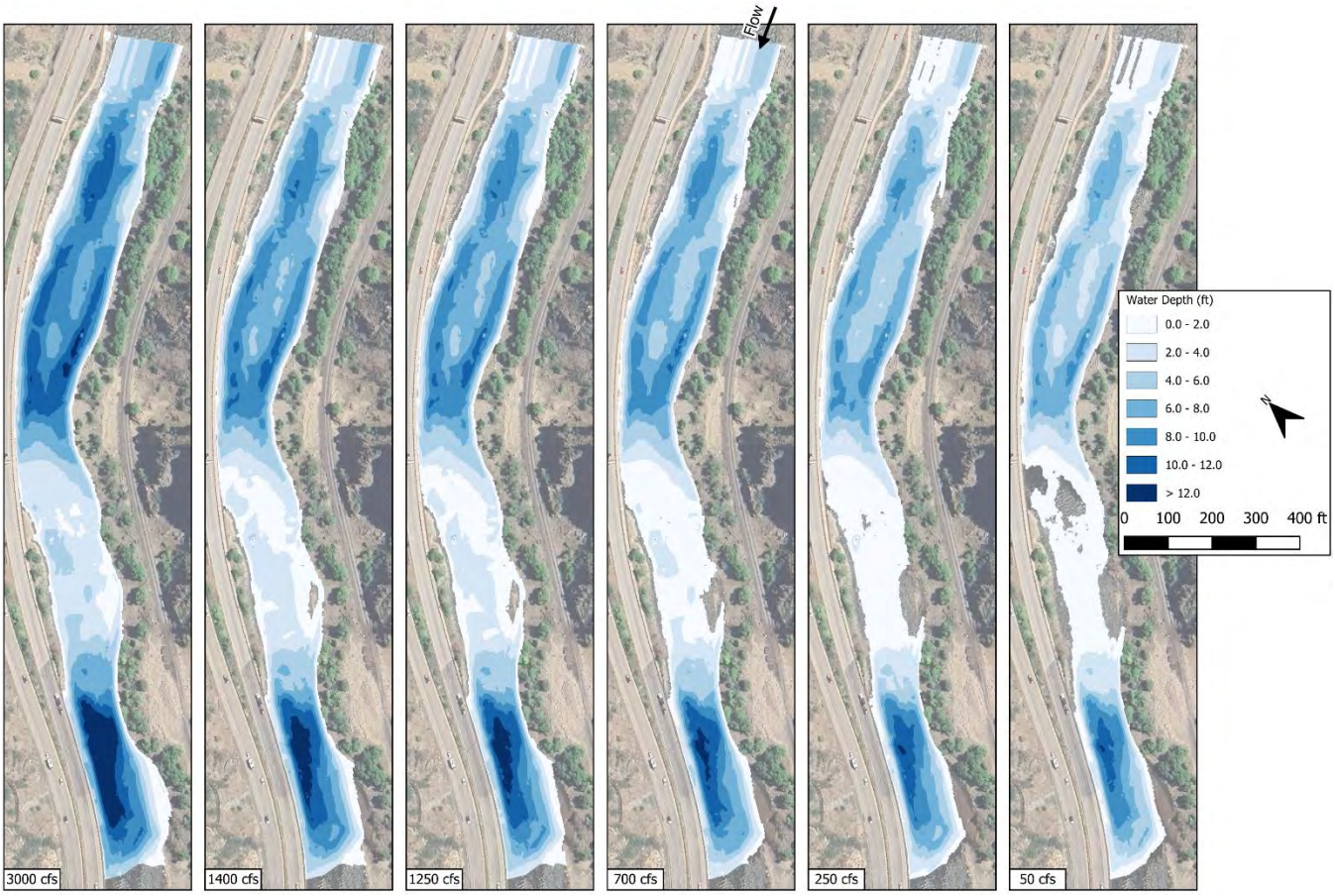


Figure 6. Model results showing depth at the flows of interest

4. SUMMARY

This report explains how survey data collected in Glenwood Canyon were used to create a calibrated 2D hydraulic model. This model was then used to predict hydraulic conditions of the study reach at a range of flows of interest to aquatic habitat at a resolution of approximately 4 ft x 4 ft. The model may have limitations at resolutions less than 4 feet length scale or at flows less than 50 cfs or greater than 3,000 cfs. Results available in the included data appendices can be used in an analysis of the available habitat within the study reach at the specified study flows.

GLENWOOD CANYON AQUATIC HABITAT STUDY
COLORADO RIVER, COLORADO

HYDROGRAPHIC SURVEY REPORT – 2023



PREPARED BY RIVERRESTORATION.ORG, DECEMBER 2023

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Russell Bair, PE – River Engineer; russell.bair@riverrestoration.org

TABLE OF CONTENTS

1. Introduction and Survey Methods 1
2. Survey Control 2
3. Survey Conditions 3
4. Survey Results and Observations 3
5. Base Map and DEM Development 5
6. Summary 6

TABLE OF FIGURES AND TABLES

Figure 1. Survey Area Overview Map 1
Figure 2. Survey Methods. GNSS rover (left) and boat mounted GNSS integrated SBES (right) 2
Figure 3. Discharge of Colorado River near Dotsero, Colorado (USGS Gage 09070500) during survey and data aquisition 3
Figure 4. Substrate Areas and DEM 4
Figure 5. (Left) Looking downstream from the right bank at the rapid in the middle of the survey area. (Right) Aerial oblique drone photo looking downstream from near the upstream end of the survey area. The riprap and concrete nature of the banks can be seen. 5

RESULTS DATA APPENDICES

GlenwoodCanyon_DEM_ft.tif
SubstrateAreas_Polygons.shp

1. INTRODUCTION AND SURVEY METHODS

A hydrographic survey covering 1854 feet of the Colorado River in Glenwood Canyon was conducted on November 6th and 8th, 2023. The survey extent encompassed two pool sections divided by a boulder/cobble rapid and bounded by a rapid on the downstream end. Survey was conducted in the channel up the ordinary high water mark (OHWM) evident in the field. A combination of wading and boat-based survey was used to cover the areas of various depths and velocities (Figure 1). The survey was performed using a combination of RTK GNSS, Single Beam Echo Sounder (SBES), and total station. The survey was conducted using the NAD83 State Plane Colorado Central coordinate reference system (CRS) in US survey feet, vertical datum of NAVD88, and using the CONUS18 geoid model. Survey control was based on points provided by CDOT and tied in local control monuments via GNSS observations. Instruments utilized included Trimble R780 and R10 GNSS units, a boat mounted Ohmex SonarMite SBES, and a Trimble 5603 DR 200+ total station.

In addition to the bathymetric survey, the bed material was characterized at each topographic survey point throughout the survey reach and high-resolution ortho imagery was captured from 100' and 200' AGL throughout the reach.



Figure 1. Survey Area Overview Map



Figure 2. Survey Methods. GNSS rover (left) and boat mounted GNSS integrated SBES (right)

2. SURVEY CONTROL

The survey was based on control provided by CDOT for monuments recovered in the vicinity of the Hanging Lake rest area. Two control monuments were utilized with the coordinates provided in Table 1; Point 2528 was held as the location of the RTK GNSS base station during both days of the survey and point 2541 was used to check the initial base set up with RTK GNSS rovers. Eight additional control monuments were found and tied into the control network using 180 second RTK GNSS observations. These monuments were on the bike path that paralleled the survey reach and consisted of brass survey markers and "X" marks scrawled in the concrete placed by CDOT. These monuments were used for internal survey checks and as the basis for a total station set up and backsight but coordinates in Table 1 should not be considered survey control quality based on the limited GNSS constellation observed at the bottom of the Glenwood Canyon. Single beam sonar sound speed was adjusted in the field to match stadia rod depth measurements and integrated with either a total station prism or a RTK GNSS rover at different times to measure locations.

Table 1. Control Point information. NAD83 State Planes Colorado Central US Survey Feet, NAVD88, Geoid CONUS18. Coordinates are based on RTK GNSS survey holding 2528 and should not be considered survey control quality for future surveys.

Source	Point	Northing	Easting	Elevation	Description
CDOT	2528	1643610.52	2523096.51	6125.178	CDOT 1075--Type 5S IN CONC BIKE PATH
CDOT	2541	1644023.31	2523811.81	6117.827	CDOT 1075--Type 5S IN CONC BIKE PATH
GPS est.	193	1640379.889	2519661.18	6023.026	Brass Marker PT 193
GPS est.	194	1640815.124	2519923.869	6027.73	Brass Marker PT 194
GPS est.	195	1641175.599	2520304.564	6026.45	Brass Marker PT 195
GPS est.	196	1641401.255	2520778.948	6029.373	Brass Marker PT 196
GPS est.	300	1641308.444	2520530.666	6027.274	Concrete Scrawl X
GPS est.	301	1641008.418	2520098.404	6027.054	Concrete Scrawl X
GPS est.	302	1640601.825	2519781.121	6024.546	Concrete Scrawl X
GPS est.	303	1640170.93	2519540.383	6022.625	Concrete Scrawl X

3. SURVEY CONDITIONS

Site survey took place on November 6th and 8th, 2023. November 6th conditions were cold and clear while on November 8th, scattered snow showers fell throughout the day. The project reach is located approximately 8.5 miles downstream of USGS stream gage 09070500 on the Colorado River near Dotsero, CO. Shoshone Power Plant was shut down during survey and no diversions were expected between the gage and the site during data collection efforts. There are no major inflows between the project reach and gage, so the gage is assumed to well represent the project reach flows. Figure 3 shows the range of flows during the survey, as well as the slightly lower flows during the acquisition of aerial imagery.

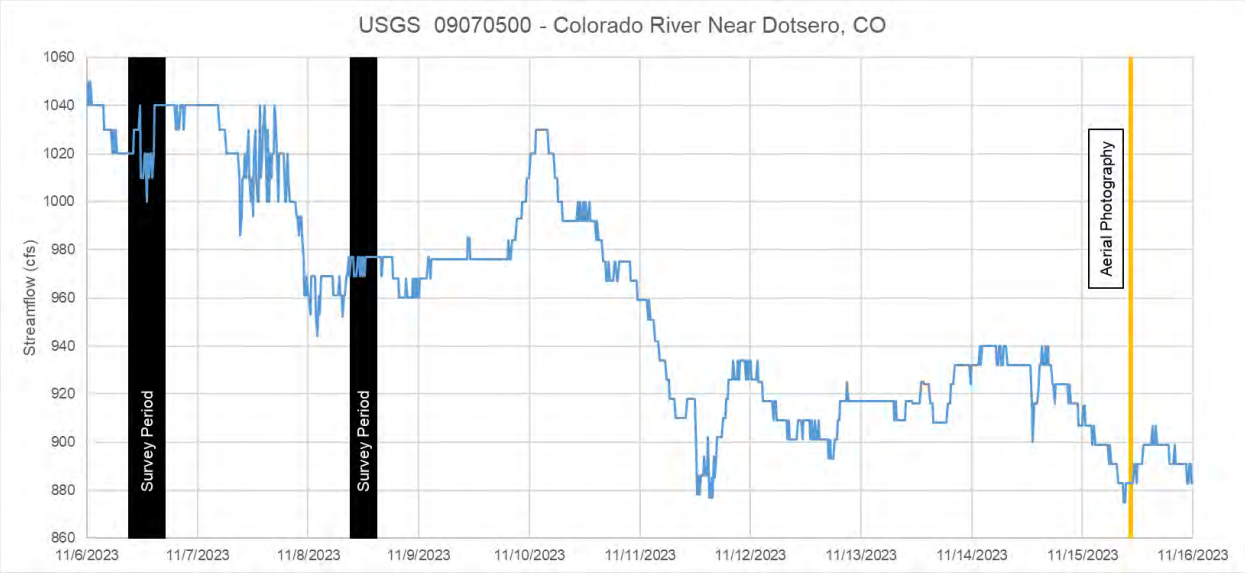


Figure 3. Discharge of Colorado River near Dotsero, Colorado (USGS Gage 09070500) during survey and data aquisition

4. SURVEY RESULTS AND OBSERVATIONS

The survey reach was selected to represent hydraulic characteristics present in the pool/rapid Glenwood Canyon reach of the Colorado River. The survey included two pools divided by one cobble/boulder rapid and was bounded by rapids on the upstream and downstream ends. The rapids generally comprised of large colluvial, and mud and debris flow materials supplied to the main channel from tributaries. Bathymetric and topographic data points were collected to represent bed elevations throughout the survey reach. Information on bed materials including sediment classes and vegetation types were recorded with the points. Areas with depositional sediments and signs of recent maximum high water levels were also recorded, as were water surface elevations (WSE) throughout the reach for the survey flow. There were areas within the survey extent where water was too deep and swift to safely survey on foot or via boat, particularly in some areas around the rapid in the middle of the project reach. Survey was completed to allow for the most accurate interpolation possible in these areas. Additionally, aerial ortho-imagery was collected to help locate larger topographic features such as mid channel boulders.

Survey observations revealed that the bed material varied throughout the study reach. Longitudinal and lateral influences impacted the bed composition. Higher up elevations near the OHWM on each bank consisted of mechanically placed riprap rock materials supporting the highway on river right and railroad on river left (Figure 5). A substantial portion of the river right bank was a vertical concrete wall under a cantilevered bike path with riprap along the right toe (Figure 5). The midchannel consisted of areas of

boulder and large cobbles on the outside of the bend and through the rapids, and large areas of sand deposition on the inside of bends in the pools. Depositional sand included areas of transporting sand over boulders in the upstream pool and also large areas of sand dunes in each pool. A large sandy beach deposit was observed on the inside river left side of the downstream pool. The rapid in the middle of the survey reach and the rapid at the downstream end both consist of large cobble and boulder material (Figure 5) that was delivered from steep tributaries that were impacted by the Grizzly Creek Fire in 2020 and the subsequent debris flows during heavy rain in 2021. The crests of these rapids act as grade controls controlling the water surface elevation of the pools immediately upstream. Sand deposits transition to a lens of alluvially transported large cobble material on the upstream approach of each rapid crest. These cobble materials acted as the hydraulic grade control of each pool at the survey flow. Larger boulders deposited by the tributaries define the main drop in WSE across the rapids. A matrix of small boulders and large cobbles surround the largest boulders with minimal areas of finer depositional material through the rapids until the hydraulic gradient reaches the next pool elevation controlled by the downstream rapid crest and the flow slows. Figure 4 shows the different substrate areas that were identified during the survey overlaid on the final digital elevation model that was created.

Riprap banks throughout the reach were not densely vegetated, but a variety of riparian plant species including willows and cottonwoods were scattered on the banks in pockets around boulders and riprap. Willows, grasses, shrubs, and smaller trees dominated the right bank, while the left bank had more mature cottonwoods.

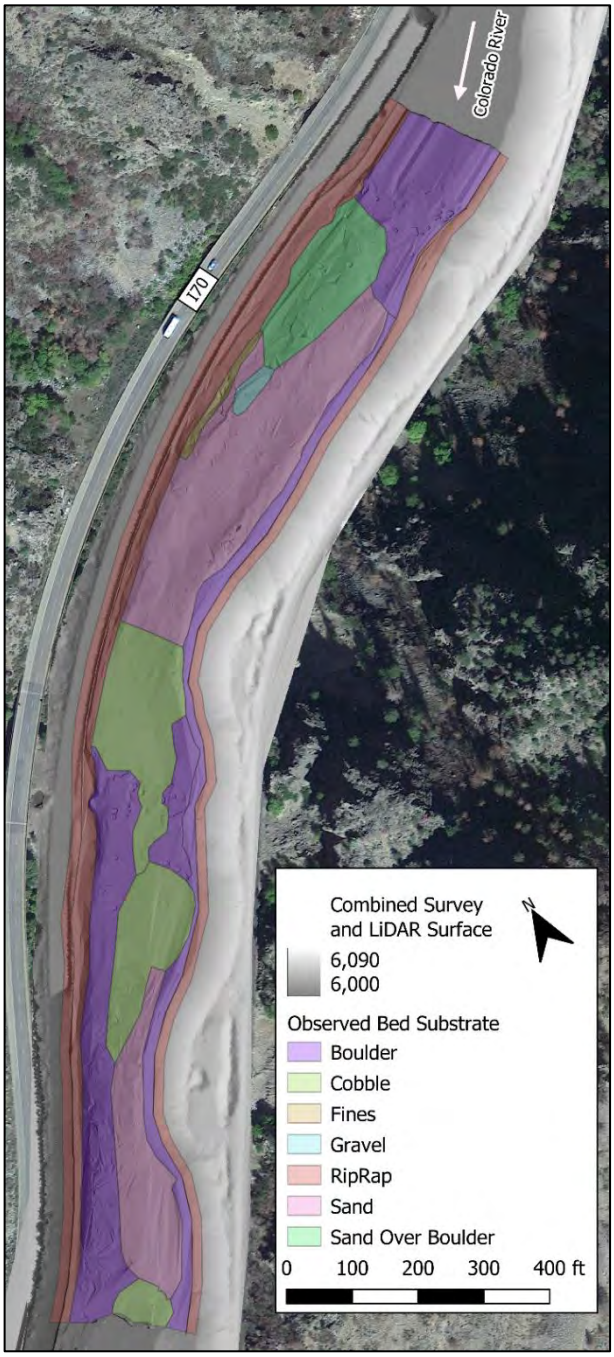


Figure 4. Substrate Areas and DEM



Figure 5. (Left) Looking downstream from the right bank at the rapid in the middle of the survey area. (Right) Aerial oblique drone photo looking downstream from near the upstream end of the survey area. The riprap and concrete nature of the banks can be seen.

5. BASE MAP AND DEM DEVELOPMENT

Survey data were post-processed to remove potential spurious data, mostly in the form of inaccurate SBES depth readings. Interpolation of some topographic data was required in areas that were unsafe to survey, but this was expected from the outset, and the majority of the survey extent was covered by on the ground field survey. A digital elevation model (DEM) was created for the entire surveyed project reach using a triangular irregular network (TIN) to connect surveyed points along with breaklines to represent the existing conditions in the field. Additional breaklines were included to represent boulder clusters and pour overs in rapids based on the collected aerial ortho-images. Elevations for some of these features had to be estimated based on nearby similar elevation features that were surveyed or nearby water surface elevations.

Field survey only took place up to the OHWM. For areas above this elevation, LiDAR data was added to the DEM. This LiDAR DEM data is publicly available data collected on flights in June of 2016 for the Colorado Water Conservation Board (https://coloradohazardmapping.com/lidarDownload). The data is formatted as a geotiff with 3 ft resolution. The LiDAR survey was carried out in the same coordinate reference system as this ground based survey; State Plane Colo. Central, NAD83, NAVD88. The LiDAR survey used the 12B geoid model as opposed to the more recent CONUS18 geoid model, but in the area of interest, this difference is not expected to have an impact. The LiDAR data inserted was well aligned with the surveyed ground elevations and required minimal editing of the DEM to mesh to two surfaces. Because the ground survey went to the elevation of the OHWM, the LiDAR based data inserted at elevations higher than this are not expected to have a meaningful impact on the flow levels of interest for this project.

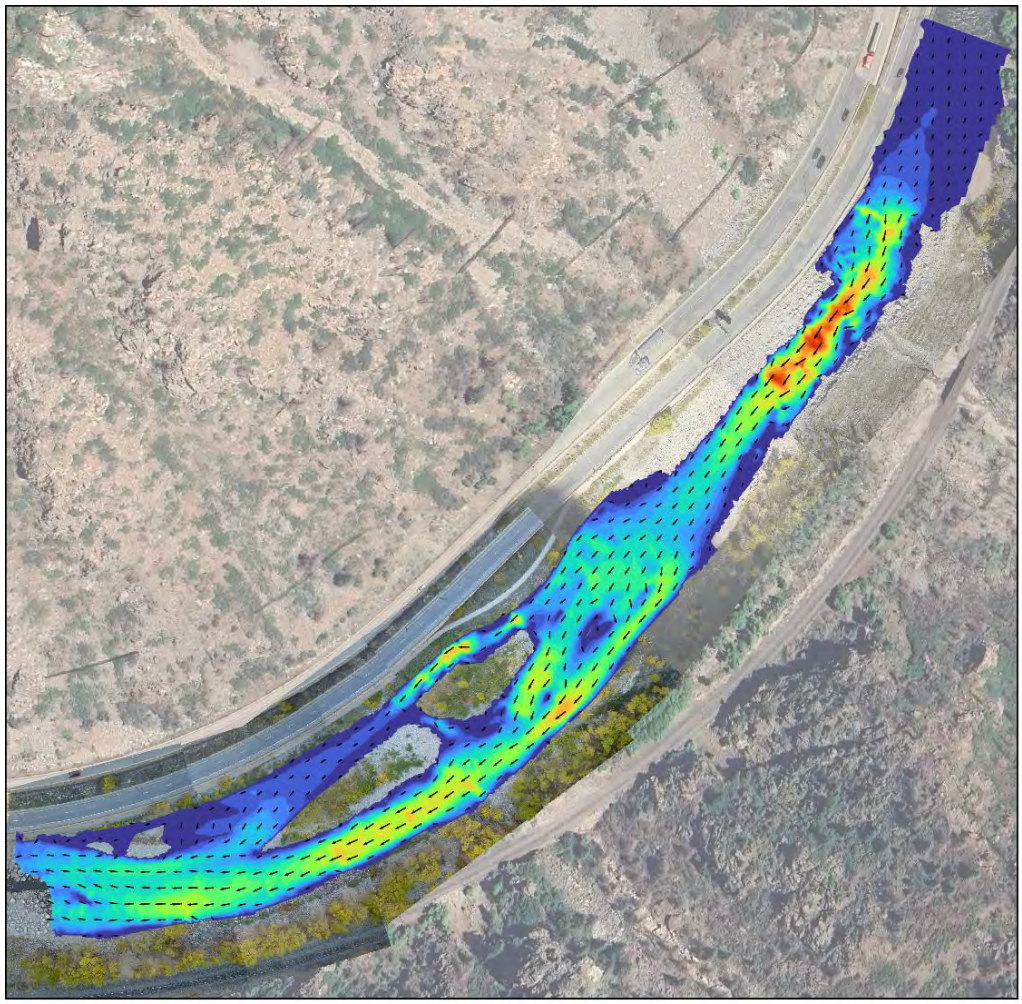
A continuous bathymetric and topographic DEM surface was created using these data described above. This DEM was used in hydraulic modeling efforts, discussed in the Hydraulic Modeling Report.

6. SUMMARY

This survey was successful in collecting sufficient data to develop a detailed DEM of the study reach in Glenwood Canyon. The DEM developed from this survey and the bed material observations were used to model 2D river hydraulics, which is described in the Hydraulic Modeling Report. The data collection described in this report was sufficient for modeling 2D river hydraulics at, or finer than the target resolution for the habitat analysis which was specified as a 25 sqft computational cell size area.

GLENWOOD CANYON AQUATIC HABITAT STUDY
COLORADO RIVER, COLORADO

HYDRAULIC MODELING REPORT – 2024



PREPARED BY RIVERRESTORATION.ORG, JANUARY 2025

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TABLE OF CONTENTS

1. Introduction 1
2. Modeling Methodology 1
3. Results 3
   3.1. Model Outputs 3
   3.2. Model Results Discussion 4
4. Summary 5
5. References 5

TABLE OF FIGURES AND TABLES

Figure 1. Glenwood Canyon 2024 downstream model domain DEM ii
Figure 2. Final spatially distributed Manning's n values used in the SRH-2D hydraulic model 2
Figure 3. Model results showing velocity at a selection of the flows of interest 4
Figure 4. Model results showing depth at a selection of the flows of interest 5

Table 1. Model Manning's n region values 3
Table 2. Model Result Output Raster Data Bands 3

RESULTS DATA APPENDICES

DS_BedElevation.tif
DS_50cfsResults.tif
DS_250cfsResults.tif
DS_700cfsResults.tif
DS_1020cfsResults.tif
DS_1250cfsResults.tif
DS_1400cfsResults.tif
DS_1500cfsResults.tif
DS_1750cfsResults.tif
DS_2000cfsResults.tif
DS_2250cfsResults.tif
DS_2500cfsResults.tif
DS_3000cfsResults.tif

1. INTRODUCTION

A 2 dimensional (2D) hydrodynamic model was used to simulate a variety of low flow conditions for a study reach on the Colorado River in Glenwood Canyon. The model was based on a digital elevation model (DEM) developed from hydrographic survey data collected over an 1,830 foot reach (Figure 1). The goal was to provide spatially discrete data of water depth, velocity, shear stress, and a Froude value for use in a usable habitat analysis.

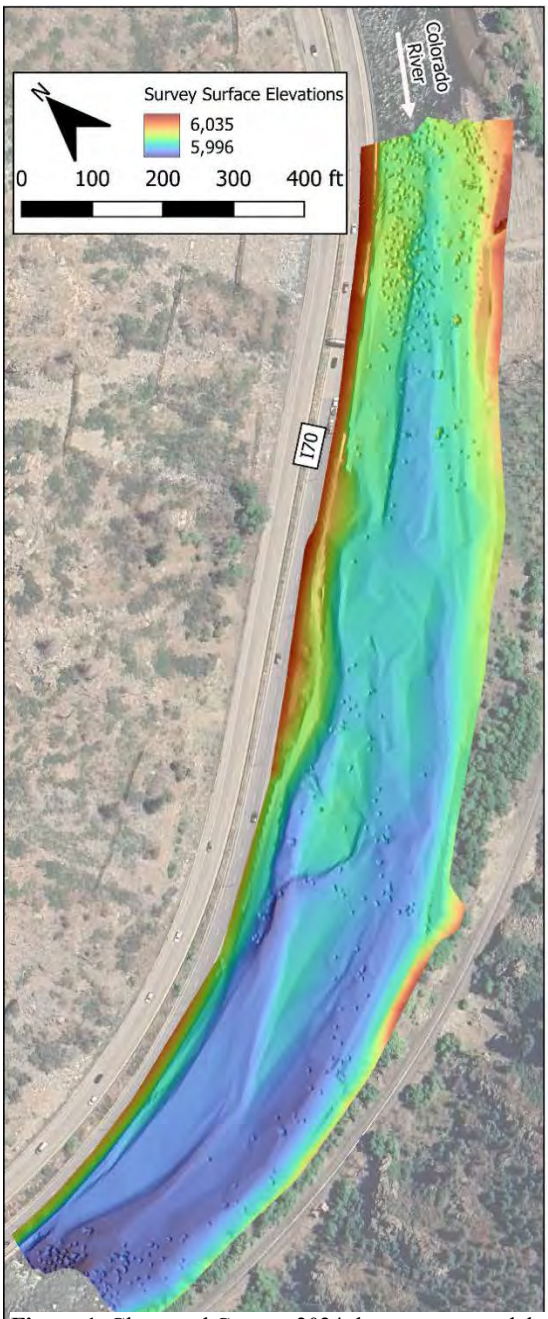


Figure 1. Glenwood Canyon 2024 downstream model domain DEM

2. MODELING METHODOLOGY

Hydrographic survey data (see Glenwood Canyon Survey Report 2024) was used to develop a DEM for the study reach. Point elevations and breaklines were used to characterize bed features like pools, rapids, and individual boulder features. This DEM is available in a geotiff format in the associated data appendices. This DEM was converted into an irregular 2D mesh with a cell sides targeted to a length of 4 feet within the channel using Aquaveo SMS software (Aquaveo, 2015). Due to the SMS software interpolating an irregular mesh, a range of cell side lengths were modeled. Both three and 4 sided cells exist in the irregular grid, leading to a range in cell areas. These cells represent the elevations of the bed and provide calculations locations with discrete boundaries for a solver to calculate a depth-averaged result within. Depth-averaged two-dimensional velocity modeling simulates hydraulics in the streamwise and lateral directions, averaging values through the water column. SRH-2D is a two-dimensional numerical model widely implemented for hydraulic applications and was used here to simulate hydraulic conditions within the project reach (Lai, Yong G. 2009, US Bureau of Reclamation Technical Service Center 2014).

The SRH-2D model requires a spatially distributed friction element in addition to elevation for each cell. This can be provided in the form of a Manning's n value layer. For the model, we used spatially discrete Manning's n values based on the bed sediments observed during the survey. The final values for each area can be found in Figure 2, these values were adjusted within a reasonable range during the model calibration process, discussed below.

In 2023 RiverRestoration completed a modeling effort an 1854 ft reach immediately upstream of the study reach discussed here. The upstream reach represents a deeper pool section of the river. The two reaches combined represent the diverse channel features present in Glenwood Canyon. In the 2023 upstream model, the upper end of the model was artificially extrapolated to allow for the model to non-uniformly distribute flow outside of the area of interest where results were reported. Similarly in the

model presented here the upstream end of the 2D mesh included 300' of bathymetry that was the downstream end of the model created in 2023 (RiverRestoration 2023). This 300' was modeled to provide an area for the inflow to non-uniformly distribute before entering the area of interest in the 2024 model domain. Results and figures provided from the modeling process used for the habitat analysis in 2024 excluded all values in the 300' upstream end.



Figure 2. Final spatially distributed Manning's n values used in the SRH-2D hydraulic model.

SRH-2D requires an upstream and downstream boundary condition. A steady flow rate was used as the upstream boundary condition for each different flow of interest and the model time was run until a steady state was achieved throughout the model domain. A constant water surface elevation (WSE) was used as the downstream boundary condition for each flow rate.

The downstream boundary in the model was set near the crest of the next rapid downstream. However, there did not appear as defined of a grade break as the previous upstream model utilized and near zero flow during and after site survey made locating a critical flow cross section subjective. A 1D flow equation was used to solve for a WSE at each flow of interest. Both a critical flow area and Manning's equations were considered. Based on the downstream boundary's position in the river that did not appear to have a sharp drop or constriction of flow and the low elevation values that a critical flow area equation produced, it was determined that Manning's Equation (Eq.1) would better represent the boundary WSE at different flows. Area (A) and hydraulic radius (R) were solved by changing WSE for the selected cross-section. A bed slope (S) value of 0.0074 was used from survey data. An n value of 0.034 was selected. This value is in line with standard values and was calculated by using the Manning's equation on a cross section near the upstream end of the study reach similar in character to the downstream boundary where a known WSE for a flow of 1020 cfs was surveyed in 2023.

Eq. 1 $$Q = \frac{1.486}{n} * AR^{2/3} * \sqrt{S}$$

Flows of interest for this study were: 50 cfs, 250 cfs, 700 cfs, 1020 cfs, 1250 cfs, 1400 cfs, 1500cfs, 1750 cfs, 2000 cfs, 2250 cfs, 2500 cfs, and 3000 cfs.

Flows remained near zero between the time of survey and the time of reporting, meaning that the collection of high flow calibration WSE data was not available. Due to this lack of available calibration data, several modeling assumptions were made based on results from the 2023 modeling efforts of the immediate upstream reach, which had 2023 calibration data available and examined the same range of flows using the same baseline resolution for calculations. A one second time step was used for model

calculation. The ke turbulence model was used within the SRH-2D. A small number of WSE calibration points for flows of 1020 cfs and 3250 cfs were available at the upstream end of the model, though these were mostly in the pool section that was excluded from the results since it was included in the domain of previous model reporting from 2023 (RiverRestoration, 2023). These available data were used to make minor adjustments to the upstream end of the DEM and to adjust spatially discrete Manning's n values, however their applicability may be limited due to the 2024 runoff occurring between the WSE measurement and the bed survey used to develop the model. Unknown channel changes may have occurred during 2024 runoff. Adjustments resulted in WSE values that matched to within -0.2' of the observed WSE at 1020 cfs at the upstream end of the reach. Manning's n values within the model were set to correspond with the observed bed sediment areas in Figure 2. Table 1 shows the final Manning's n values. Mannings n values were held consistent for all model runs between 50 cfs and 3,000 cfs.

Table 1. Model Manning's n region values

Observed bed material	Manning's n value assigned
Boulder	0.042
Large Cobble	0.041
Cobble	0.040
Vegetation	0.045

The 2024 reach represents more of a consistent riffle character with smaller pool areas around specific bathymetric grade controls, compared to the upstream 2023 reach. As such, inaccuracies or a lack of resolution in areas of the DEM that will control WSE, or pool levels, are much less likely to propagate through a large area of the model. Additionally, the near zero flow level during survey meant that the topography of the lowest sections of the channel as well the rapidly varying elevations associated with large boulders and the islands could be more accurately and completely captured resulting in a more detailed DEM in 2024.

3. RESULTS

3.1. Model Outputs

The model simulations were run until the flowrate into the model came to an equilibrium with the flow rate out of the model and was considered steady state. Results for each simulation were gridded (rasterized) for use in the habitat analysis. SRH2D integrates the governing equations spatially providing a continuously spatially variable result which was then sampled to a selected 0.25 ft X 0.25 ft resolution raster grid containing 7 data bands for each flow modeled. Table 2 shows the data reported in each data band.

Table 2. Model Result Output Raster Data Bands

Parameter	Unit
Froude Number	Dimensionless
Shear Stress	lb./ft^2
Velocity Magnitude	ft/s
Water Depth	ft
Water Surface Elevation	ft
Velocity in X direction	ft/s
Velocity in y direction	ft/s

3.2.Model Results Discussion

The model reach is bound on both sides by steep banks, including vertical concrete in the highway embankment at the upstream end, a steep railroad embankment on the entire left side, and riprap embankment below the pedestrian path on the right. The flows in the range modeled do not breach any of these higher infrastructure elevations. The model also represents areas where the channel geometry is overhung by a suspended concrete bike path on the right upper right bank. The modeled WSE in these areas remains several feet below the path elevations at the highest flow modeled for this analysis, 3000 cfs, but field observations have shown that snow melt runoff high flows in the river can reach these vertical obstructions, limiting the applicability of this model to flow levels less than or equal to 3,000 cfs.

Within the channel, varying channel elements like boulders, bars and islands lead to changes in the wetted area as flows increase. Across the flow range evaluated, the wetted flow area increased 100%. The largest changes took place in the downstream half of the reach were large depositional bars including the lower, unvegetated, areas of the island bar inundated. Much of this inundation occurred by 1500 cfs with flows growing deeper afterwards. At all flows, the highest velocities and most concentrated flow was found in the upstream rapid. The flow generally increases in velocity and depth as discharge increases (Figure 3 and 4). Depths within the study reach are generally shallower than the results from the upstream reach pools modeled in 2023. Additionally, the deepest areas also are found in the channel thalweg and also have high relative velocities, with the narrow, deep pool on the inside of the island the outlier to this trend.

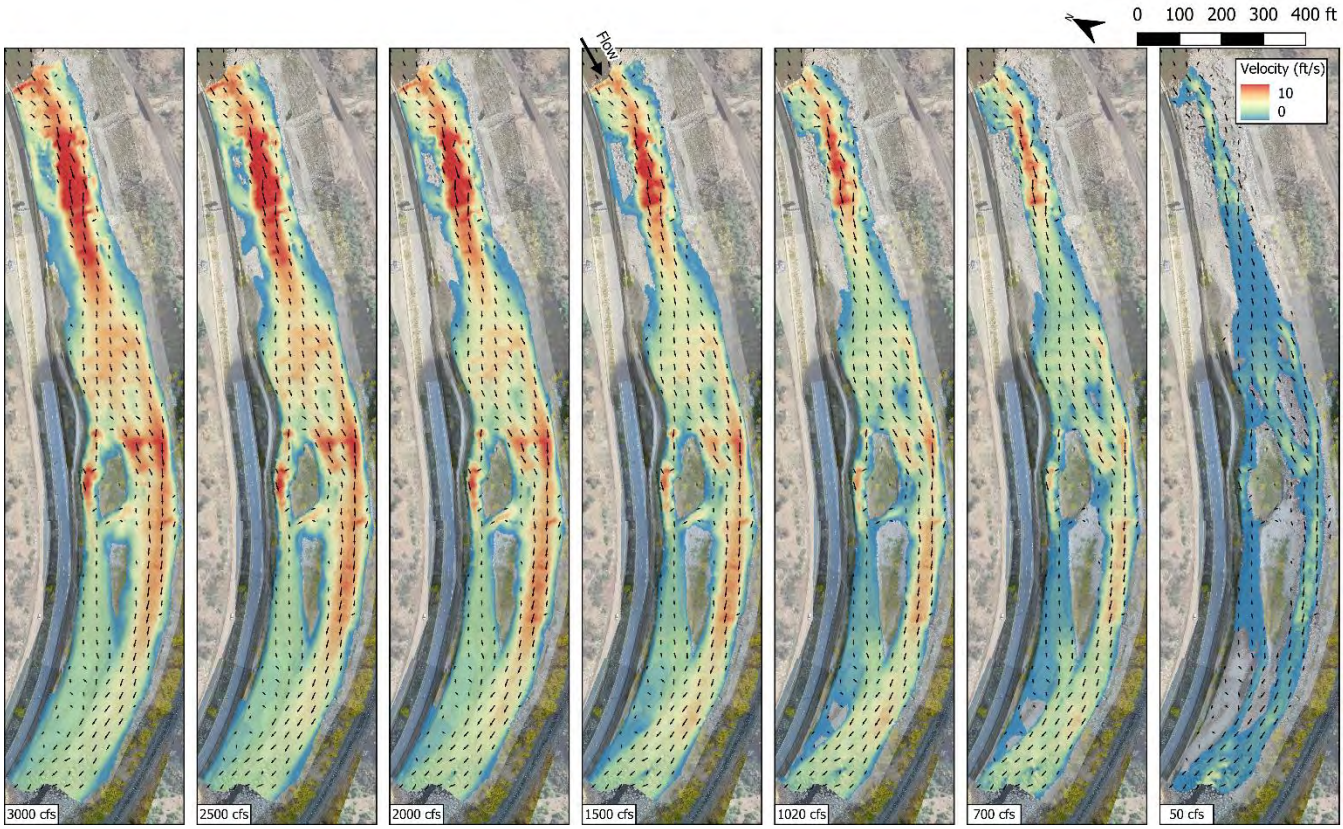


Figure 3. Model results showing velocity at a selection of the flows of interest

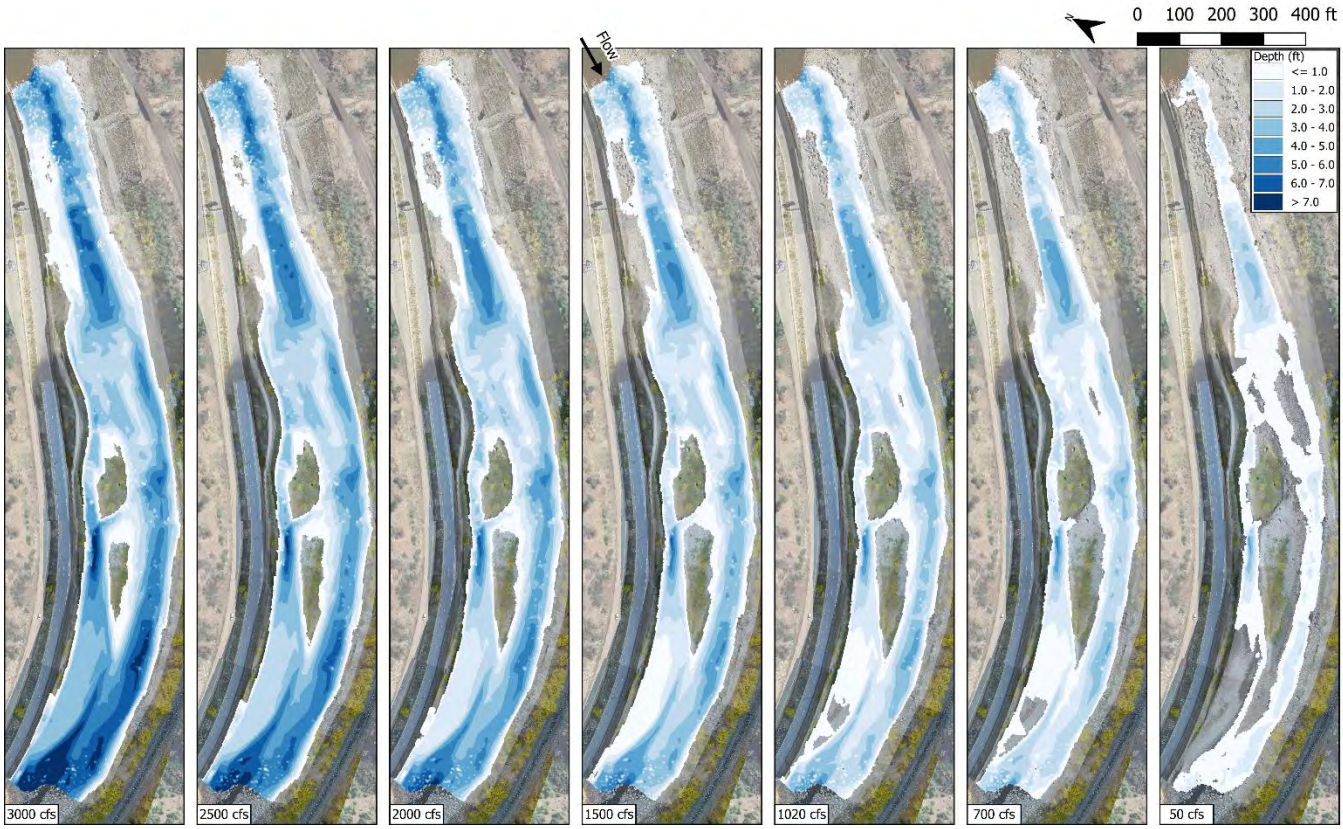


Figure 4. Model results showing depth at a selection of the flows of interest

4. SUMMARY

This report explains how survey data collected in Glenwood Canyon were used to create a 2D hydraulic model. This model was then used to predict hydraulic conditions of the study reach at a range of flows of interest to aquatic habitat at a resolution of approximately 4 ft x 4 ft. The model may have limitations at resolutions less than 4 feet length scale or at flows less than 50 cfs or greater than 3,000 cfs. Results available in the included data appendices can be used in an analysis of the available habitat within the study reach at the specified study flows.

5. REFERENCES

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GLENWOOD CANYON AQUATIC HABITAT STUDY
COLORADO RIVER, COLORADO

HYDROGRAPHIC SURVEY REPORT – 2024



PREPARED BY RIVERRESTORATION.ORG, JANUARY 2025

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TABLE OF CONTENTS

1. Introduction and Survey Methods 1
2. Survey Control 2
3. Survey Conditions 3
4. Survey Results and Observations 3
5. Sediment sample survey 7
6. Base Map and DEM Development 8
7. Summary 9

TABLE OF FIGURES AND TABLES

Figure 1. 2024 Survey Area Overview Map with low water aerial imagery 1
Figure 2. Survey Control Overview Map 2
Figure 3. Observed Substrate Areas 3
Figure 4. Facing downstream at the boulder rapid at the upstream end of survey reach. Devil's Hole Creek enters from the left. The pool at the upstream end (bottom of the image) is where the survey effort ended in 2023. 4
Figure 5. Facing downstream at the two vegetated islands on the center channel cobble bar. The outside bend riffle is on the left and the beaver check dams and pool are on the right. 5
Figure 6. Examples of smaller material within the survey reach. Left - depositional sand on the large cobble bar at the downstream end of the reach. Right – Pocket of gravel and sand behind a large boulder in the outside channel riffle near the islands. 5
Figure 7. First in the series of small beaver check dams pooling water on the inside of the islands. 6
Figure 8. Downstream end of the survey reach. On the left, the outer riffle channel shows larger material and more large boulders that likely originated as colluvium or tributary supply. On the right, the cobble bed pool is currently controlled by the large cobble deposit on the inside of the channel at the downstream end. 6
Figure 9. Sediment sample locations 7
Figure 10. Sediment sample locations at the far downstream end of the channel center cobble bar. Left – area Wolman pebble count was conducted. Right – subsurface sample location with cobble armor layer removed. 8
Figure 11. Apparent trout redd sediment sample location. Red circle indicates the redd location. 8

RESULTS DATA APPENDICES

GlenwoodCanyon_DEM_ft.tif
SubstrateAreas_Polygons.shp
Sediment Grain Size Distributions .pdfs (multiple)

1. INTRODUCTION AND SURVEY METHODS

A hydrographic survey covering 1830 feet of the Colorado River in Glenwood Canyon was conducted on October 15th and 16th. The survey extent encompassed a boulder/cobble rapid at the upstream end and a pool/riffle/island complex at the downstream end. The upstream end of the survey began at the boulder/cobble rapid of the Devil's Hole Creek confluence, where the previous survey in 2023 ended. The 2023 survey represented a reach characterized by larger pools separated by a defined rapid. Together the 2023 and 2024 reaches represent the diverse types of channel forms found in the Shoshone reach. The survey ended at the beginning of the downstream boulder/cobble rapid of an unnamed gulley confluence. Survey was conducted in the channel up to the ordinary high water mark (OHWM) evident in the field. The survey was performed on foot as there was only minimal flow in the river at the time of survey (Figure 1). The survey was performed using RTK GNSS (Figure 2). The survey was conducted using the NAD83 State Plane Colorado Central coordinate reference system (CRS) in US survey feet, vertical datum of NAVD88, and using the CONUS18 geoid model. Survey control was based on points provided by CDOT and tied in local control monuments via GNSS observations. Instruments utilized included Trimble R12i (rovers) and R10 (base) GNSS units. The base point held during the entire survey was CDOT Point 2528 in Figure 1 and Table 1.

In addition to the bathymetric survey, the bed material was characterized at each topographic survey point throughout the survey reach and high-resolution ortho imagery was captured from 200' and 400' AGL throughout the reach.



Figure 1. 2024 Survey Area Overview Map with low water aerial imagery

2. SURVEY CONTROL

The survey was based on control provided by CDOT for monuments recovered in the vicinity of the Hanging Lake rest area. Two control monuments were utilized with the coordinates provided in Table 1; Point 2528 was held as the location of the RTK GNSS base station during both days of the survey and point 2541 was used to check the initial base set up with RTK GNSS rovers. In November 2023, eight additional control monuments were found and tied into the control network using 180 second RTK GNSS observations. These monuments were on the bike path that paralleled the survey reach and consisted of brass survey markers and "X" marks scrawled in the concrete placed by CDOT. These monuments were used for internal survey checks but coordinates in Table 1 should not be considered survey control quality based on the limited GNSS constellation observed at the bottom of the Glenwood Canyon.



Figure 2. Survey Control Overview Map

Table 1. Control Point information. NAD83 State Planes Colorado Central US Survey Feet, NAVD88, Geoid CONUS18. Coordinates are based on RTK GNSS survey in 2023 holding 2528 and should not be considered survey control quality for future surveys.

Source	Point	Northing	Easting	Elevation	Description
CDOT	2528	1643610.52	2523096.51	6125.178	CDOT 1075--Type 5S IN CONC BIKE PATH
CDOT	2541	1644023.31	2523811.81	6117.827	CDOT 1075--Type 5S IN CONC BIKE PATH
GPS est.	193	1640379.889	2519661.18	6023.026	Brass Marker PT 193
GPS est.	194	1640815.124	2519923.869	6027.73	Brass Marker PT 194
GPS est.	195	1641175.599	2520304.564	6026.45	Brass Marker PT 195
GPS est.	196	1641401.255	2520778.948	6029.373	Brass Marker PT 196
GPS est.	300	1641308.444	2520530.666	6027.274	Concrete Scrawl X
GPS est.	301	1641008.418	2520098.404	6027.054	Concrete Scrawl X
GPS est.	302	1640601.825	2519781.121	6024.546	Concrete Scrawl X
GPS est.	303	1640170.93	2519540.383	6022.625	Concrete Scrawl X

3. SURVEY CONDITIONS

Site survey took place on October 15th and 16th, 2024. Both days were generally mild and clear, with light passing showers. The project reach is located approximately 9 miles downstream of USGS stream gage 09070500 on the Colorado River near Dotsero, CO. During the survey the gage was near 1,200 cfs, however the Shoshone Power Plant was diverting the entire river flow around the project reach. A small amount of flow leaks at the dam cutoff in addition to minor inflow trickles downstream of the dam, meaning there is still a small amount of water in the survey reach. This flow was assumed to be below 10 cfs, but did lead to some deep pool areas remaining.

4. SURVEY RESULTS AND OBSERVATIONS

The survey reach was selected to represent hydraulic characteristics present in the pool/rapid Glenwood Canyon reach of the Colorado River. The survey included one boulder/cobble rapid at the upstream end and an extended riffle/island/pool complex for the majority of the reach. The upstream boundary was a pool included in the original survey and modeling efforts in 2023, and the downstream boundary was the top of the next boulder/cobble riffle going downstream. Bathymetric and topographic data points were collected to represent bed elevations throughout the survey reach (Figure 3). Information on bed materials including sediment classes and vegetation types were recorded with the points. Areas with depositional sediments and signs of recent maximum high water levels were also recorded, as were water surface elevations (WSE) throughout the reach for the extreme low survey flow. Aerial ortho-imagery was collected to help locate and quantify larger topographic features such as mid channel boulders during post processing.

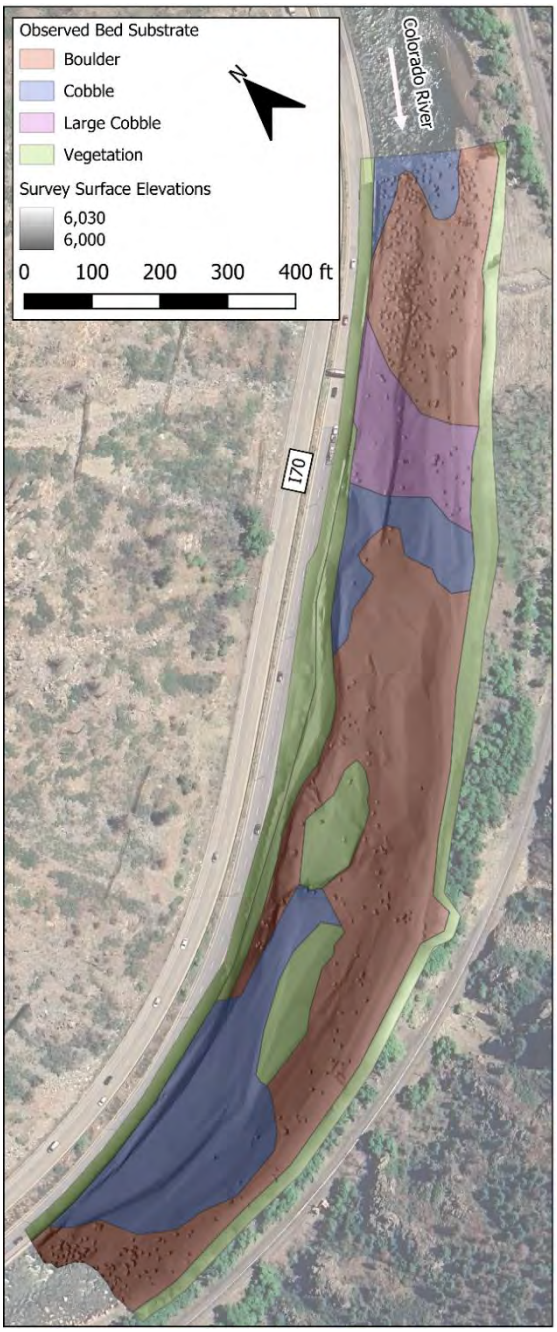


Figure 3. Observed Substrate Areas

The upstream rapid is generally comprised of large colluvial with dozens of boulders ranging from 2'-6' scattered over the top (Figure 4). Much of the material was likely deposited from post-burn flash floods debris flows out of Devil's Hole Creek on the south bank. Many boulders in the rapid were also likely mechanically placed and relocated as part of CDOT or railroad repair and protection efforts. Below the rapid, the bed slope decreases and the remaining reach is dominated by two vegetated islands (Figure 5) near the inside of the bend, a riffle on the outside of the bend, and deeper pools sheltered by the islands on the inside. The majority of the bed through this reach remains coarse and is best described as large cobbles or small boulders, with many larger boulders protruding throughout. Pockets of small material including gravels and sands were found throughout, but generally in proximity to larger boulder features or the islands (Figure 6).

The two islands exist as a part of the same midchannel bar that likely formed downstream of where the riprap right bank extends further into the channel forcing higher flows towards the left bank. The islands are separated by a low portion of the bar were only cobble and boulders are found without vegetation. The upstream island is roughly 2.5' higher in elevation and has more mature vegetation established including small trees, but the majority of the vegetation are mature willows and the downstream island is only willows and similar riparian shrubs. Both islands consist of the same coarse bed material of cobble and boulders, but the upstream island has more and larger boulders and appears more stable. The downstream island appears to be a part of the more dynamic portion of the larger cobble bar.

The left, outer, channel around the islands has more conveyance, and generally a more consistent bed slope at the time of survey. The right, inner, channel is smaller and at the time of survey had a series of beaver check dams (Figure 7) stepping down the water near the upstream island. The channel along the downstream island consists of a large pool that is controlled by a large cobble deposit near the tail of the island (Figure 8). It is anticipated that these areas may change to have more conveyance during the highest of flows. The downstream end of the survey reach is where the tail end of the mid channel cobble bar and inside cobble deposit transition to another steep boulder rapid consisting of material from a gully on the south side of the river that flashed and crossed the railroad tracks following recent wildfires. Some of this material was similarly mechanically moved and placed into the river.

Higher up elevations near the OHWM on each bank consisted of mechanically placed riprap rock materials supporting the pedestrian path and I70 on river right and railroad on river left. The upper 400 ft portion of the river right bank was a vertical concrete wall under a cantilevered bike path with riprap along the right toe.

Both banks were generally well vegetated despite their coarse riprap material, and a clear edge of vegetation boundary existed through most of the reach indicating periods of consistent flow levels through the reach. Deviations from the vegetated banks included the alluvial fan deposits of Devil's Hole Creek where only immature vegetation has established, the upper portion of the right bank where the cantilevered path exists, and the left bank near the downstream end of the reach where the channel is closer to the railroad tracks and the bank consists of steeper and looser material. Devil's Hole Creek tributary channel exhibited some incision which may be ongoing after the 2024 runoff.



Figure 4. Facing downstream at the boulder rapid at the upstream end of survey reach. Devil's Hole Creek enters from the left. The pool at the upstream end (bottom of the image) is where the survey effort ended in 2023.



Figure 5. Facing downstream at the two vegetated islands on the center channel cobble bar. The outside bend riffle is on the left and the beaver check dams and pool are on the right.



Figure 6. Examples of smaller material within the survey reach. Left - depositional sand on the large cobble bar at the downstream end of the reach. Right – Pocket of gravel and sand behind a large boulder in the outside channel riffle near the islands.



Figure 7. First in the series of small beaver check dams pooling water on the inside of the islands.

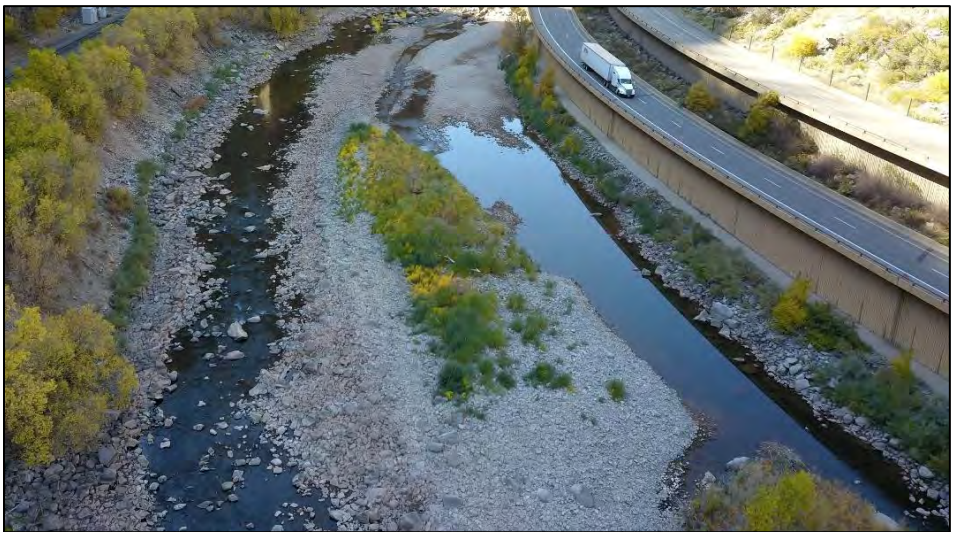


Figure 8. Downstream end of the survey reach. On the left, the outer riffle channel shows larger material and more large boulders that likely originated as colluvium or tributary supply. On the right, the cobble bed pool is currently controlled by the large cobble deposit on the inside of the channel at the downstream end.

5. SEDIMENT SAMPLE SURVEY

Bed materials in the reach were sampled at five locations to quantify the size of typical sediments present, particularly in cobble and gravel areas that may represent better aquatic habitat (Figure 9). Two Wolman pebble counts and three grab samples were completed, the grain size distribution (GSD) of each can be found in the Sediment Grainsize Distribution Appendix. The Wolman pebble counts were performed at the midpoint and downstream end of the main midchannel bar that included the two vegetated islands. These locations represented areas that are frequently inundated and contain fewer large boulder elements. Particle size distributions were similar in both of these locations with most cobbles larger than 4". The sample midway up the bar, between the two vegetated islands, skewed slightly larger, and this area also had more boulders present. A subsurface grab sample was taken in the vicinity of the downstream pebble count and sent to a lab for sieve analysis as it was a much smaller material class (Figure 10). The subsurface GSD had a D_{50} of 10.35 mm and was roughly 1/10 the diameter of the surface pebble count at the D_{10}, D_{50}, and D_{60} benchmarks. This is consistent with expected bed armoring downstream of a dam. The two remaining grabs samples were taken upstream of the islands on the inside of the bend and included both surface and subsurface material. One was taken from a depositional gravel bar above the survey water surface elevation, the other was taken from an apparent trout redd under the water (Figure 11). The trout redd was identified by apparent cleaned and sorted gravels that did not match the condition of the surrounding algae matted or fines veneered bed material. The sample in the redd location contains more coarse gravel and less sand and silt than the nearby gravel bar location. Numerous large trout were observed in the isolated pools during survey. A beaver lodge and beaver activity were also noted during survey.



Figure 9. Sediment sample locations



Figure 10. Sediment sample locations at the far downstream end of the channel center cobble bar. Left – area Wolman pebble count was conducted. Right – subsurface sample location with cobble armor layer removed.



Figure 11. Apparent trout redd sediment sample location. Red circle indicates the redd location.

6. BASE MAP AND DEM DEVELOPMENT

Survey data were post-processed to remove potential spurious data and check for consistency. Interpolation of some topographic data was required in areas where complex topography made detailed survey unsafe, but this was expected from the outset, and the majority of the survey extent was covered by on the ground field survey. A digital elevation model (DEM) was created for the entire surveyed project reach using a triangular irregular network (TIN) to connect surveyed points along with breaklines to represent the existing conditions in the field. Additional breaklines were included to represent boulder clusters based on the collected aerial ortho-images. Elevations for some of these features had to be estimated based on nearby similar elevation features that were surveyed or nearby water surface elevations.

Field survey only took place up to the OHWM. For areas above this elevation, LiDAR data was added to the DEM. This LiDAR DEM data is publicly available data collected on flights in June of 2016 for the Colorado Water Conservation Board (https://coloradohazardmapping.com/lidarDownload). The data is

formatted as a geotiff with 3 ft resolution. The LiDAR survey was carried out in the same coordinate reference system as this ground based survey; State Plane Colo. Central, NAD83, NAVD88. The LiDAR survey used the 12B geoid model as opposed to the more recent CONUS18 geoid model, but in the area of interest, this difference is not expected to have an impact. The LiDAR data inserted was well aligned with the surveyed ground elevations and required minimal editing of the DEM to mesh to two surfaces. Because the ground survey went to the elevation of the OHWM, the LiDAR based data inserted at elevations higher than this are not expected to have a significant error on the flow levels of interest for this project.

A continuous bathymetric and topographic DEM surface was created using these data described above. This DEM was used in hydraulic modeling efforts, discussed in the Hydraulic Modeling Report.

7. SUMMARY

This survey was successful in collecting sufficient data to develop a detailed DEM of the study reach in Glenwood Canyon. The DEM developed from this survey and the bed material observations were used to model 2D river hydraulics, which is described in the Hydraulic Modeling Report. The data collection described in this report was sufficient for modeling 2D river hydraulics at, or finer than the target resolution for the habitat analysis which was specified as a 25 sqft computational cell size area, or a 5 ft x 5 ft cell.

Biological and Recreational Resources Dependent on Colorado River Flows Through Glenwood Canyon

September 2024



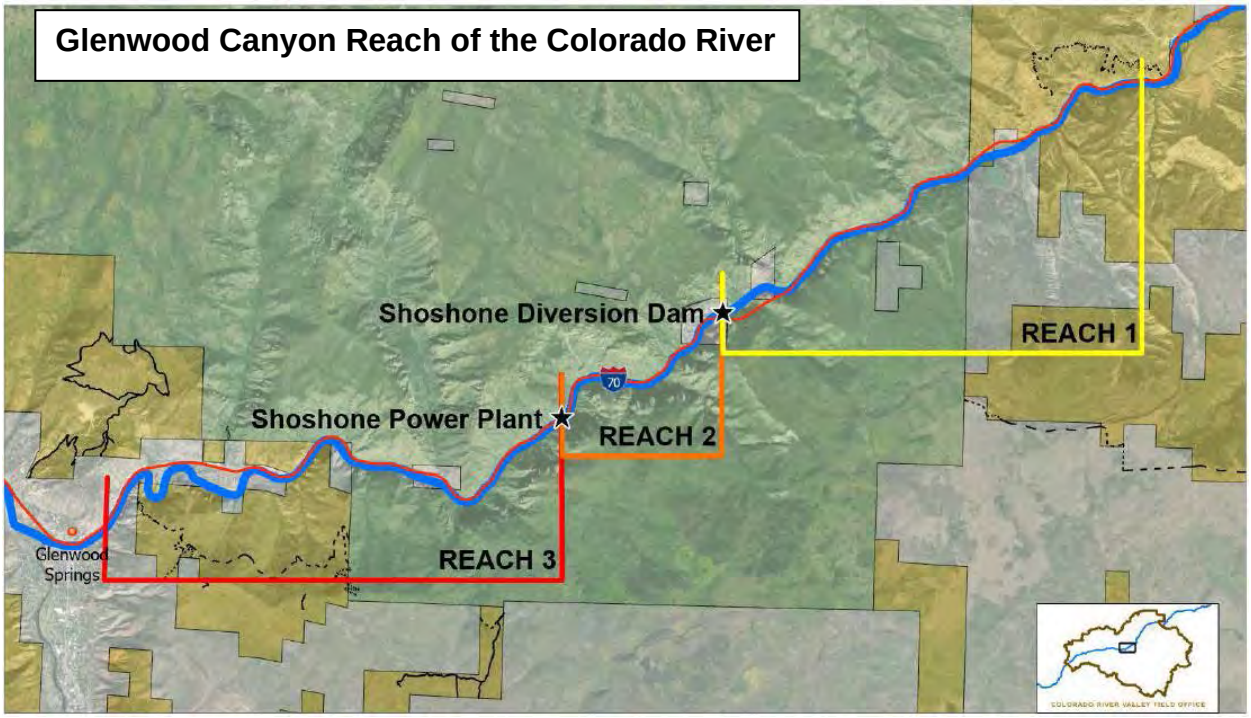
Introduction

This document provides an executive level summary of the natural environment supported by Colorado River flows in Glenwood Canyon, and qualitatively describes the relationship of that natural environment to physical infrastructure and operations of Excel's Energy's Shoshone Power Plant. This document also describes other water-dependent values upstream and downstream from Glenwood Canyon that are highly dependent on consistent flows through Glenwood Canyon. This document does not attempt to quantify natural resource benefits or impacts associated with operation of the Shoshone Power Plant, which would require intensive study of the river channel morphology, hydrology, fish populations, and riparian communities.

This document incorporates biological and recreation information available to the Bureau of Land Management (BLM) and White River National Forest (WRNF), including information from other resource management agencies. Even though this document incorporates information from other agencies, it does not purport to represent any formal position that any agency may take regarding proposed changes to land management or streamflow management in Glenwood Canyon.

Background – Land and Water Management

The Colorado River flows west/southwest through Glenwood Canyon for approximately 18 miles from west of Dotsero, Colorado to Glenwood Springs, Colorado. The river within this reach is naturally confined by a steep and narrow limestone canyon, and further constricted by a four-lane Interstate highway, railroad, and pedestrian bike path. Other infrastructure located within the river corridor includes power lines, two Colorado Department of Transportation (CDOT) rest areas, Excel Energy's Shoshone Hydropower Plant and Dam, the CDOT operations center at Hanging Lake Tunnel, Hanging Lake trailhead, the small community of No Name, and the privately owned Bair Ranch.



Glenwood Canyon is a popular destination for recreation, including but not limited to walking/jogging, biking, whitewater rafting, fishing, and viewing the scenic river corridor and riparian communities. Several small tributaries and two larger streams that contain significant fisheries, Grizzly Creek, and No Name Creek, flow into the Colorado river within this reach. In 2020, the river corridor was impacted by the Grizzly Creek Fire that burned the entire length of the canyon. Rain-induced post-fire debris flow events have impacted the river channel, highway, pedestrian bike path, and the Shoshone Power Plant since the fire.

Despite extensive human modification of the river corridor, the river still supports a regionally significant natural environment that draws many visitors to the canyon. The natural environment supports native and sport fish populations, Rocky Mountain bighorn sheep, and riparian plant communities that are adapted to the ecological constraints within the canyon. Colorado Parks and Wildlife (CPW) periodically monitors fish and big game populations in the canyon but inventories of other biological attributes, including non-game species, have been limited.

The majority of the canyon is National Forest Systems Lands managed by the White River National Forest, and in partnership with CDOT. The BLM manages lesser amounts of lands within the river corridor at each end of Glenwood Canyon. Together the WRNF and BLM emphasize management of visitation and recreation infrastructure while also supporting the ecological function of the Colorado River. In addition to further clarifying the recreational use of the Canyon, the general physical and biological attributes associated with the Canyon are outlined below.



Glenwood Canyon at the Shoshone Dam and Tunnels

In Glenwood Canyon, the Shoshone Hydropower Plant has been in existence for over 100 years and is one of the most senior water rights in the Colorado River watershed within Colorado. This senior water right assures that stream flows make it to the point of diversion when a priority call is made. The hydropower operation consists of three primary components – the Shoshone Dam, which backs up water to the point of diversion, a pipeline from the point of diversion, which operates via gravity flow, and the Shoshone Power Plant, which receives water from the pipeline. When fully operational, the powerplant can place a priority call for two water rights that are diverted to the penstocks of the powerplant, one water right for 1,250 cubic feet per second (cfs) under a 1905 priority and another water right for 158 cfs under a 1940 priority.

In 2016, multiple parties, including the U.S. Bureau of Reclamation, the Colorado Division of Water Resources, water districts, and water users, signed a 40-year agreement referred to as the "Shoshone Outage Protocol."[1] The protocol is designed to maintain the flow regime on the Upper Colorado River, even when the Shoshone Power plant is not calling for water due to operational constraints. The agreement calls for deliveries to the powerplant of 1250 cfs from March 25 to November 10 and 950 cfs from the November 11 to March 24. The agreement includes limits on the volume of water to be delivered to the powerplant each year and it also includes provisions that alter the rate and volume of water delivered to the powerplant during drought conditions.

Wild and Scenic Rivers Management

In 2014, BLM and WRNF amended their respective resource management plans and forest plans to include Wild and Scenic Rivers management prescriptions for Glenwood Canyon and for segments of the Colorado River upstream from Dotsero to Kremmling. Pursuant to study guidance found in the 1968 Wild and Scenic Rivers Act, the agencies determined that the river segments are free flowing (free of impoundments and large diversions), with the exception of the portion of Glenwood Canyon that is occupied by the diversion dam and reservoir associated with the Shoshone Power Plant. The agencies also determined that the river segments support Outstandingly Remarkable Values (ORVs), which are defined as river-related values that are unique or exemplary within the region of comparison. Given those findings, the agencies concluded four river segments are eligible for inclusion in the National Wild and Scenic Rivers System. The river segments analyzed and the ORVs identified are as follows:

Name of Segment	Outstandingly Remarkable Values
Colorado River – Gore Canyon (Segment 4)	Scenic, Recreational (Fishing, Floatboating, and Scenic Driving), Geologic, Wildlife, Historic
Colorado River – Pumphouse to State Bridge (Segment 5)	Scenic, Recreational (Fishing, Floatboating, and Scenic Driving), Geologic, Wildlife, Historic
Colorado River – State Bridge to Dotsero (Segment 6)	Scenic, Recreational (Floatboating, and Scenic Driving), Botanical, Wildlife
Colorado River – Glenwood Canyon (Segment 7)	***Recreational (Whitewater Boating, Scenic Viewing, Hiking), Scenic, Geologic***

As part of the 2014 agency evaluation of whether the river segments are suitable for inclusion in the National Wild and Scenic Rivers System, the agencies received an alternative management plan proposal from the Upper Colorado River Wild and Scenic Stakeholder Group (SG) which is designed to protect and enhance the ORVs. The SG plan was adopted by BLM and WRNF planning decisions on June 25, 2015, with the objective of assisting the two agencies in meeting management requirements under the Wild and Scenic Rivers Act for eligible stream segments on the Colorado River. Specifically, the SG plan was adopted to monitor, protect, and enhance the ORVs identified in BLM and WRNF Eligibility Reports for Segments 4 through 7.

By design, the SG plan focuses on the most highly flow dependent ORVs, specifically recreational float-boating (in segments 4-7) and recreational fishing (in segments 4-6). The

[1] Shoshone Outage Protocol Agreement Number 13XX6C0129 dated June 27, 2016.

intent of adopting the SG plan was that it will complement, and be coordinated with, BLM and WRNF land use authorities and land use decisions, enabling the federal agencies to better fulfill management requirements under the Wild and Scenic Rivers Act. The SG plan offers the benefit of monitoring streamflow through the Wild & Scenic segments, and then supplementing this with coordinated, cooperative, and voluntary water deliveries coordinated by the SG, when available. The intent of the SG plan is to balance permanent protection of the ORVs, certainty for the stakeholders, water project yield, and flexibility for waters users.

It is important to note that the SG Plan[2] relies on the existence of the Shoshone Power Plant water rights as one of its Tier 1 Long-Term Protection Measures:

> *Existing senior water rights*: The Shoshone and Cameo groups of senior water rights generally control the administrative call within the Colorado River Basin. These water rights are located downstream of the subject stream reaches; therefore, an administrative call during dry or average conditions by these water rights can curtail diversions from upstream junior water rights or require the release of water from storage to replace those junior diversions. This administrative call generally results in stream flow through the subject stream segments in amounts greater than would exist in the absence of the administrative call. (Page 36)

Fisheries Summary

The Colorado River within the canyon has three distinct reaches resulting from the presence of Excel Energy facilities: Reach 1 upstream of the Shoshone Dam, Reach 2 from Shoshone Dam to the Shoshone Power Plant outlet, and Reach 3 downstream from the Shoshone Power Plant return flow outlet.

Reach 1, upstream of the dam, is characterized by a flattened/reduced river gradient. The impounded water substantially reduces water velocities, resulting in high sediment deposition above the dam. Aquatic habitat diversity and complexity is reduced due to a lack of riffle-run sequence habitat characteristic of a typical free flowing river. In addition, the dam is a physical barrier to movement of aquatic organisms both upstream and downstream when it is not bypassing river flows and a flow velocity barrier to upstream movement when water is being bypassed. This results in fragmentation of habitat.

Reach 2 encompasses the 2.5 miles of river between the Shoshone Dam and the Shoshone Power Plant return flow outlet. During seasonal low flow periods, the reach is substantially dewatered when the plant is operating. Flows are highly variable throughout the year depending on if the plant is in operation or not. During operations, habitat in the river channel is weakly connected by small inflows of groundwater and tributary streams that fill pools and flow through the large boulder and rock substrate. This reach contains both the lower and higher gradient sections that provide a complexity of habitat when the native flows are allowed to bypass the dam. Habitat persists even during low flow periods, though wetted area in the stream channel is substantially reduced.

Reach 3 begins where native flows are returned to the river during operation of the Shoshone Power Plant and extends downstream to the city of Glenwood Springs. The river regains its natural character with a mix of riffle, run, and deep pool habitats that all contribute to improved channel complexity and diversity.

[2] https://www.upcowildandscenic.com/uploads/1/3/5/3/135388668/amended_and_restated_sg_plan_july_2024.pdf



Shoshone Powerplant

Below is a brief biological summary of the Colorado River within Glenwood Canyon based on fish sampling data, incidental aquatic invertebrate notes, and riparian habitat assessments by BLM and WRNF.

Fishery surveys on the Colorado River are conducted annually by CPW in cooperation with the BLM and WRNF. These surveys include reaches in and near Glenwood Canyon. Based on these surveys, the following fish are considered resident to the Colorado River in Glenwood Canyon:

Sportfish
Brown Trout, Rainbow Trout, Cutthroat Trout, Rainbow-Cutthroat hybrids, and Mountain Whitefish.



Rainbow Trout



Brown Trout



Mountain Whitefish

Native Fishes

Three native species, including Flannelmouth Sucker, Bluehead Sucker, and Roundtail Chub, are referred to the “Three Species” because they are the subject of a multi-state, multi-agency conservation agreement. Other native species include Colorado River Cutthroat Trout, Sculpin, and Speckled Dace.



Flannelmouth Sucker



Roundtail Chub

Invasive/Nonnative Fishes

White Sucker, Longnose Sucker, and Hybrid Suckers

As mentioned previously, the Reach 1 fishery is impacted by the Shoshone Dam, which impounds water, reduces gradient, reduces water velocities, and allows the deposition of fine sediment, resulting in decreased habitat complexity and diversity. The silting in of river substrates and the loss of riffle/run sequences limits macroinvertebrate productivity, native sculpin habitat, and juvenile fish refugia areas. Consequently, fish productivity within the reach is reduced because of limited food supplies. In addition to macroinvertebrate production, riffles and runs provide important fish spawning habitat for desirable native and sport fishes.

Reach 2 is impacted by the hydropower operations via reduced and highly variable flows depending on hydropower plant operational status. When the plant is operating, and during natural seasonal low flow periods, sediment transport is inhibited, wetted habitat is reduced, and channel/flow connectivity is impaired. The highly variable flow rates limit aquatic invertebrate productivity, an important food source for resident fish. Variable flows also can impact fish spawning activities within the reach due to impaired availability of and accessibility to preferred spawning habitat.

In Reach 3, where the natural river flow regime is reestablished, the river harbors a robust sportfish fishery comprised of Brown Trout, Rainbow Trout, and Mountain Whitefish. Despite the threats posed from invasive fish species, native Flannelmouth Sucker and Bluehead Sucker are regularly detected in the Colorado River in and adjacent to Glenwood Canyon, along with Roundtail Chub, Sculpin, and Speckled Dace. The benefits from the hydropower return flows include increased riffle, run, and pool complexes, coupled with abundant large boulders. With flows sufficient for effective sediment transport, this reach contains diverse, high-quality habitat for aquatic species. The resiliency of the aquatic ecosystem is sustained with the greater abundance of riffle habitat that improves macroinvertebrate and resident fish productivity.

Fish species composition is likely similar within the three reaches, but species relative abundance, particularly of fish species that prefer higher gradient and reduced sediment loads (Sculpin, Trout, and Mountain Whitefish), are likely reduced in Reaches 1 and 2 due to the previously mentioned modification of flow rates and channel composition. Species such as Sculpin are particularly sensitive to increases in sediment deposition as they live within the interstitial spaces amongst larger river substrates. Trout and Mountain Whitefish require clean gravel and cobble substrates for spawning and rearing of juveniles.

Importance of Flows to Federally Listed Fishes

In addition to the local fish community, Shoshone water rights help support flows important to four downstream fish species federally listed under the Endangered Species Act: Bonytail, Colorado Pikeminnow, Humpback Chub, and Razorback Sucker. Specifically, flows help support important habitat located in the “15-mile reach” of the Colorado River located from the town of Palisade to the Gunnison River confluence in Grand Junction. This reach is particularly vulnerable to very low flows as substantial water withdrawals occur just above Palisade for agricultural and other uses. This report does not attempt to quantify the timing or magnitude or flows that benefit the 15-mile reach from exercise of the Shoshone water rights.

Shoshone Reach Instream Flow Habitat Data Analysis

Freshwater Consulting, LLC, under contract to the Colorado River Water Conservation District, completed an aquatic habitat analysis for the portion of Glenwood Canyon affected by water diversions to the Shoshone Power Plant.[3] The objectives were to determine the current state of the aquatic habitat and aquatic ecosystem in the Shoshone Reach and determine expected changes to the aquatic habitat and aquatic ecosystem due to hydrologic change if the Shoshone Power Plant water rights were wholly or partially dedicated to instream flow use.

BLM and USFS aquatic resources staff reviewed the report and determined the following:

[3] Shoshone Reach Instream Flow Habitat Data Analysis, Habitat Simulations and Habitat Evaluation of the Colorado River from the Shoshone Diversion to the Shoshone Power Plant Outfall, William J. Miller, PhD, Freshwater Consulting, LLC, August 2024.

- The study utilized broadly accepted scientific procedures for two dimensional hydraulic modeling.

- The habitat suitability criteria used for the fish species of interest, which include multiple species of trout and flannelmouth sucker, appear to be appropriate and incorporate data from multiple river locations in Colorado.

- The study selected cross section and modeling locations with habitat types that are generally representative of Glenwood Canyon, including pools, riffles, rapids and runs.

- The key study conclusions, listed below, appear to be well supported by the habitat modeling results:

    - For older life stages of trout, Mountain Whitefish and Flannelmouth Sucker, the highest habitat availability is at flows that range from 750 cfs to 1,500 cfs.

    - Usable fish habitat gradually declines from 1,500 to 3,000 cfs, but there is still significant habitat available. At higher flow rates, habitat for trout fry decreases significantly.

    - Fish habitat availability quickly declines as flows decrease below 750 cfs.

- The study correctly notes that periphyton, algae, and benthic macroinvertebrates are important food resources for higher trophic levels, and that such resources are significantly impacted by no flow or low flow events caused by diversions to the Shoshone Power Plant.

- The study correctly notes that flow variability, including flood and drought events, are critical for maintaining the overall functioning of aquatic ecosystems, including the riparian communities along the river.

- BLM and USFS concur that any increases in base flows through the reach impacted by Shoshone Power Plant diversions are likely to improve and stabilize aquatic habitat.

Aquatic Invertebrates

A variety of macroinvertebrate species inhabit the Glenwood Canyon. Of primary interest are the EPT taxa (Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Tricoptera (Caddisflies), as the presence and abundance of these taxa reflect the health of aquatic systems. These and other aquatic invertebrates provide important high value food sources for resident fish, birds, and bats and are an important component of the riverscape food web.



Adult Stonefly



Adult Mayfly

Like fish, macroinvertebrate diversity and density, particularly for EPT taxa, are likely higher in Reach 3 below the Shoshone Power Plant where flow is reestablished, because the river contains less fine sediment and increased riffle habitat important for macroinvertebrate productivity. Macroinvertebrate productivity is likely reduced within Reach 2, because of reduced and highly variable flows depending on hydropower operations. Because of the dam, Reach 1 contains very few riffles, and the reduced river gradient allows fine sediments to settle out. A lack of riffle habitat and increased sediment deposition favors sediment tolerant taxa and reduces overall macroinvertebrate densities and diversity within the reach. EPT taxa are particularly sensitive to increased sediment loading and require clean, well oxygenated substrates in which to thrive.

Reduced macroinvertebrate densities can negatively affect the riverscape food web. As with fish, robust macroinvertebrate sampling would be informative regarding perceived differences in species composition and densities within the three reaches.



Rock Covered in Caddisfly Cases

Riparian Vegetation

Riparian vegetation expression is limited within Glenwood Canyon due to several factors, but the most prominent factor is that the reach is within a steep, narrow canyon controlled by bedrock. This geologic context results in a riverscape that contains only a narrow band of alluvial aquifer

on each side of the river that can support riparian vegetation. The canyon contains only short, disjunct reaches supporting significant floodplain acreage. Other factors limiting riparian vegetation extent include confinement from the interstate highway, railroad, bike path, and other previously noted infrastructure.



Glenwood Canyon Riparian Vegetation

Where present, riparian vegetation provides river cover and shading; increased bank armoring and stabilization; habitat for terrestrial insects an important food source for fish, birds, and bats; bird nesting habitat; and scenic and aesthetic values.

Primary riparian vegetation species noted within the canyon include narrowleaf cottonwood, chokecherry, red-osier dogwood, box elder, willow, wild rose, skunkbush, riparian grasses, sedges, and rush. Riparian species composition appears similar within all three reaches, but densities vary throughout the canyon.



Colorado River and Riparian Vegetation – Glenwood Canyon

Despite the natural and human induced constraints limiting the amount and spatial extent of riparian vegetation within the steep canyon, where riparian vegetation exists, it supports scenic attributes, valued ecological functions, and important wildlife habitat. BLM has completed Proper Functioning Condition riparian condition assessments on the lands it manages within Reaches 1 and 3. Given the geological and human induced limitations within the canyon, both BLM-managed riparian segments were found to be in Proper Functioning Condition.

Recreation

Recreation use in Glenwood Canyon and Colorado River segments located upstream between Kremmling and Dotsero relies heavily on flows called by the Shoshone Power Plant water rights. Visitors to these stream reaches are attracted by boatable flows and scenic canyon environments that remain largely in natural condition. Riparian communities along the river provide scenic interest, camping, fishing, and resting locations, as well as habitat for watchable wildlife. In the river segments between Kremmling and Dotsero, certain reaches provide outstanding opportunities for fishing from boat or from shore. In Glenwood Canyon and near Pumphouse and Radium upstream, trail systems parallel the river, providing hikers and bicyclists the opportunity to enjoy wildlife and river corridor views. The Upper Colorado River Scenic Byway also passes through this corridor, providing visitors with scenic driving opportunities.

<u>Kremmling to Dotsero</u>

BLM manages the public lands along with river between Kremmling and Dotsero as the Upper Colorado River Special Recreation Management Area (SRMA). BLM's broad management objectives for the SRMA include delivering personal and social benefits associated with outdoor recreation; protecting fish, wildlife, and plants from public use impacts; generating community stewardship of recreation resource and natural resources; and maintaining tourism employment and revenue for the local economy. BLM achieves these objectives by dividing the river corridor into various management zones and managing each zone for targeted experiences and recreation benefits. To support these objectives, BLM manages nine formal recreation sites between Kremmling and Dotsero, which include facilities such as parking, boat ramps, restrooms, campgrounds, public water supplies, and trailheads.



Private rafting trip taking out at BLM recreation site in Upper Colorado River SRMA.

Visitation to BLM recreation sites is recorded annually in the BLM's Recreation Management Information Systems (RMIS) database. The use at a specific site is captured as "visits" which equates to one person entering onto lands or waters managed by the BLM for the purposes of recreation. A "visitor day" is defined as a visitor spending 12 hours in an area. A family of four camping for three days would count as 12 visitor days. These visitation numbers are derived from multiple methods including records from recreation permits, campground fee envelopes, data from traffic counters, and simple observation. While technically open year-round, visitation to the campgrounds is concentrated in the summer season, generally May through September.

Visitation tracking in RMIS follows the federal fiscal year (FY), which runs from October 1 through September 30 of the following year. Within the SRMA, there were 241,417 visits in FY2020, 242,679 recreational visits in FY2021, and 257,007 visits in FY2022. Visits by recreational users more than doubled over the three-year period and averaged 238,034 visits within the SRMA. This increase in recreational use is consistent with other public lands across Colorado.

Table 1. Estimated Annual Visitation to Upper Colorado River SRMA in Visitor Days

Upper Colorado River SRMA	FY20	FY21	FY22	Average
Kremmling Field Office	149,173	175,203	180,459	168,278
Colorado River Valley Field Office	65,244	67,476	76,548	69,756
Total Annual Visitation	214,417	242,679	257,007	238,034

BLM cooperates with the Upper Colorado River Wild and Scenic Stakeholders Group to collect data concerning the number of visitor days associated with float trips. Between May 1 and September 30, 2022, a total of 42,836 visitor days were logged for commercial outfitters who were taking clients on float boating trips.[4] While the exact percentage of visitor days associated with commercial float trips varies from year to year, the 2022 surveys revealed that approximately 45% of visitor days were associated with commercial float boating trips, while approximately 55% of visitor days were associated with privately-run float boating trips.

[4] Upper Colorado River Wild & Scenic Stakeholders Group – 2022 Annual Monitoring Report.



Visitors experiencing a quiet section of the Colorado River within the SRMA.

Using this data and visitor distribution, BLM estimates there were approximately 53,272 visitor days during 2022 that were associated privately-run boating trips. If visitor days for commercial trips and privately-run boating trips are combined, BLM estimates the number of visitor days for both commercial and private boating trips for 2022 was approximately 96,000.

Much of the visitor use in the SRMA is supported by commercial outfitters, each of whom operates under a Special Recreation Permits issued by BLM. The total number of Special Recreation Permits issued to outfitters for operations within the SRMA is shown in Table 2.

Table 2. BLM Special Recreation Permits for Upper Colorado River SRMA.

Number of Special Recreation Permits	Type of Recreation Use Authorized
2	Kayaking / Canoeing
24	Fishing
50	Rafting / Floating / Rowing

Overall, outdoor recreation types on BLM-administered lands in the Kremmling Field Office and Colorado River Valley Field Office contributes $145.7 million and over 1,100 jobs annually, paying $50.4 million in labor income to Colorado's economy.[5] Public lands play an important role in stimulating the local economy by providing opportunities for recreation. Communities adjacent to public lands can benefit economically from visitors who spend money in hotels, restaurants, gas stations, gift shops, and elsewhere.

[5] BLM 2023. Valuing America's Public Lands 2023. Internet website: https://www.blm.gov/about/data/socioeconomic-impact-report-2023

Glenwood Canyon

WRNF manages the public lands along a majority of the Glenwood Canyon section of the Colorado River. This is the largest canyon on the upper Colorado River with rugged scenic walls rising over 1,300 feet on either side. The 2002 White River National Forest Land and Resource Management Plan provides Management Area direction for this area with a title of *Recreation Rivers-Designated and Eligible* and a theme of *Recreation Rivers are managed to protect and perpetuate eligible and designated recreation river segments*. These areas are managed to protect and perpetuate eligible river segments in their current condition so that their recreation river qualities are not diminished.

WRNF manages the Glenwood Canyon portion of the river as one segment, which starts at the national forest boundary on the eastern end of Glenwood Canyon and extends downstream to the national forest boundary near the west end of Glenwood Canyon. The infrastructure that supports the recreational activities in the canyon includes the Glenwood Canyon Recreation Path, two (2) boat ramps at Shoshone and Grizzly Creek, respectively, and rest areas, trailheads, parking areas, and restrooms at Hanging Lake, Grizzly Creek, and No Name rest areas, with a parking area and restroom at Bair Ranch rest area.



Visitors enjoy one of the many rapids in Glenwood Canyon

Overall visitation on the WRNF managed stretch of the Colorado River, through Glenwood Canyon, is tracked following the federal fiscal year (FY) from October 1 through September 30 of the following year. Estimated visitation includes commercial boater service days along with private boat data collected by WRNF staff at the Shoshone and Grizzly Creek boat ramps throughout the high use summer season, running from late June through late August.

Table 3. Actual and estimated visitation on the Colorado River in Glenwood Canyon based on a 70-day high use season (late June-Late August).

Glenwood Canyon	FY20	FY21	FY22
Commercial	43,089 (actual)	52,131 (actual)	53,687 (actual)
Estimated Private Use	4,138* (estimated 16,092)	1,456** (estimated 6,370)	1,609*** (estimated 3,633)
Total Combined Estimate	59,181	58,501	57,320

*18 days of private data collected,
**16 days of private data collected
***31 days of private data.

In 2018, WRNF conducted an Environmental Assessment to determine the capacity limit for commercial use of the Shoshone Rapids Section of the Colorado River in Glenwood Canyon. Through this process it was determined that 71,500 service days for commercial rafting and 750 service days for commercial kayaking, with a pool of 1,100 service days, and temporary use authorized on a requested basis by institutional type user groups, accounted for a total capacity limit of 73,350. There are currently 68,000 service days allocated to priority special use permit outfitter and guides.

These flow-dependent activities rely heavily on the amount of water in this stretch of the river. Based on input from the outfitters and experience, these commercial operations typically cease when river flows drop below 1,200 cfs. The floating visitor experience diminishes drastically once flows drop below this level.

The Shoshone rapids section of Glenwood Canyon is regionally significant to river recreation, as reliable flows create consistent Class II - IV whitewater conditions for boaters when most other popular rivers in the area have reduced flows, either by natural or controlled means. These dependable flows also contribute to the viability of long-standing outfitter's seasonal business operations and offerings to National Forest visitors.

The total number of outfitter and guide operations or educational institutions that are authorized to operate under a Special Use Permit by USFS to conduct commercial or educational activities on or along this portion of the river are outlined in Table 4.

Table 4. Number and types of 2024 USFS special use permits.

Number of permits	Types of permits	Total Priority Service Days
9	Rafting	66,977
3	Kayak	365
2	Fishing	150
3	Educational Institutions	340

Overall, WRNF directly supports 22,000 jobs with an economic impact of $1.6 billion based on data from 2019 and is considered the most visited national forest in the country.[6] Based on visitation studies conducted on a five-year cycle, forest visitation increased from 12.5 million visits in 2017 to 18.4 million visits in 2022[7]. While 11.5 million of those 2022 visits were from ski areas, the remaining 6.5 million visits were non-ski area visits. The Colorado River and public lands in Glenwood Canyon play a significant role in sustaining the local economy by providing opportunities not only directly related to recreation but also indirectly in the local communities where visitors support numerous local businesses and service providers.



Rafting the Colorado River in Glenwood Canyon.

Summary

The river-related natural environment in Glenwood Canyon has evolved in response to, and is dependent upon, the historical infrastructure and flow regime associated with operation of the Shoshone Power Plant water right. Any significant changes to the historical operation of the water right would result in corresponding changes to the natural environment, especially if the priority call associated with the water right were not exercised, resulting in increased diversions upstream. The Shoshone Outage Protocol[8], an operational agreement signed by Bureau of Reclamation,

[6] FY19 Economic Contributions from National Forests and Grasslands. USDA Forest Service, Ecosystem Management Coordination, Social Science and Economics. 2019.

[7] USDA Forest Service. National Visitor Use Monitoring Data 2017 and 2022.

[8] Shoshone Outage Protocol Agreement Number 13XX6C0129, dated June 27, 2016.

the State of Colorado, multiple local governments, and multiple entities with Colorado River water rights, recognizes the role that the water right plays in preservation of the natural environment in Glenwood Canyon, as well as the natural environment in river locations upstream and downstream. Quantification of the potential impacts associated with modified or terminated operation of the Shoshone Powerplant water right would require a detailed analysis of the historic water right call regime, hydrologic variability, and modeling of the in-channel and riparian habitat in Glenwood Canyon.

Operation of the Shoshone Power Plant water rights also has significant positive impacts both upstream and downstream from the plant. Downstream, operations of the water rights contribute to the flow rates necessary to support threatened and endangered fish species in the 15-Mile Reach near Grand Junction. Upstream, operation of the water rights supports Outstandingly Remarkable Values in three reaches of Colorado River that have been determined to be eligible for designation into the National Wild and Scenic Rivers System. Operation of the water rights also supports economically significant recreation use within BLM's Upper Colorado River SRMA and WRNF Glenwood Canyon Management Areas.

[8]

MEMORANDUM

BBA Water Consultants, Inc.

To: Peter Fleming, Brendon Langenhuizen, Andy Mueller, Jason Turner, Bruce Walters

From: Kristina Wynne, P.H. and John Shuler, P.H.

Subject: Preliminary Shoshone Historical Use Assessment –**DRAFT**

Job: 0808.06

Date: November 8, 2024

The purpose of this memorandum is to present an estimate of the historical use of the Shoshone Power Plant water rights ("Shoshone Water Right(s)"). The analysis of historical use will support the Colorado River Water Conservation District's (the "River District's") efforts to ensure the permanency of these senior non-consumptive water rights by changing their approved use in Colorado Water Court to add an alternate use for instream flow purposes to the already decreed hydropower purposes. The Shoshone Water Rights are among the largest and most senior water rights on the mainstem of the Colorado River. Since the Shoshone Power Plant began operating in 1909, the non-consumptive Shoshone Water Rights have operated nearly continuously in a manner that maximizes power production and subsequently maintains return flows for downstream water rights, including irrigation uses in the Grand Valley, municipal demands along the Colorado River west of Glenwood Canyon, and other non-consumptive uses such as assisting in the maintenance of flows for the Upper Colorado Endangered Fish Recovery Program (the "Fish Recovery Program") in the 15-Mile Reach.

The proposed change of use of the Shoshone Water Rights to include instream flow purposes will require the filing of an application with the Colorado Division 5 Water Court. Such applications are required by statute to be supported by technical determinations of the historical (in this case, non-consumptive) use of the subject water right to ensure that the water right is not expanded, that historical streamflow patterns and return flows are maintained, and that the change of use prevents injury to other water rights. The historical use and yield of the water rights are ultimately determined as part of the Water Court process. Because the River District, Public Service Company of Colorado ("PSCo"), and the Colorado Water Conservation Board ("CWCB")[1] have not yet filed a Water Court application for this change of use, and because various data sources are still being evaluated, a formal technical analysis has not yet been completed. This memorandum and the preliminary yield estimates presented herein are not intended for use in Water Court and may change in the future based upon additional data that may be evaluated or become available, and through ongoing discussions with the CWCB, PSCo, and potential opposers in the case. As with any change of water rights case, the River District seeks the ability to continue to utilize the

[1] Under statute, the CWCB is the only water user in the State of Colorado authorized to use water rights for instream flows and natural lake levels to preserve or improve the natural environment. Therefore, the CWCB will be a co-applicant with the River District and Public Service Company of Colorado when a Water Court application for a change of the Shoshone Water Rights is filed.

full Shoshone Water Rights at their decreed rates when legally and physically available, consistent with the historical use over a representative study period.

Background

The Shoshone Power Plant is located on the Colorado River in Glenwood Canyon just upstream of the City of Glenwood Springs, Colorado. The Shoshone Water Rights are diverted at an on-channel diversion dam ("Shoshone Dam") that extends across the Colorado River, approximately eight miles downstream of the USGS stream gage located near Dotsero, Colorado (USGS Gage 09070500, the "Dotsero Gage"). Water is diverted at the Shoshone Dam into an approximately 2.5-mile concrete-lined tunnel to the power plant where it is delivered to twin penstocks before dropping a total of 167 feet through two turbines to generate electricity at the Shoshone Power Plant. As part of the facility's normal operations to sluice sediment to prevent damage to the Shoshone Power Plant turbines and other infrastructure, some water is typically released from the tunnel at various locations. These uses are not consumed but must be diverted to optimize power generation at the Shoshone Power Plant, as discussed below. These diverted amounts return to the Colorado River un-depleted. The remaining water delivered to the penstocks and through the turbines to produce electricity is also not consumed, and therefore, all of the water diverted at the Shoshone Dam and delivered through the plant returns to the Colorado River at the Shoshone Power Plant outfall.

The Shoshone Power Plant is currently owned and operated by PSCo. In December 2023, the River District and PSCo entered into a purchase and sale agreement ("PSA") for the Shoshone Water Rights. As described in the PSA, the River District, in coordination with the CWCB, seeks to permanently protect the Shoshone Water Rights by changing the decreed use of the water rights to include instream flow purposes in the reach between the Shoshone Dam and the Shoshone Power plant outfall. By adding an alternate beneficial use for instream flow purposes to the Shoshone Water Rights, the rights will continue to utilize their administrative priority dates while maintaining the historical flow regime of the Colorado River within the State of Colorado.

Shoshone Water Rights

The Shoshone Water Rights include two separate absolute water rights associated with the Shoshone Power Plant. The more senior, original Shoshone Water Right was decreed for 1,250 cubic feet per second ("cfs") in Eagle County Civil Action No. 466 with a priority date of December 5, 1905. The entire 1,250 cfs was later made absolute in Eagle County Civil Action No. 553. The plant's capacity and consequent demand for water later increased by 158 cfs to a total of 1,408 cfs in 1929. The junior Shoshone Water Right was decreed for 158 cfs in Eagle County Civil Action No. 1123 and is administered with a priority date of May 31, 1940. The total decreed amount of the two water rights is 1,408 cfs, which has historically been diverted at the full rate for at least a portion of nearly every year. The combined decreed uses for the senior and junior Shoshone Water Rights are for power production purposes which are non-consumptive. The Shoshone Water Rights are more particularly described in Table 1, below.

Table 1. Shoshone Power Plant Water Rights

Case No.	Amount (cfs)	App. Date	Adj. Date	Previous Adj. Date	Priority Admin No.	Use
CA-466, CA-553	1,250	1/7/1902	12/9/1907	12/5/1905	20427.18999	Power manufacturing, mining, milling, traction, heating and lighting purposes
CA1123	158	5/15/1929	2/7/1956	5/31/1940	33023.28989	Manufacturing and generation of electrical energy

While records dating back to the initial diversion of the Shoshone Water Rights are not available, records available from the Colorado Division of Water Resources ("DWR") indicate that the Shoshone Water Rights may have placed calls since at least the mid-1960s. Calls for the Shoshone Water Rights have been and are currently administered by the DWR at the Dotsero Gage, located approximately eight miles upstream from the Shoshone Dam and approximately 10.5 miles upstream from the Shoshone Power Plant.

Plant History

Construction of the Shoshone Power Plant began in 1906, and it first operated in 1909. The tunnel at the Shoshone Power Plant can carry up to 1,408 cfs, which supplies water to two turbines at the Shoshone Power Plant which are capable of producing a combined 15,000 kW of electricity. Based on our discussions with current and past Shoshone Power Plant operators and PSCo water resources staff, we understand that unless the turbines, the plant, or the tunnel were shut down for maintenance, inspections, or for some other unforeseen circumstance, the plant was always diverting water and producing energy to the greatest extent possible. In other words, there has consistently been demand for the full amount of power that the plant can produce, in part due to the fact that the Shoshone Power Plant is a relatively small contributor to the larger energy grid. As such, over its operational lifespan, the delivery of power produced at the Shoshone Power Plant has not required reductions associated with a drop in demand at any time. Repairs to the turbines have historically been made using the same or similar parts throughout the life of the plant resulting in relatively consistent capacities, efficiencies, and operations over time.

For the majority of its 115-year history, the Shoshone Power Plant has operated constantly and exercised the Shoshone Water Rights to produce power, with routine partial shutdowns for maintenance. Review of available maintenance records from PSCo will occur prior to finalizing any historical use yield analysis. We understand from discussions with present and former PSCo staff that at least since the early 1980s, routine maintenance typically occurred from one to three months during the winter when streamflow is low, and the operators could minimize lost power

production. During that time, maintenance of the turbines was reportedly achieved by shutting down one turbine while keeping the other turbine online.

Based on DWR records which date back to the mid-1970s, and Historic Users Pool ("HUP") Annual Reports, which records span 1998-2014, the Shoshone Power Plant operated consistently with minor shutdowns (most often related to planned maintenance) until approximately 2002 when PSCo voluntarily reduced its call from 1,408 cfs to 1,000 cfs to allow upstream junior water rights to divert or store water from June 13, 2002 through June 26, 2002. This informal "Shoshone Call Relaxation" was again implemented in 2003, when PSCo voluntarily reduced the Shoshone Water Rights call to 704 cfs in the winter and spring despite the fact that there was physically available flow to divert at a greater rate for a portion of this period and there was demand for the power at the full capacity of the plant.[2] A formal call reduction agreement between PSCo and the Board of Water Commissioners for the City and County of Denver ("Denver Water") was signed in 2007.

In addition to the negotiated and voluntary call reduction agreements described above, the frequency of days during which the Shoshone Power Plant was not operational and unable to exercise the Shoshone Water Rights significantly increased after 2003, mostly due to natural phenomena or unforeseen circumstances beyond the control of PSCo and for which it worked diligently to make repairs necessary to get the plant back online and continue to meet the power demand. These major outages include but are not limited to the following events:

- 2004: PSCo conducted a major automation of the power plant's operations, which required the plant to be offline between mid-March and mid-July.
- 2007-2008: A major penstock rupture on June 20, 2007 resulted in the plant being offline until April 25, 2008. Operational issues following the penstock failure and repair persisted through water year 2008.
- 2010: Unscheduled maintenance was required due to a generator fire in late 2009.
- 2012: The plant operated with only one turbine to reduce the head at the Shoshone Dam to reduce seepage and other issues at the dam.
- 2013: Denver Water call relaxation agreement was in effect.
- 2020: The plant was shut down during the spring of 2020 due to a flood that required the replacement of the turbine exciters. The Grizzly Creek Fire started on August 10, 2020 and closed Glenwood Canyon for 13 days. The Shoshone Power Plant was offline following

[2] The 2003 informal "Shoshone Call Relaxation" was conducted in accordance with the March 21, 2003 "Agreement Concerning Proposed Operation of the Shoshone Power Call" between the River District and the City and County of Denver, acting by and through its Board of Water Commissioners.

the highway closure because powerlines destroyed during the fire had to be repaired or replaced.

- 2021: The plant was partially or fully offline for much of 2021 for reasons that included a large debris flow between the Shoshone Dam and the Shoshone Power Plant. Rock debris was stuck in the diversion tunnel.

- 2022: The plant shut down due to specialized turbine and casing inspections.

- 2023-2024: The plant shut down due to hazardous rockfall at the Shoshone Power Plant site and safety concerns for on-site staff and facilities. During the extended outage, the runner in Turbine A was sent off-site for significant repairs and refurbishment.

As shown in Table 2 below, reported days of full outages were much more frequent after 2004, indicating that the post-2003 period is not representative of the long-term historical use of the Shoshone Water Rights and the consistent operation of the plant due largely to extreme circumstances beyond the control of the plant operators.

Table 2: Summary of Days of Full Outage at the Shoshone Power Plant[3]

Period	Total Days of Full Outage	Average Annual Days of Full Outage
1975-2003 (29 years)	89	3
2004-2022 (19 years)	1,493[4]	77

Available Data Sources

There are two readily available data sources associated with the administration, diversion, and deliveries attributable to the Shoshone Water Rights: (1) records available from the DWR's Colorado Decision Support System ("CDSS") database which are characterized as "diversion records," and (2) administrative flow calculations quantified at the Dotsero Gage, where the Shoshone Water Rights are administered, as made available by the DWR through the Division Engineer's Office for Colorado Water Division 5. The CDSS records and administrative flow data are described in more detail below.

CDSS Records

Daily records for the Shoshone Power Plant from 1975 to present are available from the CDSS database. However, records for some periods are missing or appear to be repeated for many days

[3] Full daily outage based on days with reported zero or no data in CDSS records.

[4] Value based upon CDSS records. PSCo data suggests that there may have been up to approximately 30 days, primarily in November 2013, when the plant was operational to some degree. However, CDSS records report zero.

or months in a row. While these data entries are represented as "diversion records," these records are not based on the measurement of diversions or deliveries to the Shoshone Power Plant during this period. Rather, we understand that these records are based on power production records kept by the plant operators which were then converted to a flow rate based on a typical hydropower equation and an assumed unit efficiency of 81%. Generating unit efficiency was measured and variable unit efficiency curves were developed in the 1930s but were not used to develop the records that are currently available from the CDSS database.

Like most diversion structures and water rights uses, all the water diverted at the Shoshone Dam upstream of the plant and delivered through the tunnel is necessary for optimum operation of the Shoshone Power Plant even though not all the water diverted runs through the turbines to produce power. Analogous to other losses that are inherently included in and necessary for the operation of a reasonably efficient system and utilization of a water right, water is released through various tunnel "adits" or outlets. The Shoshone Power Plant operators open low level valves in the tunnel at several adits to clear sediment from the tunnel before the water reaches the penstocks in order to protect the turbine runners and other power plant infrastructure from damage and excessive wear. Based on discussions with operators at the plant, water may be released through the adits for many weeks at a time and releases may equal up to several hundred cfs. While water released through the adits returns directly to the Colorado River and is not run through the turbines, it is necessary for these amounts to be diverted to allow power to be generated in the safe operation of the power plant.

Because the CDSS records are based only on power produced at the Shoshone Power Plant, the additional water that was required to be diverted to enable the beneficial purposes at the plant is not included in the record. As a result, the CDSS records are more reflective of historical deliveries to the turbines than historical diversions from the river. The CDSS records underestimate the total amount of water actually available and diverted at the dam and subsequently delivered through the tunnel. Therefore, reliance on the CDSS records alone may not adequately protect the return flows historically available to downstream junior water rights because the CDSS records do not include water that was necessarily diverted to achieve the end beneficial use and that was returned to the river without directly producing power.

An additional consideration of the CDSS records is that at times they include reservoir water released for downstream users to fill any remaining tunnel capacity. The Shoshone Power Plant historically diverted and created power using the physically available flow, up to the plant's capacity, and the CDSS records inherently include at least some water that was released from upstream storage and bound for downstream use, such as support for the Fish Recovery Program in the 15-Mile Reach. This water, often referred to as "virtual pipeline water" or "shepherded water," is water that the Shoshone Power Plant may physically divert but that it does not have the right to call for. Diversion of shepherded water at the Shoshone Power Plant was allowed by the Division Engineer, as the Shoshone Water Rights are used for non-consumptive power generation and the water diverted would still be available for downstream users. Although the shepherded water cannot be "called" for by the Shoshone Water Rights, the diversion and beneficial use of that water demonstrates that except for periods of reduced use or non-use described above, the Shoshone Power Plant has a constant demand for 1,408 cfs.

Administrative Flow Data

While the Shoshone Power Plant may divert water on a year-round basis through the plant up to its capacity at any time, the ability for the Shoshone Water Rights to place a call has historically been administered by the Division 5 Engineer's Office ("DEO") based on the available "administrative flow" or "natural flow" at the Dotsero Gage. The administrative flow is determined by the DEO based on information from the U.S. Bureau of Reclamation ("USBR") and other users to account for upstream reservoir releases that must be shepherded to users below the Shoshone Power Plant including, but not limited to, contract water and HUP water released from Green Mountain Reservoir for use in the Grand Valley and water released for the Fish Recovery Program from Lake Granby, Wolford Mountain Reservoir, or other upstream sources. The DEO is charged with ensuring that this shepherded water is delivered past downstream intervening diversions to the final place of use. The administrative flow is therefore equal to the measured streamflow at the Dotsero Gage less the shepherded water. Because releases of contract water, HUP water, and water from other upstream sources generally only occur during the late summer months, the administrative flow is generally equal to the measured flow at the Dotsero Gage except from July through October.

The administrative flow has been formally considered and enforced as part of the DEO's administration of the Colorado River since 1998, following the start of the Fish Recovery Program releases on the Upper Colorado River in 1997. Based upon preliminary review of USBR Colorado River operations records and other DWR records, it appears that contract releases made above the Shoshone Power Plant and bound for users below the plant were minimal prior to 1998. Administrative flow calculations were made available by the DEO from 2017-2022. All administrative flow records prior to that period (back to 1998) were calculated based on the same sources of data and the same processes used by the DEO.

We understand that, until the mid-1980s, the administrative practice of the DWR and/or USBR may have been to limit the administration of the Shoshone Water Rights call to 1,250 cfs under the senior Shoshone Water Right. However, based on conversations with PSCo administrators and plant operators, in addition to streamflow records available pre-1998, there was always a demand for the full 1,408 cfs when such water was legally and physically available. Moreover, written call records from the 1980s indicate that plant operators at the Shoshone Power Plant routinely requested that DWR administer the entire 1,408 cfs when demands were not being met at the power plant. Therefore, for purposes of this analysis, we assumed that the administrative flow prior to 1998 is equal to the measured flow at the Dotsero Gage, limited to 1,408 cfs.

There was always demand for power generated at the Shoshone Power Plant and therefore the administrative flow could always be utilized so long as the power plant was operating at capacity and provided such water was legally and physically available. The administrative flow includes all water necessary to operate the plant to generate electricity including water released from the tunnel via the adits for sediment sluicing and other uses consistent with reasonably efficient operations. Consequently, the administrative flow is the best representation of the actual historical use of the Shoshone Water Rights and also more accurately reflects the historical impact to upstream water users during times when the plant was operating. Moreover, the administrative flow also includes

100% of the return flows from the historical exercise of the Shoshone Water Rights, which will be required to be maintained in a change of water right to prevent injury to downstream users. Because the administrative flow is most representative of historical conditions at the Shoshone Dam, it is also the most appropriate basis for determining the amount of water available for the alternate instream flow use within the proposed instream flow reach.

Additional Data and Records

For purposes of the analysis described in this memorandum, we relied on records available on DWR's CDSS database and administrative flow data recorded at the Dotsero Gage. Moving forward, the analysis of historical use described in this memorandum may be supplemented as additional information and data is discovered.

Preliminary Yield Analysis

In any change of use in Colorado Water Court, the historical use of the subject water right must be quantified based on the actual historical beneficial use of the water right for its decreed purposes to prevent the expansion of the water right and prevent injury to other water rights holders upstream and downstream. As described above, and for purposes of this analysis, the administrative flow is more representative of historical conditions than the "delivery" records available from the CDSS database.

Study Period

While the CDSS records are not the most representative data to reflect what flow rate was diverted under the Shoshone Water Rights, these records are available on a daily basis back to 1975 and indicate when the plant was operating, and that water was being used for its decreed purposes. The CDSS records, along with notes regarding the operations at the plant and calls by the Shoshone Water Rights, also show that the ability to operate the plant and divert water to the fullest extent was reduced after 2003. As described above, this was due to various reasons that were beyond the control of PSCo and, therefore, the post-2003 period is not reflective of the long-term historical exercise of the Shoshone Water Rights. Pursuant to Colorado law (e.g., CRS § 37-92-305(3)(d)), the entire study period of available data need not be considered in a change case provided that the selected study period is sufficiently long to show the true historical use of the water right to be changed.

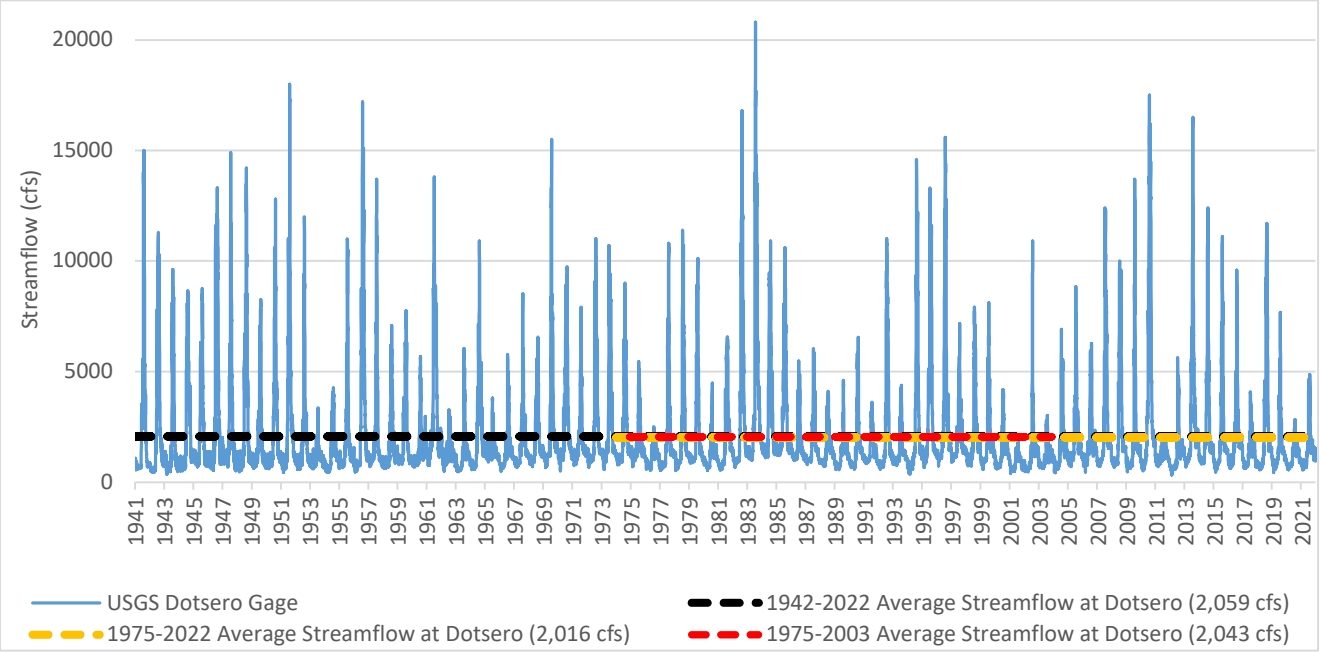
In other words, "quantification of the historical consumptive use of a water right must be based on an analysis of the actual historical use of the water right for its decreed purposes during a representative study period that includes wet years, dry years, and average years. The representative study period:

> (I) Must not include undecreed use of the subject water right; and
>
> (II) Need not include every year of the entire history of the subject water right."

Section 37-92-305(3)(d), C.R.S.

For the determination of the yield of the Shoshone Water Rights presented herein, a 1975 through 2003 water year study period was selected. This period represents years during which information regarding the operation of the plant is available and is reflective of a period of consistent operations at the plant and the exercise of the Shoshone Water Rights. The 29-year period of record also contains periods of wet, dry, and average hydrologic years, similar to years before and after the study period, as demonstrated below in Figure 1.

Figure 1 – Hydrograph of total Dotsero Gage streamflow with averages for different study periods to show that 1975-2003 study period is hydrologically representative.



Dotsero Gage data are available with minimal data gaps from 1942 to present. As shown in Figure 1, the entire period of record and the 1975-2003 period of record both include periods of wet, dry, and average streamflow years. Despite fluctuations in streamflow over the years, the average streamflow from 1942 to present is nearly identical to the average streamflow during the 1975-2003 study period (less than 1% difference). Similarly, the 1975-2022 average streamflow is approximately equal to the previous study periods (within approximately 2%). This indicates that any variance in average annual yield of diversions of the Shoshone Water Rights and plant operations after 2003 is not due to significant changes in physical supply available at Dotsero. Water diverted at the Shoshone Dam has historically fluctuated with the hydrograph given the nature of the operations, limited to the Shoshone Water Rights flow rate and the capacity of the plant.

Historical Use Quantification

Any change of a water right must ensure that the proposed changed use of the water right is not expanded and that historical streamflow patterns and return flows are maintained. This is most typically done through the imposition of decreed volumetric limits (which may be multi-year or annual averages) and return flow obligations. Volumetric limits can be determined by quantifying

the average historical use of a water right over a representative study period and may then be applied as a decreed limit to the future changed uses over a period of time consistent with the study period. Incorporating a running-average volumetric limitation based on a longer period of time allows a water right to operate with some flexibility and fluctuations in response to variable hydrology, just as it operated in the past, but prevents the expansion of the water right by limiting the running average annual diversion to the long-term historical average. Because the Shoshone Water Rights are non-consumptive water rights, maintaining the historical pattern of use will also maintain the historical return flows.

Therefore, we quantified the average annual yield of the Shoshone Water Rights for the representative study period of 1975-2003 by converting the daily administrative flow from 1998-2003 and the Dotsero Gage flow from 1975-1997 (limited to 1,408 cfs) to acre-feet ("ac-ft") of water beneficially used and then summed the daily values over each month of the selected study period (i.e., 1975-2003). The monthly averages from 1975-2003 were then summed to determine an average annual historical yield.

To best reflect the historical exercise of the Shoshone Water Rights, and to maintain the historical streamflow patterns and return flows relied upon by downstream water users, it was necessary to make the following reasonable adjustments and assumptions regarding the administrative flow:

- As described above, the administrative flow record was estimated using methods confirmed by the DEO and DWR-provided data back to 1998. Information regarding any water shepherded past the Dotsero Gage is limited, though the volumes and daily flow rates of shepherded water would have been minimal and occurred only during the irrigation season. Therefore, for purposes of this analysis, we assumed that prior to 1998, the administrative flow is equal to the flow at the Dotsero Gage, with additional limitations described below.

- Daily flows included in the yield analysis are limited to the lesser of the administrative flow and the total 1,408 cfs available under the Shoshone Water Rights.

- While the administrative flow was determined for all days in the 1975-2003 study period, the Shoshone Water Rights could not take advantage of and beneficially use the flow during periods of outage at the plant. Therefore, days of full outage were excluded from the calculation of total yield. As shown in Table 2, during the 1975-2003 study period, there were 89 days of full outage, based upon days with no data or days with zero diversions in the CDSS records. Data which specifically indicate the periods of partial outages are not available and therefore no corresponding adjustments have been made to this analysis.

- During the 1975-2003 study period, the power plant operated consistently, with only brief periods of partial outage to address routine maintenance issues according to PSCo staff.

Utilizing the data described above, with the appropriate adjustments, our preliminary calculation of average annual yield for the 29-year study period of 1975-2003 is equal to 844,644 ac-ft. This value, when applied on a rolling 29-year average basis (i.e., not an annual volumetric limit) is an appropriate volumetric limit for the changed use of the Shoshone Water Rights. For purposes of comparison, the preliminary average annual yield presented here is less than the measured Dotsero

Gage flow (limited to 1,408 cfs). As shown in Table 3, the preliminary average annual yield is also significantly less than if the historical use was assumed to be the total Shoshone Water Rights of 1,408 cfs or the senior right of 1,250 cfs.

Table 3: Average Annual Yield Comparison for Study Period 1975-2003

Data Source	Average annual yield (ac-ft)
Calculated Administrative Flow	844,644
Measured Dotsero Streamflow (limited to 1,408 cfs)	857,696
1,408 cfs year-round	1,019,360
1,250 cfs year-round	904,972

It is important to note that the historical use of the Shoshone Water Rights fluctuated with historical hydrology. Additionally, the maximum administrative flow rate diverted at the plant over the 1975-2003 study period was equal to 1,408 cfs at least once in each month throughout the entire period of study (i.e., the administrative flow was equal to 1,408 cfs in at least one January, one February, etc. over the entire study period). Thus, the full decreed rate of flow should be available for both continued hydropower production and for instream flow use based on the actual historical diversion and use of the Shoshone Water Rights for their originally decreed purposes. However, because the full decreed rate was not continuously available on a daily basis in all months, the future use of the Shoshone Water Rights will be limited to the 29-year running average annual volume of use in order to prevent an expansion of the water right.

The yield estimate based upon the adjusted administrative flow record from 1975-2003 is reflective of a period of continuous exercise of the Shoshone Water Rights at the Shoshone Power Plant and the conditions on the mainstem of the Colorado River. Unlike the CDSS records, the administrative flow includes all water diverted that was necessary to generate power at the plant as well as the water that was returned to downstream users to prevent injury to vested water rights.

Conclusion

Under the PSA, the River District seeks to acquire the Shoshone Water Rights for the purpose of changing the decreed use of the water rights to include an alternate beneficial use by the CWCB for instream flow purposes. The change of use must be reflective of the historical beneficial use of the Shoshone Water Rights for the decreed non-consumptive uses and will require the continuation of historical streamflow patterns and return flows to the Colorado River that has occurred in conjunction with the consistent exercise of the Shoshone Water Rights.

For purposes of this analysis, adjusted administrative flows at the Dotsero Gage were used to determine the yield of the Shoshone Water Rights which is equal to a running 29-year annual average of 844,644 ac-ft during the 1975-2003 study period. This study period is representative of consistent operations of the Shoshone Power Plant and exercise of the Shoshone Water Rights and

excludes periods of extended unplanned outages that were outside of PSCo's control such as the 2007 penstock rupture, wildfire and subsequent debris flows in Glenwood Canyon, and other events. In addition, this historical average yield value is conservative because it does not include the virtual pipeline/shepherded water that was historically used by the Shoshone Power Plant to produce power. The yield analysis presented here is not only representative of the operation and beneficial use of the water rights necessary for hydropower production but also maintains the return flows resulting from diversions of these nonconsumptive water rights and preserves the historical streamflow regime on the Colorado River.

Ultimately, the historical yield of the water rights that may be changed for instream flow purposes will be determined through the Colorado Water Court process. Thus, the analysis of historical use described in this memorandum may be revised as additional information and data is discovered.

JOINT MEMORANDUM

TO: United States Bureau of Reclamation

FROM: Bruce C. Walters, Colorado River Water Conservation District

Kirsten M. Kurath, on behalf of the Orchard Mesa Irrigation District and the Grand Valley Water Users Association

Frederick G. Aldrich, on behalf of the Grand Valley Irrigation Company

RE: The Shoshone Water Rights, the Orchard Mesa Check Case, and Green Mountain Reservoir's Historic Users Pool "Surplus" Releases to the 15-Mile Reach

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The Colorado River Water Conservation District and a coalition of West Slope governments, municipalities, and major water entities seek to secure the permanent protection of the river flow regime created by the historical exercise of the "Shoshone Water Rights" as part of the Shoshone Water Rights Preservation Project.[1] Ensuring the continuation of this critical flow regime also protects a number of associated benefits downstream of the Shoshone Power Plant, including the availability of water to the 15-Mile Reach in the Grand Valley.

The Shoshone Water Rights are a foundational component of the administration of the upper Colorado River, from the headwaters in Grand County, Colorado, downstream to the Colorado-Utah state line. Maintenance of the historical exercise of the Shoshone Water Rights is critical to the annual determination by a group of water users in the Grand Valley to decare a "surplus" of water stored in Green Mountain Reservoir's Historic Users Pool ("HUP Surplus"). In most years, the HUP Surplus provides the single largest source of upstream storage available for release to supplement low flows in the 15-Mile Reach,[2] thereby supporting the substantial benefits to the 15-Mile Reach of the Colorado River Programmatic Biological Opinion. The continued maintenance of the historical flow regime created by the exercise and administration of the Shoshone Water Rights will ensure that the call attributable to the senior "Cameo" group of water rights in the Grand Valley (the "Cameo Call") is reduced in amount and duration, reducing the amount of time that the Cameo Call "sweeps" the river just above the 15-Mile Reach and increasing the times during which there will be HUP Surplus available to benefit the 15 Mile Reach.

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[1] As defined in the Check Case Stipulation, "Shoshone [Water] Rights" means the water rights decreed for and associated with the Shoshone Hydroelectric Power Plant, adjudicated for 1,250 c.f.s. on December 19, 1907, with an appropriation date of January 7, 1902, and adjudicated for 158 c.f.s. on February 7, 1956, with an appropriation date of May 15, 1929. *See* Stipulation, p. 3, ¶ 1.

[2] The "15-Mile Reach" is the reach of the Colorado River which extends, from the point at which the tailrace common to the Grand Valley Power Plant (and now the Vinelands Power Plant) and the OMID pumping plant returns to the Colorado River below the GVIC diversion dam, downstream to the confluence of the Colorado River and Gunnison River. *See* Stipulation, p. 2, ¶ 1.

History and Background.

In 1991, the Orchard Mesa Irrigation District ("OMID"), the Grand Valley Water Users Association ("GVWUA"), and the United States of America ("United States") jointly filed a water court application in Case No. 91CW247, District Court, Water Division No. 5 (the "Check Case"). In the application, the co-applicants requested approval of an absolute water right associated with the historical operation of an appropriative right of exchange for the structure commonly referred to as the Orchard Mesa Check (the "Check"). *See* Decree, ¶¶ 6, 7.7. The Check provides a mechanism by which the water that is used by OMID, GVWUA and the United States to generate power and by OMID to lift water to a canal system on Orchard Mesa can be directed back upstream of the Grand Valley Irrigation Company's ("GVIC's") diversion dam. *Id.*

Operationally, the exchange first involves the diversion of water out of the Colorado River at the Grand Valley Project's diversion dam (the "Roller Dam").[3] *Id.* at ¶ 7.1. Once that water is diverted by GVWUA at the Roller Dam, it is then delivered through the Government Highline Canal and into the Orchard Mesa Power Canal for delivery to OMID's pumping plant and/or the Grand Valley/Vinelands Power Plant. *Id.* at ¶¶ 7.2–7.6. Once used for power and pumping purposes, the return flow is conveyed from an afterbay to a point upstream via the Check channel into the Colorado River just above GVIC's diversion dam, where the water may then be diverted by GVIC. *See* Figure 1.[4] The federal facilities, rights, and interests involved in the case are fundamental to the operation of the Check and the annual determination of whether a HUP Surplus exists.

The Check Case Stipulation.

In addition to formally adjudicating the long-standing Check exchange operation, the Check Case addressed several interrelated issues on a critically important stretch of the Colorado River for the four Colorado River Endangered Fish Species.

The 1996 Check Case Stipulation (the "Stipulation")—which was expressly incorporated into the Decree—provides that the co-applicants (including the United States and GVIC) agree to: (1) reduce the overall demand of the Cameo group of water rights from 2,260 c.f.s. to 1,950 c.f.s., and (2) annually make a declaration as to whether a HUP Surplus exists for supplementing low flows in the 15-Mile Reach. More particularly, because Check operations can reduce the amount of water released from the 66,000 acre-feet HUP on an annual basis, the Stipulation also implements the Green Mountain Reservoir HUP Operating Criteria (the "Operating Criteria," Decree, Ex. D),

[3] The Roller Dam is located on the Colorado River just above Plateau Creek and is operated by GVWUA in conjunction with the Bureau. Some of the water diverted by the Roller Dam is also delivered to GVWUA, Palisade Irrigation District, and Mesa County Irrigation District via the Government Highline Canal.

[4] With respect to Figure 1, the Check channel is referred to as the "bypass channel." In addition, although Figure 1 shows 310 c.f.s. going to the Vinelands Power Plant in this graphic, the United States' power right is decreed for 400 c.f.s. during the irrigation season and there are certain conditions when the full 400 c.f.s. water right can be diverted to the power plant.

which criteria contemplates the existence of "HUP Surplus" water (i.e., the volume of water, if any, in excess of the amount of water necessary to meet the demands of HUP beneficiaries). Under the Operating Criteria, HUP Surplus water is delivered to the 15-Mile Reach through non-consumptive use contracts with Grand Valley entities.

As it relates to the Shoshone Water Rights, the Stipulation sets forth terms and conditions under which the co-applicants and GVIC agree to forgo placing an administrative call against upstream HUP beneficiaries provided the following three conditions are met:

(1) The Check structure is physically operable;
(2) There is at least 66,000 acre-feet of water available in Green Mountain Reservoir for the benefit of HUP beneficiaries when Green Mountain Reservoir ceases to be in-priority for its initial fill (i.e., at the end of the reservoir's fill season); and
(3) The Shoshone Water Rights continue to be exercised in "a manner substantially consistent with their historical operations[.]"

See Stipulation, pp. 5–6, ¶¶ 3.b., 3.b.(1) –3.b.(3).

Thus, per the Stipulation, if any one of the three conditions are not met during the period extending from April 1 through October 31, then the Operating Criteria *and* the Stipulation's non-curtailment provisions with respect to HUP beneficiaries may be declared inoperative by the concurrence of any of the three Co-Applicants and GVIC. *Id.* at p. 6, ¶ 3.b.(5). The Stipulation provides that the immediate impact of an "inoperative" declaration is that "no water in the HUP shall be deemed to be surplus to the needs of the HUP beneficiaries." *Id.* In other words, if the third condition in the Stipulation is not satisfied (i.e., the Shoshone Water Rights are no longer exercised in "a manner substantially consistent with their historical operations"), then the HUP Surplus could not be relied on as the single largest source of stored water available to supplement low flows in the 15-Mile Reach.

Conclusion.

The permanent protection of the river flow regime created by the historical exercise of the Shoshone Water Rights is necessary to continue the critical benefits to the 15-Mile Reach created by the operation of all the terms of the Check Case. Any failure to operate the Shoshone Water Rights "in a manner substantially consistent with historical operations," could trigger a potential loss of the benefits that the HUP Surplus provides to all Colorado River water users within the state.

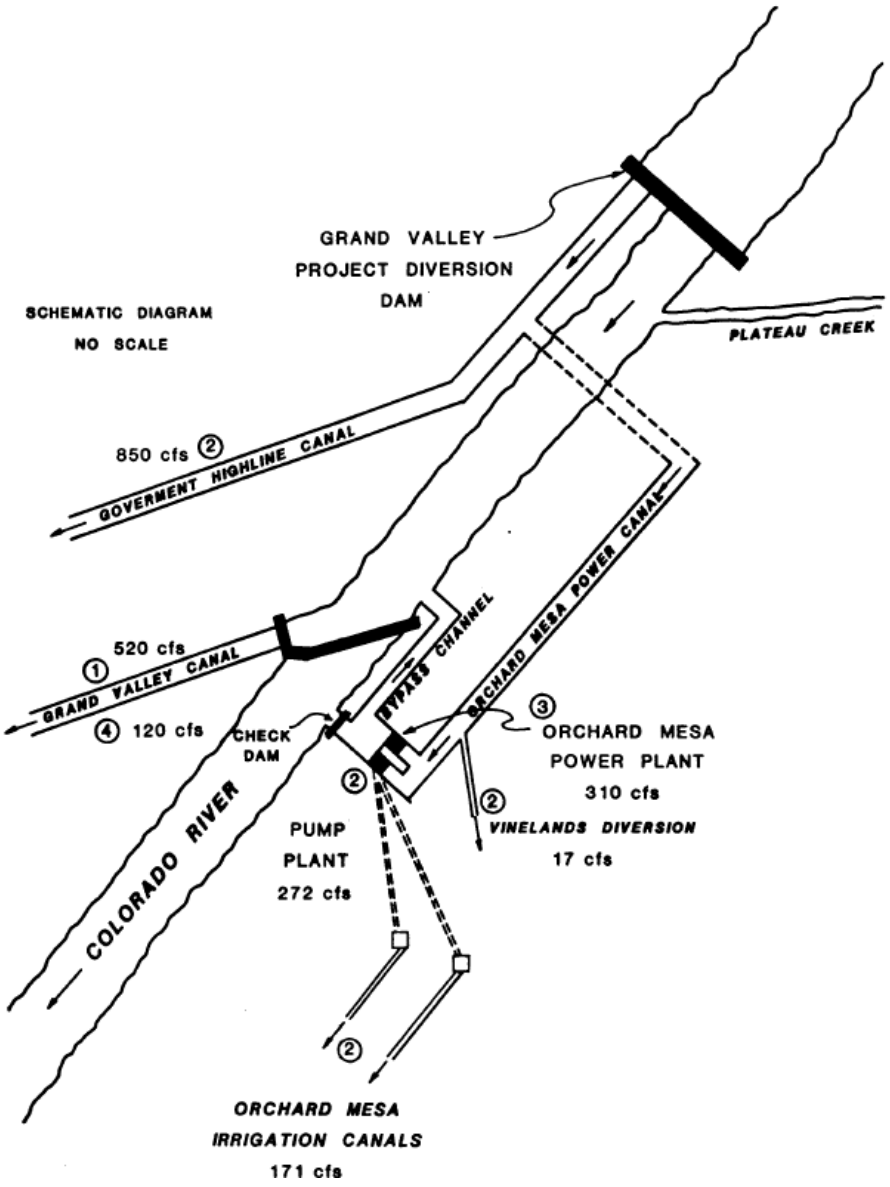


Figure 1: "Proposed Solution to the Orchard Mesa 'Check' Problem," prepared by the Colorado River Water Conservation District in cooperation with the Grand Junction Projects Office, U.S. Bureau of Reclamation, Case No. 91CW247, District Court, Water Division 5 (October 7, 1988).

PURCHASE AND SALE AGREEMENT

THIS PURCHASE AND SALE AGREEMENT (this "**Agreement**") is made as of the **Effective Date** by and between Colorado River Water Conservation District, a political subdivision of the state of Colorado (the "**River District**") and Public Service Company of Colorado, a Colorado corporation ("**PSCo**"). PSCo and the River District may be hereinafter referred to individually as a "**Party**," and together as the "**Parties**." All capitalized terms used but not immediately thereafter defined shall have the meanings ascribed thereto elsewhere in this Agreement.

RECITALS

A. PSCo owns the Shoshone Water Rights (defined below in Article 2), which are diverted at the Shoshone Dam, located in Glenwood Canyon, Colorado, and used for non-consumptive hydro-power generation at the Shoshone Hydroelectric Generation Station ("**Power Plant**"). Water delivered to the Power Plant is discharged and returned directly into the Colorado River at the outfall of the Power Plant.

B. Operation of the Shoshone Water Rights for hydropower purposes for over 100 years has had the added benefits of maintaining administrative stability of water rights in the Colorado River basin, , helping Colorado to meet the recovery requirements of endangered fish species under the federal Endangered Species Act, contributing significant flows to the interstate Colorado River System, and providing stream flows necessary to meet municipal, agricultural, environmental and recreation needs on Colorado's western slope.

C. The River District represents western slope interests that desire to maintain in perpetuity the operation of the Shoshone Water Rights in a manner consistent with their historical operation in order to preserve the benefits described above.

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the parties agree as follows:

ARTICLE 1. BASIC TERMS

1.1	Effective Date:	January 1, 2024
1.2	Seller:	PUBLIC SERVICE COMPANY OF COLORADO, a Colorado Corporation
1.3	Buyer:	COLORADO RIVER WATER CONSERVATION DISTRICT, a political subdivision of the state of Colorado
1.4	Subject Property:	The Shoshone Water Rights, as more particularly described in Article 2, below.
1.5	Purchase Price:	NINETY-EIGHT MILLION FIVE HUNDRED THOUSAND DOLLARS ($98,500,00.000).

1.6	Transaction Costs:	Five Hundred Thousand Dollars ($500,000.00), as more particularly defined in Article 3, below.
1.7	Due Diligence Period:	The period beginning on the Effective Date and ending on May 15, 2024.
1.8	Closing Date:	Thirty (30) days following the satisfaction of the Closing Conditions.
1.9	Exhibits:	Exhibit A: Escrow Agreement Exhibit B: PSCo's Due Diligence Deliveries Exhibit C: Special Warranty Deed Exhibit D: Lease of Shoshone Water Rights Exhibit E: Promissory Note Exhibit F: Deed of Trust

ARTICLE 2. PROPERTY DEFINED

2.1 **Shoshone Water Rights**. As used in this Agreement, the property being conveyed is the following described water rights:

(a) The Shoshone Power Plant senior water right decreed as the Glenwood Power Canal and Pipeline water right on Dec. 9, 1907, in Civil Action No. 0466, Eagle County District Court, in the amount of 1,250 cfs with an appropriation date of Jan. 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as further decreed by the Eagle County District Court on Feb. 27, 1911, in Civil Action No. 553; and

(b) The Shoshone Power Plant junior water right decreed as the Shoshone Hydro Plant Diversion No. 2 on Feb. 7, 1956 in Civil Action No. 1123, Eagle County District Court, in the amount of 158 cfs with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy.

together, (the "**Shoshone Water Rights**").

ARTICLE 3. PURCHASE & SALE

3.1 **Agreement of Purchase and Sale**. Subject to the terms and conditions of this Agreement, PSCo agrees to convey to River District, and River District agrees to purchase from PSCo the Shoshone Water Rights for the Purchase Price. The River District's payment of the Purchase Price to PSCo shall be as follows:

(a) Deposit. Not later than ten (10) business days following the Effective Date, River District shall deliver FIVE HUNDRED THOUSAND and 00/100 DOLLARS ($500,000.00), by wire transfer or bank or cashier's check, at its election (the "**Initial Deposit**") to the escrow holder defined below (the "**Escrow Holder**"). The Initial Deposit shall be deposited with and held by Escrow Holder as a deposit against the Purchase Price in accordance with the terms and provisions of this Agreement, and shall be credited against the Purchase Price if the transaction closes. All interest accruing on the Initial Deposit shall accrue to PSCo and be applied

against the Purchase Price at Closing. In the event this Agreement is terminated pursuant to the terms of this Agreement, the Escrow Holder shall distribute the Initial Deposit and interest accrued thereon in a manner consistent with Section 4.5, below.

(b) Escrow Holder. The Escrow Holder shall be First American Title Insurance Company, 1380 17th Street, Denver, CO 80202, Attn: Nichole Segura, Vice President, Commercial Escrow Officer. Upon execution of this Agreement, the Parties shall execute an escrow agreement as reasonably requested by the Escrow Holder, subject to PSCo's and River District's review and approval, not to be unreasonably withheld (the "**Escrow Agreement**"), substantially in the form of Exhibit A attached hereto. Escrow Holder shall hold and dispose of the Deposit in accordance with the terms of this Agreement and the Escrow Agreement.

(c) Transaction Costs. In addition to the Purchase Price, the River District shall pay PSCo FIVE HUNDRED THOUSAND and 00/100 DOLLARS ($500,000.00) (the "**Transaction Cost Prepayment**") as prepayment for PSCo's legal and consulting fees and costs incurred in negotiating this Agreement, negotiating associated agreements with the River District, Colorado Water Conservation Board and Denver Water; participating in filing and prosecuting a change application in Water Court, and participation in other negotiations, agency or regulatory approval processes, including the Colorado Public Utilities Commission, or other actions related to this transaction ("**Transaction Costs**"). The River District shall pay the Transaction Cost Prepayment no later than ten (10) days following the Effective Date by delivering the same directly to PSCo by wire transfer pursuant to instructions provided by PSCo. The Transaction Cost Prepayment to PSCo shall not be refundable in any amount to River District, except upon early termination of this Agreement and shall not be applied or credited against the Purchase Price at Closing. If the total Transaction Costs exceed the Transaction Cost Prepayment, the River District shall pay the difference at Closing (the "**Final Transaction Costs**"). Prior to Closing, at least every sixty (60) days, PSCo shall provide an up-to-date accounting of the Transaction Costs incurred by PSCo which will identify the billing entity, the total billed by such entity, and a brief description of the work performed. Before any funds may be transferred to PSCo as contemplated by this paragraph, PSCo must provide a signed W-9 to the River District, be set up as a vendor in the River District's billing/accounting system, provide its wiring instructions to the River District, and participate in a wire confirmation call with the River District.

(d) Closing Payment.

1. On the day of the Closing, SEVENTY-EIGHT MILLION FIVE HUNDRED THOUSAND and 00/100 DOLLARS ($78,500,000.00) of the Purchase Price, as adjusted by the Initial Deposit, and any interest accrued thereon, shall be paid in cash to PSCo by wire transfer (the "**Closing Payment"**). Notwithstanding the foregoing, the River District may, in its sole option and discretion, choose to pay more than the Closing Payment at Closing.

2. The balance of the Purchase Price, if any, after payment of the Closing Payment, and any other amounts tendered by the River District at Closing pursuant to Section 3.1(d)1. above, shall be paid to PSCo over ten (10) years in equal annual installment due on or before April 30 each year, as set forth in the promissory note (the "**Promissory Note**") attached hereto as Exhibit E and

incorporated herein by reference. The Promissory Note and Deed of Trust attached assumes the remaining balance will be TWENTY MILLION and 00/100 DOLLARS ($20,000,000.00) and the Parties agree to adjust the principal sum stated on the Promissory Note and Deed of Trust to reflect the actual balance of the Purchase Price prior to its execution. If the River District tenders the entire Purchase Price at Closing, the Promissory Note and Deed of Trust will not be required to close the transaction contemplated by this Agreement.

ARTICLE 4. DUE DILIGENCE AND CONDITIONS PRECEDENT TO CLOSING

4.1 PSCo's Due Diligence Deliveries. PSCo shall deliver or make available to River District, within fourteen (14) business days after the Effective Date, complete, legible copies of the items described in Exhibit B attached to this Agreement to the extent such items are in the possession or control of PSCo (collectively, "**PSCo's Due Diligence Deliveries**"). The Due Diligence Deliveries shall be considered to be Common Interest Information pursuant to the Common Interest, Confidentiality and Joint Defense Agreement executed by the Parties as of March 15, 2023 (the "**JDA**"). In the event that the Closing hereunder shall not occur for any reason whatsoever, River District shall promptly return PSCo's Due Diligence Deliveries to PSCo and shall destroy all copies and abstracts thereof.

4.2 Right of Inspection.

(a) During the Due Diligence Period and prior to Closing, River District shall, at its own cost and expense, have the right to review all aspects of the Shoshone Water Rights and conduct such inspections as it determines are necessary for completion of the transaction. River District shall schedule and coordinate all physical inspections of the Shoshone Water Rights and/or the Power Plant with PSCo and shall give PSCo at least seven (7) days' prior notice thereof. The River District, and its authorized agents and employees, must be escorted by a badged PSCo representative at all times while the River District is at the Power Plant or on other PSCo-owned property. The River District, and its authorized agents and employees, must observe PSCo's safety and security policies at all times while at the Power Plant or on other PSCo-owned property. PSCo shall reasonably cooperate with River District's inspections (including without limitation River District's interviews with PSCo personnel) so long as such cooperation is at no material expense to PSCo. River District shall not, in connection with its investigations, unreasonably interfere with Power Plant operations.

(b) To the extent allowed by applicable law, the River District shall indemnify, defend and hold PSCo harmless from and against all costs, expenses, damages, liabilities, liens or claims, including, without limitation, attorneys' fees and court costs, directly related to any entry on property associated with the Power Plant or Shoshone Water Rights by the River District, its agents, employees or contractors in the course of performing inspections, tests and/or inquiries provided for under this Agreement, or resulting from any conditions on such property created by River District's entry and testing (but not including any claims resulting from the discovery or disclosure of pre-existing physical or environmental conditions or any claims resulting solely from the gross negligence or willful misconduct of PSCo or its agents, representatives, employees or contractors). The foregoing indemnity shall survive the Closing Date or earlier termination of this Agreement.

4.3 Due Diligence Review; Approval. River District shall promptly commence, and shall diligently and in good faith pursue, its due diligence reviews hereunder within the Due Diligence Period. If, prior to the expiration of the Due Diligence Period, based upon such review, examination or inspection, River District determines in its sole and absolute discretion that it no longer intends to acquire the Shoshone Water Rights, the River District shall promptly notify PSCo of such determination in writing ("**Disapproval Notice**") whereupon this Agreement, and the obligations of the Parties to purchase and sell the Shoshone Water Rights, shall terminate, except those provisions that expressly survive the termination hereof, and the Initial Deposit shall be returned to the River District. If River District fails to deliver the Disapproval Notice to PSCo on or before the expiration of the Due Diligence Period, River District shall be deemed to have approved of all of the foregoing matters, and the transaction shall proceed to Closing, subject to completion of the Closing Conditions described in Section 4.4, below. In the event River District fails to deliver the Disapproval Notice on or before the expiration of the Due Diligence Period, River District shall be deemed to have accepted the condition of the Shoshone Water Rights in their "AS IS, WHERE IS" and "WITH ALL FAULTS" condition subject to the representations and warranties expressly made by PSCo in this Agreement.

4.4 Conditions Precedent to Obligations of River District and PSCo to Close. In addition to the River District's approval of its due diligence review as provided in Section 4.3, PSCo and River District agree that the Parties' obligation to complete the transaction hereunder shall be subject to the satisfaction or mutually agreed upon waiver of the following conditions at or prior to Closing (the "**Closing Conditions**"):

(a) Negotiate Use of the Shoshone Water Rights by CWCB for Instream Flow Purposes. The Parties agree to use their best efforts to mutually negotiate an agreement between the PSCo, the River District, and the Colorado Water Conservation Board ("**CWCB**") to enable the Shoshone Water Rights to be used for instream flow purposes when they are not being used for power generation purposes (the "**Instream Flow Agreement**"). The Instream Flow Agreement shall be executed prior to filing the Change Application described in Section 4.4(c), below, *provided however* that the Instream Flow Agreement will be effective as of the Closing Date of this Agreement, and will be held in escrow by the Parties pending delivery at Closing. The Instream Flow Agreement with the CWCB shall include the following provisions:

1. Use of the Shoshone Water Rights by the CWCB shall be subject to the lease of said water rights after Closing by the River District, as lessor, to PSCo, as lessee, for continued hydroelectric generation purposes (the "**Lease**").

2. PSCo's continued use of the Shoshone Water Rights pursuant to the Lease shall have precedence over use of the said water rights for instream flow purposes.

3. The use of the Shoshone Water Rights by the CWCB shall be conditioned upon the Closing of this Agreement and the issuance of a final Water Court Decree (as defined in Section 4.4(c) below), which changes the use of the Shoshone Water Rights to include instream flow purposes.

(b) Negotiate with Certain Potential Water Court Objectors. As described in subsection (c), below, the Parties intend to file a joint application to change the Shoshone Water Rights to include instream flow uses as an additional decreed use. Prior to filing such application, the Parties agree to use their best efforts to identify third parties who would likely file statements of opposition to the Change Application, and to enter into negotiations with said third parties to address their concerns with the goal of eliminating or minimizing objections to the Change Application. Closing is not specifically dependent on the Parties' success in reaching an agreement or stipulation with any of the potential water court objectors.

(c) Obtain Decree for Change of Shoshone Water Rights. The Parties and the CWCB will file an application with the Water Court, Water Division 5, seeking to change the Shoshone Water Rights to add instream flow uses as an additional decreed use (the "**Change Application**"). The Parties agree to prosecute the Change Application with diligence with the goal of obtaining a final decree (the "**Water Court Decree**"), with all rights of appeal exhausted or expired, by June 30, 2026; provided, however, that the deadline for completion of litigation may be extended by the Parties by mutual agreement to address unforeseen circumstances in completing the litigation. Should PSCo, in its sole and absolute discretion, determine that the adjudication of the Change Application would negatively impact the Shoshone Water Rights, impair PSCo's ability to continue hydroelectric generation at the Power Plant, or otherwise impair significant PSCo business interests, PSCo may withdraw the Change Application and terminate this Agreement. Should the River District, in its sole and absolute discretion, determine that the adjudication of the Change Application would prevent the acquisition of these rights from providing the intended benefit, the River District may withdraw the Change Application and terminate this Agreement.

Should either Party make a determination to withdraw the Change Application in accordance with this subparagraph (c), such Party shall provide notice of its intent to withdraw to the other Party, and the Parties shall then have sixty (60) days (the "**Review Period**") from the date of such notice during which the Parties shall discuss the concerns of the issuing Party and attempt to resolve those concerns and prevent withdrawal of the Change Application and termination of this Agreement. If the Parties are unable to resolve the issuing Party's concerns within the Review Period, the Party who issued the notice may withdraw from the Change Application and terminate this Agreement.

(d) Negotiate Amendment of Shoshone Relaxation Agreement with Denver Water. Effective January 1, 2007, PSCo entered into that certain Agreement Concerning Reduction of Shoshone Call (the "**Relaxation Agreement**") with the City and County of Denver, acting by and through its Board of Water Commissioners ("**Denver Water**"). The Parties to this Agreement will seek to negotiate the following amendments to the Relaxation Agreement with Denver Water (the "**Amendment to the Relaxation Agreement**"), to be effective upon Closing of this Agreement:

1. Modify the term of the Relaxation Agreement to be perpetual instead of terminating on February 28, 2032;

2. Allow all or part of the Relaxation Agreement to be assigned by PSCo to the River District if PSCo permanently ceases operation of the Power Plant;

3. Remove or modify the bidding rights granted to Denver in paragraph 13 of the Relaxation Agreement;

4. Include new provisions that would provide for the Relaxation Agreement to continue to operate in a manner that replicates historical Power Plant outages for regular maintenance activities if Power Plant operations permanently cease and the Shoshone Water Rights are used solely for instream flow purposes.

(e) Approval of the Public Utility Commission. PSCo shall obtain any final, non-appealable, approvals and decisions from the Colorado Public Utilities Commission ("**PUC**") legally required to effectuate the transaction contemplated by this Agreement (the "**PUC Decision**"), which must be fully acceptable to PSCo, and shall not impose any unsatisfactory conditions nor revise the terms and conditions of this Agreement, PSCo's tariffs, or any related agreements in any material respect. PSCo shall commence the approval process with the PUC upon satisfaction of Section 4.4(a), (c) and (d) and receipt from the River District of evidence that the River District has sufficient funds to make the Closing Payment. The Parties shall cooperate to seek such PUC Decision, including, without limitation, preparing responses to any information requests, providing any testimony or witnesses, and filing any supporting briefs or affidavits as may be useful and helpful to obtain regulatory approval. PSCo agrees to pursue the PUC Decision with diligence with the goal of obtaining the same by twelve (12) months from the date of PSCo's first public filing in the PUC approval process; provided, however, that the deadline for obtaining the PUC Decision may be extended by the Parties by mutual agreement to address unforeseen circumstances in completing the PUC approval process. PSCo, in its sole and absolute discretion, shall have the right to file any application for rehearing, reargument, and reconsideration with the PUC or to appeal any decision of the PUC to the courts.

(f) River District Financing. River District shall have available sufficient funds to make the Closing Payment to PSCo, and evidence of the same must be submitted to PSCo prior to commencing the PUC process outlined in subsection (e) immediately above. The Parties recognize that the River District anticipates a portion of the Closing Payment will be paid using funding from governmental funding sources (i.e. municipal, county, state, or federal governments or agencies, including but not limited to the River District) and that evidence of available sufficient funds from governmental sources in this paragraph shall include funds that are appropriated and/or otherwise committed by the governmental entity or entities toward the purchase of the Shoshone Water Rights.

(g) Release of PSCo Corporate Indenture. Following expiration of the Due Diligence Period, PSCo shall make application for a release of the Shoshone Water Rights from the lien of PSCo's corporate indenture ("**Indenture Release**"). In the event the Indenture Release is not issued, for any reason, on or before Closing, PSCo may, at PSCo's option, extend the Closing Date by written notice to River District for up to six (6) successive thirty (30) day periods or until such Indenture Release is issued.

(h) Waiver of Closing Conditions. The conditions set forth in Section 4.4(a) through (g) are for the mutual benefit of River District and PSCo. Unless stated otherwise therein, to the extent that one or more of the Closing Conditions have not been satisfied, the Parties may only waive such Closing Condition by mutual agreement in writing.

4.5 Termination.

(a) Except as may otherwise be indicated, if any of the conditions expressly set forth in Sections 4.4(a)-(f) have not been satisfied, extended or waived by mutual agreement of the Parties by December 31, 2027, or in the event of termination pursuant to Section 5.2(c), this Agreement may be terminated, with both Parties consenting to and acknowledging such termination in writing, and the terms hereof shall be of no further force and effect, except those provisions that expressly survive the termination hereof. In the event of termination in accordance with this Section 4.5(a), the Initial Deposit, and any accrued interest thereon, shall be released to PSCo.

(b) In the event of termination pursuant to Section 4.3, Section 4.4(g), and Section 5.1(h), the Initial Deposit, and any accrued interest thereon, shall be released to the River District.

(c) If this Agreement is terminated pursuant to a termination right expressly set forth in this Section 4.5, then:

1. within ten (10) business days following such termination and to the extent not otherwise prohibited by applicable law, River District shall deliver to PSCo all of the PSCo Due Diligence Deliveries it holds in non-electronic form or shall certify the destruction of same;

2. any documents deposited with Escrow Holder by River District shall be returned to River District, and any documents deposited with Escrow Holder by PSCo shall be returned to PSCo;

3. the Parties shall equally share any cancellation fee of the Escrow Holder;

4. the Parties shall withdraw the Change Application if it is pending, with a preference to withdraw the Change Application without prejudice;

5. PSCo shall withdraw the PUC application if it is pending;

6. if the Instream Flow Agreement has been finalized, the Parties and CWCB shall terminate such agreement;

7. if the Amendment to the Relaxation Agreement has been finalized, the Parties and Denver Water shall terminate such agreement;

8. the Parties shall execute all documents necessary to direct the Escrow Holder to release the Initial Deposit, in accordance with Sections 4.5(a) and 4.5(b) above; and

9. neither Party shall have any further obligations to the other hereunder, except for those obligations and indemnities which are expressly made to survive the termination.

(d) If the transaction contemplated by this Agreement is terminated prior to the Closing Date, PSCo, within ninety (90) days after the termination, shall provide an accounting of its actual Transaction Costs as of the date of termination to the River District and

1. if the actual Transaction Costs have not exceeded the Transaction Cost Prepayment, PSCo shall within that ninety (90) day period return to the River District any unapplied balance of the Transaction Cost Prepayment; or

2. if the actual Transaction Costs have exceeded the Transaction Cost Prepayment, the River District shall within that ninety (90) day period pay to PSCo the amount of the Transaction Costs which have exceeded the Transaction Cost Prepayment.

Before any funds may be transferred to the River District as contemplated by this paragraph, the River District must provide a signed W-9 to PSCo, be set up as a vendor in PSCo's billing/accounting system, provide its wiring instructions to PSCo, and participate in a wire confirmation call with PSCo.

(e) Pre-Closing Default. EXCEPT FOR THE RELEASE OF THE INITIAL DEPOSIT TO PSCO WHERE SPECIFIED HEREIN AND THE PAYMENT OF INCURRED TRANSACTION COSTS TO PSCO, SUBJECT TO ACCOUNTING IN THE EVENT OF TERMINATION, THE PARTIES HEREBY SPECIFICALLY WAIVE ANY SPECIAL, CONSEQUENTIAL, PUNITIVE, SPECULATIVE OR DIRECT DAMAGES AND ANY RIGHT EITHER PARTY MAY HAVE TO SPECIFIC PERFORMANCE IN THE EVENT OF A TERMINATION PURSUANT TO THIS SECTION 4.5.

ARTICLE 5. REPRESENTATIONS, WARRANTIES, AND COVENANTS

5.1 PSCo's Representations and Warranties. PSCo represents and warrants to River District as of the Effective Date and again as of Closing as follows:

(a) PSCo is a Colorado corporation, duly organized and validly existing and in good standing under the laws of the State of Colorado.

(b) This Agreement and all documents executed by PSCo that are to be delivered to River District at the Closing are, or at the time of Closing will be, duly authorized, executed and delivered by PSCo and are, or at the time of Closing will be, legal, valid and binding obligations of PSCo.

(c) To the best of PSCo's knowledge as of the Effective Date, PSCo has received no notice from any governmental authority with jurisdiction over the Shoshone Water Rights of any current violation of any laws or regulations applicable to the Shoshone Water Rights.

(d) To the best of PSCo's knowledge, there is no material litigation pending or threatened against PSCo that arises out of the ownership of the Shoshone Water Rights.

(e) To the best of PSCo's knowledge, no condemnation or other eminent domain proceedings are pending or threatened against the Shoshone Water Rights.

(f) PSCo is not and has never been a "foreign person" within the meaning of Section 1445 of the Internal Revenue Code of 1986, as amended, and any applicable regulations promulgated thereunder. Neither PSCo nor, to PSCo's knowledge, any of its affiliates or their respective partners, members, shareholders or other equity owners is a person or entity with whom U.S. Persons or entities are restricted from doing business under regulation s of the Office of Foreign Asset Control ("OFAC") of the Department of the Treasury or under any statute, executive order, or other governmental action.

(g) To the best of PSCo's knowledge, PSCo has not received any written notice that the Shoshone Water Rights are in breach of any "Environmental Requirements," meaning all laws, ordinances, statutes, codes, rules, regulations, agreements, judgments, orders, and decrees, now or hereafter enacted, promulgated or amended, of the United States, the State of Colorado, local governmental entities or any other political subdivision or agency exercising jurisdiction over the owner of the Shoshone Water Rights, the Shoshone Water Rights, or the use of the Shoshone Water Rights, relating to pollution, the protection or regulation of human health, natural resources, or the environment, or the emission, discharge, release or threatened release of pollutants, contaminants, chemicals of industrial, toxic or hazardous substances or waste or hazardous materials into the environment (including, without limitation, ambient air, surface water, ground water or land or soil).

(h) **To the extent that PSCo becomes aware after the Effective Date and prior to the Closing that any of the representations and warranties set forth in this Section 5.1, are no longer true and correct, PSCo shall promptly, and in any event prior to the Closing, provide River District with written notice thereof and explain in reasonable detail the facts giving rise to the change. Unless PSCo elects to cause and does cause the representation or warranty to again become true or correct prior to Closing, River District shall have the right to terminate the Agreement based any changes in the representations set forth in Section 5.1.**

The representations and warranties of PSCo set forth in Section 5.1, as updated as of the Closing Date in accordance with the terms of this Agreement, shall survive Closing for a period of six (6) months (the "**Survival Period**"), and upon expiration thereof shall be of no further force or effect except to the extent that, with respect to any particular alleged breach, River District gives PSCo written notice so as to be received by PSCo on or before the expiration of the Survival Period of such alleged breach with sufficient detail summarizing the nature of such alleged breach (a "**Claim Notice**") and files an action against PSCo with respect thereto within sixty (60) days of the date of such Claim Notice. Notwithstanding anything to the contrary contained herein, PSCo shall have no liability to the River District for the breach of any representation or warranty made in this Agreement or in PSCo's closing documents unless the loss resulting from PSCo's breach of its representations and warranties exceeds, in the aggregate, Twenty-Five Thousand Dollars ($25,000.00), in which event PSCo shall be liable for each dollar of damages resulting from the breach or breaches of its representations and warranties, but in no event shall PSCo's total liability for any such breach or breaches exceed, in the aggregate, five percent (5%) of the Purchase Price (the "**Cap**"); provided, however, that the Cap shall not apply to any claims made by River District due to any PSCo fraud. In no event shall any claim for a breach of any representation or warranty of PSCo be actionable or payable if the breach in question results from or is based on a condition, state of facts or other matter which was actually known by River District or any of River District's

employees, without any duty of inquiry, prior to Closing. PSCo shall indemnify and defend River District, its directors, officers, employees, agents, successors and assigns from and against any claim, loss, liability or expense, including reasonable attorneys' fees that, during the Survival Period, arise out of or result from the breach by PSCo of any of the foregoing representations or warranties.

With the sole exception of the representations and warranties set forth in this Agreement or in the closing documents executed by PSCo at Closing ("**PSCo Closing Documents**"), the agreement between River District and PSCo for the sale of the Shoshone Water Rights is made without representation or warranty of any kind by PSCo. With the sole exception of the representations and warranties set forth in this Agreement or in the PSCo Closing Documents, PSCo makes no representation or warranty of any kind with regard to the quality or quantity of the Shoshone Water Rights or the physical condition of any infrastructure associated therewith, with regard to any restrictions, requirements, costs or constraints that may be associated with the Shoshone Water Rights, or with regard to the suitability of the Shoshone Water Rights for River District's purposes, it being the parties' express understanding and agreement that River District shall fully inspect the Shoshone Water Rights and all aspects thereof during the Due Diligence Period and prior to Closing, and that River District will rely solely upon its own inspection in determining the physical condition and other features of the Shoshone Water Rights, any restrictions, requirements, costs or constraints that may be associated with the Shoshone Water Rights, and whether the Shoshone Water Rights are suitable for River District's intended purposes. With the sole exception of the representations and warranties set forth in this Agreement or in the PSCo Closing Documents, River District will acquire the Shoshone Water Rights in an "AS IS" and "WITH ALL FAULTS" condition. Without limiting the generality of the foregoing, except to the extent the representations and warranties set forth in this Agreement or in the PSCo Closing Documents are not true and correct, River District, for itself and its successors and assigns, releases PSCo and PSCo's agents, employees, managers, members, brokers, contractors and representatives from, and waives any and all causes of action or claims against any of such persons for, (a) any and all liability attributable to any physical condition of Shoshone Water Rights, including, without limitation, the presence of any hazardous materials; and (b) any and all liability resulting from the failure of the Shoshone Water Rights to comply with any applicable laws, including, without limitation, any environmental laws. Wherever herein a representation is made based upon the knowledge of, or notice to, PSCo, such knowledge or notice, is limited to the actual knowledge without duty of inquiry of, or notice received by Donald Hartinger, Director, Plant Operations, and Patrick Martinez, Sr. Manager, Operations, all of Xcel Energy Services Inc., provided nothing in this Agreement will be deemed to be a representation made by any named individual other than in their respective representative capacity, and the River District hereby expressly releases such individuals from any and all personal liability arising out of this Agreement or the representations made herein.

5.2 River District's Representations and Warranties. River District hereby represents and warrants to PSCo as of the Effective Date and again as of Closing as follows:

(a) River District is a body corporate and politic and a political subdivision of the state of Colorado duly organized and validly existing under the laws of the state of Colorado, with full right, power and authority to take title to the Shoshone Water Rights and to enter into and otherwise perform and comply with the terms of this Agreement.

(b) This Agreement and all documents executed by River District that are to be delivered to PSCo at the Closing are, or at the time of Closing, will be duly authorized, executed and delivered by River District and are, or at the time of Closing will be legal, valid and binding obligations of River District.

(c) To the extent that River District becomes aware after the Effective Date and prior to the Closing that any of the representations and warranties set forth in Section 5.2 are no longer true and correct, River District shall promptly, and in any event prior to the Closing, provide PSCo with written notice thereof and explain in reasonable detail the facts giving rise to the change. Unless River District elects to cause and does cause the representation or warranty to again become true or correct prior to Closing, PSCo shall have the right to terminate the Agreement based on any material change in the representations set forth in Section 5.2.

(d) The representations and warranties of River District set forth in Section 5.2 as updated as of the Closing in accordance with the terms of this Agreement, shall survive Closing for a period of six (6) months.

5.3 PSCo's Covenants. Between the Effective Date and the Closing or earlier termination of this Agreement, or for such other time period as set forth below, PSCo covenants and agrees as follows:

(a) PSCo shall operate and maintain the Shoshone Water Rights in substantially the same manner in which PSCo is currently operating the Shoshone Water Rights, subject to outages at the Power Plant due to necessary maintenance and repairs.

(b) Except for the existing lien of PSCo's corporate Indenture, PSCo shall not sell, mortgage, pledge, transfer or dispose of the Shoshone Water Rights, or any interest therein, except as contemplated as a condition of this Agreement. PSCo shall not create any new encumbrances on, or limitations on the exercise of, the Shoshone Water Rights.

(c) PSCo will not directly or indirectly solicit, actively encourage, initiate, entertain, substantively review, or participate in any negotiations or discussions with any other person or entity with respect to any offer or proposal to sell or finance the Shoshone Water Rights or any part thereof.

ARTICLE 6. CLOSING

6.1 Date and Location. The closing of this transaction (the "**Closing**") shall occur at a mutually agreeable time and place as the Parties and Escrow Holder may mutually agree to in writing, but not later than sixty (60) days following issuance of the PUC Decision and the expiration of all periods of appeal of such decision without contest (the "**Closing Date**").

6.2 Transactions at Closing.

(a) On or before the Closing Date, PSCo shall deliver or cause to be delivered to the Escrow Holder, with appropriate instructions for recording and disbursement consistent with this Agreement, the following documents duly executed and acknowledged where appropriate:

1. The Special Warranty Deed substantially in the form of Exhibit C.

2. The Lease to PSCo substantially in the form attached as Exhibit D.

3. The Indenture Release.

4. A Certificate of non-foreign status pursuant to Section 1445 of the Internal Revenue Code of 1986, as amended, together with any Certificates required pursuant to Colorado law.

5. The Amendment to the Relaxation Agreement.

6. The PUC Decision.

7. A W-9 Form.

8. Such other documents as may be reasonably necessary and appropriate to complete the Closing as contemplated herein.

(b) On or before the Closing Date, River District shall deliver or cause to be delivered to the Escrow Holder, with appropriate instructions for recording and disbursement consistent with this Agreement, the following documents to be duly executed an acknowledged where appropriate:

1. An executed Promissory Note substantially in the form attached as Exhibit E.

2. A Deed of Trust substantially in the form attached as Exhibit F.

3. The Lease.

4. The Instream Flow Agreement.

5. The Water Court Decree.

6. A W-9 Form.

7. Such other documents as may be reasonably necessary and appropriate to complete the Closing contemplate herein.

8. The Closing Payment.

9. The Final Transaction Costs, if any.

(c) Each Party shall, at Closing or from time-to-time prior to Closing, execute and deliver such further instruments, affidavits, and documents as the other Party or the Escrow Holder may reasonably request to effectuate the intent of this Agreement or as required by applicable law.

(d) The Escrow Holder shall record and/or distribute the Closing Documents and shall release the Initial Deposit, the Closing Payment, and Final Transaction Costs to PSCo.

(e) River District shall pay for the cost of recording of all deeds. The Parties shall each pay for one-half (1/2) of the cost of recording any of the other Closing Documents. The Parties shall each pay one-half (1/2) of the Escrow Holder costs. Except as provided in Section 3.1(c) above, each Party shall pay its own attorneys' fees.

ARTICLE 7. GAINS ON SALE

The River District recognizes and agrees that any decision on how PSCo allocates or uses the gains on sale, if any, from the transaction contemplated by this Agreement (the "**Gains**") is a business decision within the discretion of PSCo. In addition to the foregoing, the Parties recognize and agree that the allocation or use of the Gains may be limited by the PUC Decision.

PSCo and the River District share an interest in the ecological and environmental health of the Colorado River. The Parties also share an interest in the benefits of emerging and next-generation utility projects, and PSCo plans to pursue these types of projects across Colorado. Should PSCo identify a project located in the western Colorado region served by the River District which advances these shared interests, and which provides a benefit to PSCo's ratepayers across the State of Colorado, and should PSCo decide to allocate, use or invest any of the Gains to finance such a project, the Parties agree to work together to promote such projects.

Notwithstanding the foregoing, the River District will not make any public statements in opposition to PSCo's business decisions on how to allocate or use the Gains in accordance with Section 4.4(e).

ARTICLE 8. POST-CLOSING DEFAULTS AND REMEDIES

8.1 Events of Default. After Closing, each of the following shall constitute an "**Event of Default**":

(a) Default by either Party in the due and punctual performance of any of its covenants, conditions, agreements, payments or other provisions contained in this Agreement on its part to be performed, if such default continues for thirty (30) days after written notice specifying such default and requiring the same to be remedied is given by the non-defaulting Party; provided that if such default cannot be cured within such thirty (30) days, and during such period corrective action has commenced to remedy such default and subsequently is diligently pursued to the completion of such performance, an Event of Default shall not be deemed to have occurred until one hundred and twenty (120) days after written notice has been delivered.

(b) Subject to any of the survival provisions of Sections 5.1 and 5.2 (Survival), any of the representations or warranties made by a Party shall prove to have been materially incorrect under the circumstances when made.

8.2 Remedies, Generally. Upon the occurrence and continuation of an Event of Default, the following remedies shall be available to the Parties:

(a) Except as provided in Section 8.2(b) below, if an Event of Default by PSCo, River District may in its sole discretion:

1. Waive such default or condition; or

2. If the Event of Default by PSCo is not cured as provided in Section 8.1, above, River District shall have the right to damages, EXCEPT THAT RIVER DISTRICT SPECIFICALLY WAIVES ANY SPECIAL, CONSEQUENTIAL, PUNITIVE, SPECULATIVE OR INDIRECT DAMAGES.

(b) If the Event of Default consists of a default by River District under Section 8.1, above, PSCo may in its sole discretion:

1. Waive such default or condition; or

2. If the Event of Default by River District is not cured as provided in Section 8.1, above, PSCo shall have the right to damages, EXCEPT THAT PSCo SPECIFICALLY WAIVES ANY SPECIAL, CONSEQUENTIAL, PUNITIVE, SPECULATIVE OR INDIRECT DAMAGES.

ARTICLE 9. NOTICES

Any notice, demand, claim or other written instrument required or permitted to be given pursuant to this Agreement shall be in writing signed by the Party giving such notice and shall be sent by electronic mail, hand messenger delivery, overnight courier service or certified mail (receipt requested) to the other Party at the addresses set forth below and shall be deemed to have been duly given by delivery to the respective addresses provided below, or such other address changed by the recipient by notice consistent with this Article: (i) on the date and at the time of delivery if delivered personally to the Party to whom notice is given at such address; (ii) on the date and at the time of delivery or refusal of acceptance of delivery if delivered or attempted to be delivered by an overnight courier service to the Party to whom notice is given as such address; (iii) on the date of delivery or attempted delivery shown on the registered or certified mail, return receipt requested, postage prepaid and properly addressed to such address; (iv) if an email address is specified, on the date and at the time shown on the sent email message if sent to the e-mail address specified below:

If to PSCo: Public Service Company of Colorado
Attn: Environmental Services - Water Resources
1800 Larimer Street, Suite 1300
Denver, CO 80202

With Copy to: Public Service Company of Colorado
Attn: Director, Community Relations
1800 Larimer Street, Suite 1400
Denver, CO 80202

and: Xcel Energy
Attn: Frances A. Folin, Esq.
1800 Larimer Street, 14th Floor
Denver, CO 80202
Frances.A.Folin@xcelenergy.com

and: Welborn Sullivan Meck & Tooley, P.C.
1401 Lawrence Street, Suite 1800
Denver, CO 80202
Attn: Carolyn Burr, Esq.; James M. Noble, Esq.
cburr@wsmtlaw.com
jnoble@wsmtlaw.com

If to River District: Andy Mueller, Esq.
General Manager
Colorado River Water Conservation District
201 Centennial St., #200
Glenwood Springs, CO 81601
amueller@crwcd.org

With Copy to: Peter Fleming, Esq.
General Counsel
Colorado River Water Conservation District
201 Centennial St., #200
Glenwood Springs, CO 81601
pfleming@crwcd.org

If to Escrow Holder: First American Title Insurance Company
1380 17th Street
Denver, CO 80202
Attn: Nichole Segura, Vice President
303.876.1112
nsegura@firstam.com

ARTICLE 10. MISCELLANEOUS

10.1 No Third-Party Beneficiary: No Waiver of Governmental Immunity. This Agreement shall not create any duty of care or liability with respect to any person or entity not a Party to this Agreement, or waive any of the privileges or immunities River District or its officers, employees, successors and assigns may present pursuant to law, including, but not limited to, the Colorado Governmental Immunity Act, C.R.S. 24-10-101, et seq., as amended.

10.2 Limits on Governmental Immunity. River District represents that, pursuant to C.R.S. Section 24-10-106, its governmental immunity is limited to claims for injury that lie in tort or could lie in tort. Under existing law, River District is not entitled to raise the defense of

sovereign immunity in connection with any legal proceeding to enforce or collect upon contractual obligations, including this Agreement, or any amendments or exhibits to this Agreement, including the payment of any amounts due thereunder, provided however that no term or condition of this Agreement shall be construed or interpreted as a waiver, express or implied, of any of the privileges or immunities River District, its officers, employees, successors or assigns may present pursuant to law, including but not limited to the Colorado Governmental Immunity Act, C.R.S. Section 24-10-101 et seq., as amended.

10.3 Mediation. If any dispute arises under this Agreement (including as to whether either Party has breached this Agreement or whether an Event of Default has occurred), then either Party may require that the other engage in nonbinding dispute resolution processes upon delivery of a written notice (a "**Dispute Notice**") setting forth the disputed matter. Upon receipt by the other party of such Dispute Notice, the Parties shall use commercially reasonable efforts to negotiate a resolution of the dispute for a period of sixty (60) days (the "**Dispute Resolution Period**") which may include mediation using a mediator chosen by the Parties. During the Dispute Resolution Period, no Party may bring a claim or commence legal action related to or in connection with the matter set forth in the Dispute Notice until the Dispute Resolution Period ends. This section shall not alter any date in this Agreement, unless the Parties agree otherwise in writing.

10.4 Time. Except as otherwise provided in this Agreement, time is of the essence as to each provision of this Agreement and the performance of each Party's obligations hereunder.

10.5 Attorneys' Fees. If any legal action or other proceeding is commenced to enforce or interpret any provision of this Agreement, the prevailing Party (defined below) shall be awarded its attorneys' fees and expenses, in addition to any other relief granted. The phrase "**Prevailing Party**" shall include the Party who receives substantially the relief desired whether by dismissal, summary judgment, judgment or otherwise. This provision shall survive the termination of this Agreement.

10.6 No Waiver. No waiver by any party of the performance or satisfaction of any covenant or condition shall be valid unless in writing and shall not be considered to be a waiver by such party of any other covenant or condition hereunder. Any failure of a Party to enforce any of the provisions of this Agreement or to require compliance with any of its terms at any time during the pendency of this Agreement shall in no way affect the validity of this Agreement, or any part hereof, and shall not be deemed a waiver of the right of such Party thereafter to enforce any and each such provision.

10.7 Entire Agreement. This Agreement contains the entire agreement between the Parties. This Agreement may only be modified by mutual written agreement duly authorized and executed by the Parties.

10.8 Survival. The provisions of this Section and Sections 3.1(d), 4.2, 4.3, 5.1, 5.2, and 10.5 shall survive the Closing or any earlier termination of this Agreement.

10.9 Publicity. Neither PSCo nor River District shall issue any public announcement referencing the Purchase Price or the other economic terms of this Agreement without the prior

written consent of the other. The Parties agree to work cooperatively and in good faith to jointly prepare all public announcements involving this Agreement.

10.10 Assignment. River District may not assign or otherwise transfer this Agreement or any of its rights or obligations hereunder without first obtaining PSCo's prior consent and approval thereto.

10.11 Governing Law and Construction. This Agreement, including any instrument or agreement required hereunder, and all matters arising out of or in connection with this Agreement (whether in contract, tort or otherwise) shall be construed in accordance with and governed by the laws of the State of Colorado without giving effect to any conflict of law principles that would require the application of the laws of another jurisdiction. The Parties hereby agree that the normal rule of construction to the effect that any ambiguities are to be resolved against the drafting party shall not be employed in the interpretation of this Agreement or any amendments or exhibits hereto.

10.12 Venue. All actions or proceedings arising out of or relating to this Agreement and any dispute shall be litigated in the District Court in Garfield County, Colorado. Each Party accepts for itself, generally and unconditionally, the exclusive jurisdiction and venue of the aforesaid court, submits itself to the personal jurisdiction of such courts and waives any defense of forum non conveniens or any similar defense. Each Party hereby waives its respective right to a trial by jury for any claim or cause of action based upon or arising out of or related to this Agreement in any action, proceeding, or other litigation of any type brought by any Party against any other Party, whether with respect to contract claims, tort claims, or otherwise. Each Party agrees that any such claim or cause of action will be tried by a court trial without a jury.

10.13 Joint Effort. Preparation of this Agreement has been a joint effort of the Parties and the resulting document shall not be construed more severely against one Party than against the other Party.

10.14 Days. In the event any time period set forth in this Agreement commences, expires or is determined from a date which falls on a Saturday, Sunday, legal holiday of the State of Colorado, the date of such commencement, performance, expiration or determination shall automatically be extended to the next business day. As used in this Agreement "business day" means any day except any Saturday, Sunday, any day which is a Federal or State of Colorado legal holiday, or any day on which banking institutions in the State of Colorado are authorized or required by law or other governmental action to close.

10.15 Counterparts; Electronic Signatures. This Agreement may be executed in any number of multiple counterparts, each of which shall be deemed to be an original copy and all of which shall constitute one agreement, binding on all parties hereto. PDF or DocuSign signatures shall be sufficient to bind the Parties.

10.16 Integrated Agreement. This Agreement, including all exhibits referenced herein, constitutes the complete, unseverable, unitary, integrated agreement between PSCo and River District concerning the subject matter hereof. The parties hereto acknowledge that they negotiated this Agreement, including all exhibits, as a single transaction and would not have entered into any

portion of the Agreement without the rights and obligations conferred by the Agreement as a whole. In the event of a conflict between the terms of this Agreement and any exhibits, the terms of this Agreement shall control unless such exhibit specifically identifies the Section(s) of this Agreement that will be superseded.

10.17 Approval.

(a) THE OBLIGATIONS OF THE RIVER DISTRICT ARE EXPRESSLY CONTINGENT UPON THE APPROVAL OF THIS AGREEMENT BY THE BOARD OF DIRECTORS OF THE RIVER DISTRICT.

(b) The River District's Board will not publish notice of its intent to consider this Agreement for approval, in accordance with Colorado law, until receiving written confirmation of final approval of this Agreement by the Board of Directors of PSCo and its parent company. Upon confirmation of the River District's Board's approval of this Agreement at a public meeting, each Party shall execute and deliver the Agreement to the other. The Parties may elect and mutually agree to a time and place for in-person execution of this Agreement.

10.18 Requirement of Good Faith and Reasonable Judgment. Unless otherwise expressly provided in this Agreement, all decisions to be made by a Party or jointly by the Parties shall be interpreted to require the exercise of each Party's reasonable judgment, acting in good faith, in rendering such decision.

10.19 Severability. In case any one or more of the provisions contained in this Agreement for any reason is held to be invalid or unenforceable, the invalidity or unenforceability will not affect any other provision of this Agreement, which will be construed as if the invalid or unenforceable provision had not been contained in this Agreement and, in lieu of each invalid or unenforceable provision, there will be added automatically as a part of this Agreement a provision as similar in terms to the invalid or unenforceable provision as may be possible and be valid and enforceable.

10.20 No Warranty of Tax Treatment. Each party is relying solely on itself and its own tax advisors regarding the tax treatment of the transactions contemplated under this Agreement.

10.21 Cooperation. At the request of the other Party, each Party, on its own behalf, covenants that it shall reasonably cooperate with the other Party, at no cost to the cooperating Party, except as provided in Section 3.1(d), in negotiating with other parties, or obtaining governmental approvals which are required to implement the Agreement.

[Signatures on Next Page]

IN WITNESS WHEREOF, the parties hereto have duly executed this Agreement as of the Effective Date.

Public Service Company of Colorado, a Colorado Corporation:

By: _____

Name: Robert S. Kenney
Title: President, Public Service Company of Colorado

Colorado River Water Conservation District, a political subdivision of the State of Colorado

By: _____

Name: Kathy Chandler-Henry
Title: President, Colorado River Water Conservation District

EXHIBIT A

ESCROW AGREEMENT

See attached.



1380 17th Street
Denver, CO 80202

ESCROW INSTRUCTIONS

File # _____

First American Title Insurance Company ("Escrow Agent"), hereby agrees to act as the escrow agent for funds deposited with it by the other parties to this Escrow Agreement ("the Agreement") under the terms and conditions set forth herein.

1. Colorado River Water Conservation District, a political subdivision of the state of Colorado ("Purchaser"), hereby deposits, in escrow with Escrow Agent, funds in the amount of FIVE HUNDRED THOUSAND and 00/100 DOLLARS ($500,000.00) (the "Escrowed Funds").

2. Escrow Agent is authorized to hold the Escrowed Funds in a segregated deposit account. The segregated deposit account [*check one:* _X__ shall _____ shall not] be an interest-bearing deposit account.

3. If Public Service Company of Colorado, a Colorado corporation ("Seller") and Purchaser do not jointly and timely authorize the closing of the transaction contemplated by that certain Purchase and Sale Agreement dated effective as of January 1, 2024 by and between Seller and Purchaser (the "PSA"), or if the PSA is terminated by either party pursuant to the terms thereof, Escrow Agent is instructed to follow the terms of the PSA with respect to the Escrowed Funds. Additionally, Escrow Agent shall obtain the written permission of both parties hereto prior to disbursing the Escrowed Funds. In doing so, Escrow Agent shall be relieved of any further responsibility or liability in connection with this Agreement or the Escrowed Funds.

4. The parties hereto agree that Escrow Agent has not yet made a search of the public records with respect to the transaction contemplated under the PSA, nor has Escrow Agent any documents deposited with Escrow Agent for validity, execution or their effect upon title, if any.

5. The parties agree to pay Escrow Agent any and all fees incurred pursuant to this Agreement or with respect to the escrowed funds and/or documents.

6. The parties hereto agree to hold Escrow Agent harmless, from and against any and all liabilities, losses, damages, expenses and charges, including but not limited to, attorney's fees and expenses of litigation, including those necessary to enforce this indemnification paragraph, which may be sustained or incurred by Escrow Agent and its agents under, or arising directly or indirectly out of such any claim, action, proceeding, or judgment arising from the escrowed documents and/or funds. In the event of a dispute between the parties to this Agreement, Escrow Agent shall be permitted in its sole discretion: (a) not to act unless pursuant to an order of a court, or (b) to file a complaint in interpleader and deposit the documents and/or funds with the court, less all out-of-pocket fees and expenses incurred by Escrow Agent, including attorneys' fees. Upon so acting under 6(a) or (b), Escrow Agent shall be released and forever discharged of all liability under the terms of this Agreement or with respect to the documents and/or funds escrowed.

7. Escrow Agent shall not be personally liable for any act it may do or omit to do hereunder as such agent, while acting in good faith and in the exercise of its own best judgment, and any act done or omitted by it pursuant to the advice of its own attorneys shall be conclusive evidence of such good faith. Escrow Agent shall not be under any duty or obligation to ascertain the identity, authority or rights of the parties executing or delivering or purporting to execute or deliver these instructions or any documents or papers or payments deposited or called for hereunder, and assumes no responsibility or liability for the validity or sufficiency of these instructions or any documents or papers or payments deposited or called for hereunder.

8. The Agreement may be supplemented, altered, amended, modified or revoked by writing only, signed by all of the parties hereto.

Dated effective: January 1, 2024.

Purchaser:

COLORADO RIVER WATER CONSERVATION DISTRICT, a political subdivision of the state of Colorado

By: _____
Name: Kathy Chandler-Henry
Title: President, Colorado River Water Conservation District

Escrow Agent:

FIRST AMERICAN TITLE INSURANCE COMPANY

By: _____
Name: _____
Title: _____

Seller:

PUBLIC SERVICE COMPANY OF COLORADO, a Colorado corporation

By: _____
Name: Robert S. Kenney
Title: President, Public Service Company of Colorado

EXHIBIT B

PSCo's DUE DILIGENCE DELIVERIES

Pursuant to Section 4.1 of the Agreement, PSCo shall provide any of the following documents in possession of PSCo, its agents, contractors, agents and/or attorneys to the River District within 14 days after the Effective Date of the Agreement:

1. Any and all title work, title opinions, correspondence, court documents related to the existence, title, ownership, conveyance, of title related to the Shoshone Water Rights.

2. Any and all documents related to historical diversion of the Water Rights.

3. Any official correspondence or notices from any and all government officials or agencies related to the diversion, beneficial use, or existence of the Shoshone Water Rights.

4. Any public document or correspondence from third parties related to the diversion, beneficial use or existence of the Shoshone Water Rights and/or the validity of the ability or right of the Shoshone Water Rights to call out junior water rights.

5. Any valuation, appraisal or assessment of the value of the Shoshone Water Rights.

EXHIBIT C

SPECIAL WARRANTY DEED

See attached.

SPECIAL WARRANTY DEED
(Grant of Water Rights)

THIS SPECIAL WARRANTY DEED, dated this ___ day of _____, 202_, is from Public Service Company of Colorado, a Colorado corporation ("Grantor"), whose address is 1800 Larimer Street, Suite 1300, Denver, Colorado 80202, to the Colorado River Water Conservation District ("Grantee"), a political subdivision of the State of Colorado, whose address is 201 Centennial Street, Suite 200, Glenwood Springs, Colorado 81601.

WITNESSETH, that Grantor, for and in consideration of the sum of Ten Dollars ($10.00) and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged does grant, sell, transfer, convey, and assign unto Grantee, its successors, and assigns, all of Grantor's right, title, and interest in and to the following water rights:

(a) The water right decreed as the Glenwood Power Canal and Pipe Line water right on December 9, 1907, in Civil Action No. 466, Eagle County District Court, in the amount of 1,250 cubic feet per second with an appropriation date of January 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as further decreed by the Eagle County District Court on February 27, 1911, in Civil Action No. 553; and

(b) The water right decreed as the Shoshone Hydro Plant Diversion No. 2 First Enlargement on February 7, 1956 in Civil Action No. 1123, Eagle County District Court, in the amount of 158 cubic feet per second with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy,

TOGETHER with all and singular the hereditaments and appurtenances thereto belonging, or in anywise pertaining, and the reversion and reversions, remainder and remainders, and all the estate, right, interest, claim and demand whatsoever of the Grantor, in law or equity, of, in, and to the above-described water rights. (the "Shoshone Water Rights").

TO HAVE AND TO HOLD, the Shoshone Water Rights, together with any and all rights incident thereto, forever, and all the estate, right, title and interest of Grantor in the Shoshone Water Rights unto the Grantee. Grantor further represents that it has the authority to convey to Grantee all rights described herein. Grantor, for itself, its successors and assigns, covenants and agrees that it will warrant title and forever defend the Shoshone Water Rights in the quiet and peaceable possession of Grantee, its successors and assigns, against all and every person or persons claiming the whole or any part thereof, by, through, or under the Grantor.

[signature page follows]

SPECIAL WARRANTY DEED
(Grant of Water Right)

IN WITNESS WHEREOF, Grantor has executed this Special Warranty Deed on the date set forth above.

GRANTOR

_____
Robert S. Kenney, President
Public Service Company of Colorado

NOTARIZATION

STATE OF COLORADO)
) ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me on the _____ day of _____ by as President of the Public Service Company of Colorado.

Witness my hand and official seal. My Commission Expires: _____

_____
Notary Public

EXHIBIT D

LEASE OF SHOSHONE WATER RIGHTS

See attached.

WATER LEASE

This WATER LEASE ("Lease") is entered into this ____ day of _____ (the "**Effective Date**"), by and between the COLORADO RIVER WATER CONSERVATION DISTRICT, a political subdivision of the state of Colorado ("**River District**"), and PUBLIC SERVICE COMPANY OF COLORADO, a Colorado corporation ("**PSCo**").

RECITALS

WHEREAS, River District owns the following water rights, which were conveyed to it by PSCo pursuant to the Special Warranty Deed dated _____, 202_, and are diverted at the Shoshone Dam, located in Glenwood Canyon, Colorado, and historically used for non-consumptive hydro-power generation at the Shoshone Hydroelectric Generation Station ("**Power Plant**").

(a) The Power Plant senior water right decreed as the Glenwood Power Canal and Pipeline water right on Dec. 9, 1907, in Civil Action No. 0466, Eagle County District Court, in the amount of 1,250 cfs with an appropriation date of Jan. 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as further decreed by the Eagle County District Court on Feb. 27, 1911, in Civil Action No. 553; and

(b) The Power Plant junior water right decreed as the Shoshone Hydro Plant Diversion No. 2 on Feb. 7, 1956 in Civil Action No. 1123, Eagle County District Court, in the amount of 158 cfs with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy.

together, (the "**Shoshone Water Rights**"); and

WHEREAS, PSCo desires to lease the Shoshone Water Rights from River District for continued use at the Power Plant for as long as the Power Plant is being operated to produce hydroelectric power; and

WHEREAS, River District is willing to lease the Shoshone Water Rights to PSCo for use at the Power Plant;

NOW THEREFORE, for good and valuable consideration, the receipt and adequacy of which are hereby acknowledged, River District and PSCo agree as follows.

LEASE

1. Water Rights Lease. River District hereby leases to PSCo, and PSCo hereby leases from the River District, the above-described Shoshone Water Rights for use at the Power Plant for hydroelectric generation purposes.

2. Term of Lease. The term of this Lease begins on the Effective Date and terminates upon permanent abandonment and/or decommissioning by PSCo of Power Plant operations for hydroelectric generation purposes (the "**Term**"). Any temporary suspension of operations at the

Power Plant due to operational considerations, maintenance, replacement, repairs or for other reasons shall not constitute permanent abandonment or decommissioning. Notwithstanding the foregoing, PSCo may terminate this Lease during the Term for any reason by delivering one (1) year's advance written notice to River District. Additionally, refer to Paragraph 12 for provisions relating to termination for cause.

3. Annual Lease Fee. PSCo shall pay to River District annual rent in the amount of ten dollars ($10.00) (the "**Annual Lease Fee**") on or before January 15 of each calendar year during the Term. For any Annual Lease Fee payment not already prepaid by PSCo, the River District will provide an invoice of the Annual Lease Fee to PSCo by December 31 of each calendar year prior to the due date of the Annual Lease Fee payment. PSCo may, in its discretion, prepay the Annual Lease Fee for more than one year of the Lease at any point during the Term. River District acknowledges that it has received a payment of $500.00 from PSCo as of the Effective Date, representing payment of the Annual Lease Fee in advance for fifty (50) years through 20__.

4. Use of Water Rights.

a. PSCo shall use the water delivered pursuant to the Shoshone Water Rights only for power generation purposes at the Power Plant, consistent with the Shoshone Water Rights decrees. PSCo shall not use the Shoshone Water Rights for any other uses or at any other location. PSCo shall take and use the water delivered pursuant to the Shoshone Water Rights to the fullest extent practical, and shall undertake no action that could be construed as abandonment of the Shoshone Water Rights. At times when PSCo is operating the Power Plant, delivery of the Shoshone Water Rights to the Power Plant shall take precedence over any other use of the Shoshone Water Rights.

b. At times when the Power Plant is temporarily not operating or is not fully operating due to maintenance or repair issues, or due to other business considerations, the Shoshone Water Rights may be made available to the Colorado Water Conservation Board pursuant to the terms of the Instream Flow Agreement dated _____, 202_, between the River District, PSCo and the CWCB, and the decree entered in Division 5 Case No. ___CW____. PSCo shall provide advance written notice to River District at least thirty (30) days prior to any scheduled shutdown of Power Plant operations, and shall provide notice as soon as reasonably possible of any unscheduled shutdown of Power Plant operations. Such notice, whether for scheduled or unscheduled shutdown of Power Plant operations shall also provide River District notice of the anticipated amount of time that the Power Plant will be shutdown or partially shutdown.

5. Power Plant Operations. PSCo shall conduct Power Plant operations, including but not limited to replacing, reconstructing, upgrading, adding to, improving, or altering the Power Plant, in its sole discretion, so long as the same does not change the point of diversion, flow rate, and non-consumption of the Shoshone Water Rights through the Power Plant. If PSCo determines to decommission and/or permanently suspend operations of the Power Plant it will provide written notice to River District at least six (6) months before operations at the Power Plant permanently cease and this Lease shall automatically terminate as of the date of completion of decommissioning by PSCo and/or permanent abandonment of the Power Plant.

6. Restriction on Sublease and Assignment. Upon thirty (30) days advanced written notice to the River District, PSCo may assign this Lease only to a successive owner or operator of the Power Plant for power generation purposes. Otherwise PSCo shall not rent, sublet, transfer or convey the right to use the Shoshone Water Rights.

7. No Vested Interest in Shares or Joint Venture. River District grants no interest in the Shoshone Water Rights to PSCo other than as explicitly set forth in this Lease. PSCo shall make no claim to any rights, title, or interest in the Shoshone Water Rights other than as explicitly set forth in this Lease. This Lease does not create a partnership or joint venture of any kind between the parties. River District shall not be entitled to any claim based on revenue generated by PSCo by use of the Shoshone Water Rights at the Power Plant. Likewise, PSCo shall bear the entirety of any loss, cost, or expense incurred through its use of the Shoshone Water Rights at the Power Plant, including but not limited to the cost or expense related to any federal "headwaters benefit" charge. River District shall have no obligation express or implied to maintain, operate and or have any role in the decommissioning of the plant and or repair, replacement or removal of any infrastructure owned and/or operated by PSCo. PSCo hereby indemnifies and holds harmless the River District from any and all obligations, financial or otherwise related to the repair, replacement, removal of infrastructure arising from PSCo's operation or decommissioning of the Power Plant or its associated infrastructure including but not limited to the current or future Shoshone dam.

8. No Guarantee of Yield. PSCo is entitled to receive the amount of water yielded by the Shoshone Water Rights by operation of the decrees therefore and administration of the same by the Colorado Division of Water Resources. River District makes no warranty, guarantee, or representation of any kind regarding the quality or physical yield of water to be delivered pursuant to the Shoshone Water Rights. PSCo shall not hold River District liable for any failure in delivery of the water pursuant to the Shoshone Water Rights, including, but not limited to, that caused by force of nature or failure of water supply infrastructure, except if such failure is a result of the exercise of the Shoshone Water Rights by the CWCB.

9. Maintenance of Infrastructure and Power Plant. During the Term, PSCo shall be responsible for the maintenance, construction, repair, operation, replacement, reconstruction, inspection, and improvement of:

a. the infrastructure and other personal property necessary to deliver water pursuant to the Shoshone Water Rights at PSCo's own cost and expense. PSCo shall undertake the foregoing as may be necessary to keep the infrastructure and other personal property in good working condition during the Term of this Lease, as reasonably practicable in PSCo's discretion.

b. the Power Plant at PSCo's own cost and expense. PSCo may, in its sole discretion, conduct any of the foregoing at any time during the Term of this Lease so long as the Shoshone Water Rights' use, and point of diversion remain unchanged by PSCo's activities.

Any temporary shutdowns, suspensions, or reductions in operation of the Power Plant due to any of the foregoing activities shall not constitute a default pursuant to Paragraph 12 of this Lease.

10. Environmental Indemnity. Except to the extent that the same arise from any use of the Shoshone Water Rights by the River District, or any third party, or the River District's obligations under this Lease, PSCo hereby agrees to indemnify, defend, and hold harmless the River District and its agents, affiliates, officers, directors and employees of and from any and all liability, claims, demands, actions, and causes of action whatsoever (including without limitation reasonable attorneys' fees and expenses, and costs and expenses reasonably incurred in investigating, preparing or defending against any litigation or claim, action, suit, proceeding or demand of any kind or character) arising out of or related to the use of the Shoshone Water Rights in the Power Plant and the (1) alleged contamination by any hazardous substance, pollutant or contaminant, or petroleum or any fraction thereof of the Shoshone Water Rights, or (2) alleged injury or threat of injury to human health or safety or to the environment, or (3) alleged noncompliance with any with any federal, state, and local environmental statutes, regulations, ordinances, and any permits, approvals, or judicial or administrative orders issued thereunder, giving rise to liability under any federal, state or local environmental statutes or ordinances, including without limitation the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq., as amended from time to time, or under any common law claim, including claims for personal injury or property damage or for injunctive relief of any kind.

11. Notice. All notices to be given under this Lease shall be (1) sent by certified or registered mail, return receipt requested, (2) hand-delivered at the addresses set forth below, or (3) by electronic mail requiring confirmation of receipt. Either party shall provide written notice to the other party if the appropriate contact information changes.

If to PSCo:	Public Service Company of Colorado Attn: Water Resources 1800 Larimer Street, Suite 1300 Denver, CO 80202
With Copy to:	Public Service Company of Colorado Attn: Director, Community Relations 1800 Larimer Street, Suite 1100 Denver, CO 80202
And:	Xcel Energy Attn: Legal Dept. – Real Estate 1800 Larimer Street, 14th Floor Denver, CO 80202
and:	Welborn Sullivan Meck & Tooley, P.C. 1401 Lawrence Street, Suite 1800 Denver, CO 80202 Attn: Carolyn Burr, Esq.; James M. Noble, Esq. cburr@wsmtlaw.com jnoble@wsmtlaw.com

If to River District: Andy Mueller, Esq.
General Manager
Colorado River Water Conservation District
201 Centennial St., #200
Glenwood Springs, CO 81601
amueller@crwcd.org

With Copy to: Peter Fleming, Esq.
General Counsel
Colorado River Water Conservation District
201 Centennial St., #200
Glenwood Springs, CO 81601
pfleming@crwcd.org

12. Default and Remedies.

a. If either River District or PSCo fails to comply with a term or condition herein, such failure constitutes a default of this Lease. The non-defaulting party may declare the default by providing written notice to the defaulting party in accordance with Paragraph 11 above. Upon receipt of this notice of default, the defaulting party will have thirty (30) days within which to cure the default.

b. If, in the sole discretion of the non-defaulting party, the default has not been cured, a cure has not commenced, or the defaulting-party has ceased to pursue the cure with diligence during such 30-day cure period, or after any written extension thereof mutually agreed upon by the parties, the non-defaulting party may treat the Lease as continuing and the non-defaulting party shall have the right to injunctive relief, specific performance or damages, or both, and to avail itself of any other remedy at law or equity. The failure of either party to declare a default or material breach does not establish a precedent or constitute an implied waiver of any subsequent breach of the terms and conditions in this Lease.

c. In the event either party is unable to perform its obligations under the terms of this Lease because of acts of God, strikes, stoppage of labor, riot, fire, flood, rock or mud slides, acts of war, insurrection, accident, order of any court, equipment or transportation failure or damage reasonably beyond its control, or other causes reasonably beyond its control, such party shall not be liable for damages to the other for any damages resulting from such failure to perform or otherwise from such causes.

d. All of the rights and remedies set forth in this Paragraph 12 shall be cumulative. In any action to enforce or construe the terms of this Lease, the substantially prevailing party shall recover all legal and related court costs, including all reasonable attorneys' fees and expert witness fees, costs and expenses.

13. No Third Party Beneficiaries. Nothing in this Lease, express or implied, is intended to confer any rights or remedies upon any parties other than PSCo and River District, or their respective permissible successors in interest.

14. Recovery of Costs and Fees. In addition to any remedies otherwise available, a party that is successful in a legal action commenced against the other due to a default or material breach of this Lease may recover from the defaulting party reasonable costs and attorneys' fees incurred during the course of such legal action.

15. Governing Law and Venue. This Lease shall be governed by and enforced in accordance with the laws of the State of Colorado. Proper venue for any action arising out of this Lease is the District Court for Garfield County, Colorado, or the Division 5 Water Court for the State of Colorado.

16. Severability. In the event a provision of this Lease is held invalid or unenforceable by a court of competent jurisdiction, such holding will not invalidate any other provision herein, and the remainder of the Lease should be interpreted in accordance with the intent of the parties.

17. Integration. This Lease constitutes a complete integration of the understanding and Lease between River District and PSCo with respect to the subject matter herein. No representations, negotiations, or warranties, express or implied, exist between River District and PSCo except as explicitly set forth in this Lease. This Lease may only be modified in a written form duly authorized, approved, and executed by River District and PSCo.

18. Counterparts. This Lease may be executed in counterparts, each of which shall be deemed an original, and all of which together shall constitute one and the same instrument. Executed copies of this Lease may be delivered by electronic means. The parties agree to accept and be bound by signatures hereto delivered by electronic means.

19. Recording. PSCo shall not record this Lease in the real property records of any jurisdiction. This Lease is not intended to run with the land as a covenant burdening real property.

[signature page follows]

IN WITNESS WHEREOF, the undersigned parties have executed this Water Lease on the date first set forth above.

Public Service Company of Colorado, a Colorado Corporation

By: _____
Name: _____
Title: _____

Colorado River Water Conservation District, a political subdivision of the state of Colorado

By: _____
Name: _____
Title: _____

EXHIBIT E

PROMISSORY NOTE

See attached.

PROMISSORY NOTE

$20,000,000.00 (Twenty Million Dollars) _____, 20__

FOR VALUE RECEIVED, the Colorado River Water Conservation District, a political subdivision of the state of Colorado ("**Borrower**") promises to pay to Public Service Company of Colorado, a Colorado corporation ("**Lender**") the principal sum of TWENTY MILLION and No/100 DOLLARS ($20,000,000.00) (the "**Principal Amount**"), with interest on the unpaid balance thereof at the Effective Rate (hereinafter defined) in effect from time to time.

1. All sums owing hereunder are payable in lawful money of the United States of America, in immediately available funds.

2. For the purposes of this promissory note (this "**Note**"), the "**Effective Rate**" shall mean the Secured Overnight Financing Rate in effect on the date of this Note on a per annum basis. The Effective Rate is identified on the payment schedule attached hereto as Schedule 1 (the "**Payment Schedule**").

3. The outstanding principal balance of this Note, together with all accrued and unpaid interest, shall be due and payable in annual installments calculated based on a 10-year amortization. The annual installment payments shall begin on the April 30, _____ and shall continue to be due on or before the 30th day of each subsequent April until the principal amount is paid in full, and shall be paid to Lender in accordance with the Payment Schedule.

4. Payment by Borrower shall be made to Lender by wire or electronic funds transfer per the instructions provided by Lender, or at such other place as may be designated by written notice to Borrower by Lender.

5. Payments will be applied first to any late fees, then to accrued interest, and the remainder, if any, to the then-outstanding Principal Amount. Any reductions of the Principal Amount may not be re-borrowed.

6. Any remaining Principal Amount, and any accrued interest thereon, that has not been paid in full on or before April 30, 20___ ("**Maturity Date**") shall be due and payable on the Maturity Date.

7. The River District may prepay the then-outstanding amount of this Note, along with any outstanding interest, at any time without penalty or premium.

8. If any payment required by this Note is not paid when due the indebtedness shall bear interest at the rate of Effective Rate plus 5% per annum until such payment is made. Further, if any payment is not paid within 30 days of its due date, Borrower shall pay Lender a late payment charge of 10% of the amount of such annual payment. Should the Borrower fail to pay any payment due pursuant to this Note within sixty (60) days, Lender shall be entitled to accelerate the entire remaining principal amount then outstanding and all accrued interest and penalties thereon.

9. Nothing in this Note is intended or shall be construed to create a multiple fiscal year financial obligation or debt of the Borrower. Where activities or payment obligations provided in

this Note extend beyond the then-current fiscal year, continued payments, expenditures, or appropriations are contingent on the approval of the Board of Directors of the Borrower.

10. The indebtedness evidenced by this Promissory Note is secured by a Deed of Trust, of even date herewith, and, until released, the Deed of Trust contains additional rights of Lender. Such rights may cause acceleration of the indebtedness evidenced by this Promissory Note. Reference is made to said Deed of Trust for such additional terms. Said Deed of Trust grants rights in certain property located in the County of Garfield, State of Colorado, described as follows (the "**Property**"):

(a) The Shoshone Power Plant senior water right decreed as the Glenwood Power Canal and Pipeline water right on Dec. 9, 1907, in Civil Action No. 0466, Eagle County District Court, in the amount of 1,250 cfs with an appropriation date of Jan. 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as further decreed by the Eagle County District Court on Feb. 27, 1911, in Civil Action No. 553; and

(b) The Shoshone Power Plant junior water right decreed as the Shoshone Hydro Plant Diversion No. 2 on Feb. 7, 1956 in Civil Action No. 1123, Eagle County District Court, in the amount of 158 cfs with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy.

11. Any notice, demand, claim or other written instrument required or permitted to be given pursuant to this Promissory Note shall be in writing signed by the Party giving such notice and shall be sent by electronic mail, hand messenger delivery, overnight courier service or certified mail (receipt requested) to the other Party at the addresses set forth below and shall be deemed to have been duly given by delivery to the respective addresses provided below, or such other address changed by the recipient by notice consistent with this paragraph: (i) on the date and at the time of delivery if delivered personally to the Party to whom notice is given at such address; (ii) on the date and at the time of delivery or refusal of acceptance of delivery if delivered or attempted to be delivered by an overnight courier service to the Party to whom notice is given as such address; (iii) on the date of delivery or attempted delivery shown on the registered or certified mail, return receipt requested, postage prepaid and properly addressed to such address; (iv) if an email address is specified, on the date and at the time shown on the sent email message if sent to the e-mail address specified below:

If to Lender:	Public Service Company of Colorado 1800 Larimer Street, Suite 1100 Denver, CO 80202 Attn: Director, Environmental Services
with a copy to:	Frances A. Folin, Esq. Xcel Energy Services Inc. 1800 Larimer Street, 14th Floor Denver, CO 80202 303-294-2222 Frances.A.Folin@xcelenergy.com

and:	Welborn, Sullivan, Meck & Tooley, P.C. 1401 Lawrence Street, Suite 1800 Denver, Colorado 80202 Attn: Carolyn Burr, Esq., James M. Noble, Esq. (303) 830-2500 cburr@wsmtlaw.com, jnoble@wsmtlaw.com
If to Borrower:	Andy Mueller, Esq. General Manager Colorado River Water Conservation District 201 Centennial St., #200 Glenwood Springs, CO 81601 970-945-8522 amueller@crwcd.org
with a copy to:	Peter Fleming, Esq. General Counsel Colorado River Water Conservation District 201 Centennial St., #200 Glenwood Springs, CO 81601 970-945-8522 pfleming@crwcd.org

12. A waiver of any term of this Note or the Deed of Trust or of any of the obligations secured thereby must be made in writing and shall be limited to the express written terms of such waiver. In the event of any inconsistencies between the terms of this Note and the terms of any other document related to the loan evidenced by this Note, the terms of this Note shall prevail.

13. This Note shall be construed and enforced in accordance with the laws of the State of Colorado.

14. The provisions of this Note may be amended or revised only by an instrument in writing signed by the Borrower and Lender.

BORROWER:

Colorado River Water Conservation District,
a political subdivision of the State of Colorado

By: _____

Schedule 1
(Payment Schedule)

[insert amortization/payment schedule prior to closing]

EXHIBIT F

DEED OF TRUST

See attached.

Following recording return to:
Public Service Company of Colorado
c/o Xcel Energy
Attn: Legal Dept. – Real Estate
1800 Larimer Street, 14th Floor
Denver, Colorado 80202

DEED OF TRUST

THIS DEED OF TRUST is made this _____ day of _____, 20____, by the COLORADO RIVER WATER CONSERVATION DISTRICT, a political subdivision of the State of Colorado ("Trustor"), whose address is 201 Centennial Street, Suite 200, Glenwood Springs, Colorado 81601, in favor of the PUBLIC TRUSTEE OF GARFIELD COUNTY, COLORADO ("Trustee"), for the benefit of PUBLIC SERVICE COMPANY OF COLORADO, a Colorado corporation ("Beneficiary"), whose address is 1800 Larimer Street, Suite 1100, Denver, Colorado 80202.

1. **Property in Trust**. Trustor, in consideration of the indebtedness herein recited and the trust herein created, hereby grants and conveys to Trustee, for the benefit of Beneficiary, in trust, with power of sale, all of Trustor's right, title, and interest in the following legally described property located in the COUNTY OF GARFIELD, STATE OF COLORADO (the "Property"):

(a) The Shoshone Power Plant senior water right decreed as the Glenwood Power Canal and Pipeline water right on Dec. 9, 1907, in Civil Action No. 0466, Eagle County District Court, in the amount of 1,250 cfs with an appropriation date of Jan. 7, 1902, for power, mining, milling, manufacturing, lighting and heating and traction purposes, and as further decreed by the Eagle County District Court on Feb. 27, 1911, in Civil Action No. 553; and

(b) The Shoshone Power Plant junior water right decreed as the Shoshone Hydro Plant Diversion No. 2 on Feb. 7, 1956, in Civil Action No. 1123, Eagle County District Court, in the amount of 158 cfs with an appropriation date of May 15, 1929, for manufacturing and generation of electrical energy.

2. **Note; Obligations Secured**. This Deed of Trust is given to secure to Beneficiary:

(a) the repayment of the indebtedness evidenced by Trustor's promissory note ("Note"), dated as of _____, in the principal sum of TWENTY MILLION and 00/100 DOLLARS (U.S. $20,000,000.00), with interest as specified in the Note;

(b) the payment of all other sums as specified in the Note disbursed by Beneficiary in accordance with this Deed of Trust to protect the security of this Deed of Trust; and

(c) the performance of the covenants and agreements of Trustor herein contained.

If not sooner paid, the entire principal amount outstanding and accrued interest thereon shall be due and payable on _____.

3. **Title**. Trustor covenants that Trustor has taken no action to alienate and/or convey the title to the Property received from Beneficiary via Special Warranty deed dated the same date as this Deed of Trust.

4. **Payment of Principal and Interest**. Trustor shall promptly pay when due the principal of and interest on the indebtedness evidenced by the Note, and any late charges or other charges as provided in the Note, and shall perform all of Trustor's other covenants contained in the Note.

5. **Application of Payments**. All payments received by Beneficiary under the terms hereof shall be applied by Beneficiary first in payment of amounts due pursuant to §8 (Protection of Beneficiary's Security), and the balance in accordance with the terms and conditions of the Note.

6. **Prior Mortgages and Deeds of Trust; Charges; Liens**. Trustor represents and warrants that there are no prior deeds of trust, charges or liens on the Property.

7. **Preservation and Maintenance of Property**. Trustor shall not commit waste or permit impairment or deterioration of the Property and shall comply with the provisions of any lease if this Deed of Trust is on a leasehold. Trustor shall perform all of Trustor's obligations under any declarations, covenants, by-laws, rules, court decrees, or other documents governing the use or ownership of the Property.

8. **Protection of Beneficiary's Security**. If Trustor fails to perform the covenants and agreements contained in this Deed of Trust, or if a default occurs in a prior lien, or if any action or proceeding is commenced which materially affects Beneficiary's interest in the Property, then Beneficiary, at Beneficiary's option, with notice to Trustor if required by law, may make such appearances, disburse such sums, and take such action as is necessary to protect Beneficiary's interest, including, but not limited to:

(a) any general or special taxes or ditch or water assessments levied or accruing against the Property;

(b) the premiums on any insurance necessary to protect any improvements comprising a part of the Property;

(c) sums due on any prior lien or encumbrance on the Property;

(d) if the Property is a leasehold or is subject to a lease, all sums due under such lease;

(e) the reasonable costs and expenses of defending, protecting, and maintaining the Property and Beneficiary's interest in the Property, including repair and maintenance costs and expenses, costs and expenses of protecting and securing the Property, receiver's fees and expenses, inspection fees, appraisal fees, court costs, attorney fees and costs, and fees and costs of an attorney in the employment of Beneficiary or holder of the certificate of purchase;

(f) all other costs and expenses allowable by the evidence of debt or this Deed of Trust; and

(g) such other costs and expenses which may be authorized by a court of competent jurisdiction.

Trustor hereby assigns to Beneficiary any right Trustor may have by reason of any prior encumbrance on the Property or by law or otherwise to cure any default under said prior encumbrance.

Any amounts disbursed by Beneficiary pursuant to this §8, with interest thereon, shall become additional indebtedness of Trustor secured by this Deed of Trust. Such amounts shall be payable upon notice from Beneficiary to Trustor requesting payment thereof, and Beneficiary may bring suit to collect any amounts so disbursed plus interest specified in the Note. Nothing contained in this §8 shall require Beneficiary to incur any expense or take any action hereunder.

9. **Condemnation**. The proceeds of any award or claim for damages, direct or consequential, in connection with any condemnation or other taking of the Property, or part thereof, or for conveyance in lieu of condemnation, are hereby assigned and shall be paid to Beneficiary as herein provided. In the event of a total taking of the Property, the proceeds shall be applied to the sums secured by this Deed of Trust, with the excess, if any, paid to Trustor.

In the event of a partial taking of the Property, the proceeds remaining after taking out any part of the award due any prior lien holder (net award) shall be divided between Beneficiary and Trustor, in the same ratio as the amount of the sums secured by this Deed of Trust immediately prior to the date of taking bears to Trustor's equity in the Property immediately prior to the date of taking. Trustor's equity in the Property means the fair market value of the Property less the amount of sums secured by both this Deed of Trust and all prior liens (except taxes) that are to receive any of the award, all at the value immediately prior to the date of taking.

If the Property is abandoned by Trustor or if, after notice by Beneficiary to Trustor that the condemnor offers to make an award or settle a claim for damages, Trustor fails to respond to Beneficiary within 30 days after the date such notice is given, Beneficiary is authorized to collect and apply the proceeds, at Beneficiary's option, either to restoration or repair of the Property or to the sums secured by this Deed of Trust.

Any such application of proceeds to principal shall not extend or postpone the due date of the installments referred to in §4 (Payment of Principal and Interest) nor change the amount of such installments.

10. **Trustor not Released**. Extension of the time for payment or modification of amortization of the sums secured by this Deed of Trust granted by Beneficiary to any successor in interest of Trustor shall not operate to release, in any manner, the liability of the original Trustor, nor Trustor's successors in interest, from the original terms of this Deed of Trust. Beneficiary shall not be required to commence proceedings against such successor or refuse to extend time for payment or otherwise modify amortization of the sums secured by this Deed of Trust by reason of any demand made by the original Trustor nor Trustor's successors in interest.

11. **Forbearance by Beneficiary Not a Waiver**. Any forbearance by Beneficiary in exercising any right or remedy hereunder, or otherwise afforded by law, shall not be a waiver or preclude the exercise of any such right or remedy.

12. **Remedies Cumulative**. Each remedy provided in the Note and this Deed of Trust is distinct from and cumulative to all other rights or remedies under the Note and this Deed of Trust or afforded by law or equity, and may be exercised concurrently, independently or successively.

13. **Successors and Assigns Bound**; **Joint and Several Liability; Captions.** The covenants and agreements herein contained shall bind, and the rights hereunder shall inure to, the respective successors and assigns of Beneficiary and Trustor, subject to the provisions of §21 (Transfer of the Property; Assumption). All covenants and agreements of Trustor shall be joint and several. The captions and headings of the sections in this Deed of Trust are for convenience only and are not to be used to interpret or define the provisions hereof.

14. **Notice**. Except for any notice required by law to be given in another manner, (a) any notice to Trustor provided for in this Deed of Trust shall be in writing and shall be given and be effective upon (1) delivery to Trustor or (2) mailing such notice by first class U.S. mail, addressed to Trustor at Trustor's address stated herein or at such other address as Trustor may designate by notice to Beneficiary as provided herein, and (b) any notice to Beneficiary shall be in writing and shall be given and be effective upon (1) delivery to Beneficiary or (2) mailing such notice by first class U.S. mail, to Beneficiary's address stated herein or to such other address as Beneficiary may designate by notice to Trustor as provided herein. Any notice provided for in this Deed of Trust shall be deemed to have been given to Trustor or Beneficiary when given in any manner designated herein.

15. **Governing Law; Severability**. The Note and this Deed of Trust shall be governed by the laws of the State of Colorado. In the event that any provision or clause of this Deed of Trust or the Note conflicts with the law, such conflict shall not affect other provisions of this Deed of Trust or the Note which can be given effect without the conflicting provision, and to this end the provisions of the Deed of Trust and Note are declared to be severable.

16. **Acceleration; Foreclosure; Other Remedies**. Except as provided in §21 (Transfer of the Property; Assumption), upon Trustor's breach of any covenant or agreement of Trustor in this Deed of Trust, at Beneficiary's option, all of the sums secured by this Deed of Trust shall be immediately due and payable (Acceleration). To exercise this option, Beneficiary may invoke the power of sale, may commence and maintain an action to foreclose this instrument and in such event Borrower specifically waives the defense of laches and any applicable statutes of limitation, and/or may exercise any other remedies permitted by law. Beneficiary shall be entitled to collect all reasonable costs and expenses incurred in pursuing the remedies provided in this Deed of Trust, including, but not limited to, reasonable attorney's fees.

If Beneficiary invokes the power of sale, Beneficiary shall give written notice to Trustee of such election. Trustee shall give such notice to Trustor of Trustor's rights as is provided by law. Trustee shall record a copy of such notice and shall cause publication of the legal notice as required by law in a newspaper of general circulation in each county in which the Property is situated, and shall

mail copies of such notice of sale to Trustor and other persons as prescribed by law. After the lapse of such time as may be required by law, Trustee, without demand on Trustor, shall sell the Property at public auction to the highest bidder for cash at the time and place (which may be on the Property or any part thereof as permitted by law) in one or more parcels as Trustee may think best and in such order as Trustee may determine. Beneficiary or Beneficiary's designee may purchase the Property at any sale. It shall not be obligatory upon the purchaser at any such sale to see to the application of the purchase money.

Trustee shall apply the proceeds of the sale in the following order: (a) to all reasonable costs and expenses of the sale, including, but not limited to, reasonable Trustee's and attorney's fees and costs of title evidence; (b) to all sums secured by this Deed of Trust; and (c) the excess, if any, to the person or persons legally entitled thereto.

17. **Trustor's Right to Cure Default**. Whenever foreclosure is commenced for nonpayment of any sums due hereunder, the owners of the Property or parties liable hereon shall be entitled to cure said defaults by paying all delinquent principal and interest payments due as of the date of cure, costs, expenses, late charges, attorney's fees and other fees all in the manner provided by law. Upon such payment, this Deed of Trust and the obligations secured hereby shall remain in full force and effect as though no Acceleration had occurred, and the foreclosure proceedings shall be discontinued.

18. **Appointment of Receiver; Beneficiary in Possession**. Beneficiary or the holder of the Trustee's certificate of purchase shall be entitled to a receiver for the Property after Acceleration under §16 (Acceleration; Foreclosure; Other Remedies), and shall also be so entitled during the time covered by foreclosure proceedings and the period of redemption, if any; and shall be entitled thereto as a matter of right without regard to the solvency or insolvency of Trustor or of the then owner of the Property, and without regard to the value thereof. Such receiver may be appointed by any Court of competent jurisdiction upon ex parte application and without notice; notice being hereby expressly waived.

Upon Acceleration under §16 (Acceleration; Foreclosure; Other Remedies) or abandonment of the Property, Beneficiary, in person, by agent or by judicially-appointed receiver, shall be entitled to enter upon, take possession of and manage the Property and to collect the rents of the Property including those past due. All rents collected by Beneficiary or the receiver shall be applied, first to payment of the costs of preservation and management of the Property, second to payments due upon prior liens, and then to the sums secured by this Deed of Trust. Beneficiary and the receiver shall be liable to account only for those rents actually received.

19. **Release**. Upon payment of all sums secured by this Deed of Trust, Beneficiary shall cause Trustee to release this Deed of Trust and shall produce for Trustee the Note. Trustor shall pay all costs of recordation and shall pay the statutory Trustee's fees. If Beneficiary shall not produce the Note as aforesaid, then Beneficiary, upon notice in accordance with §14 (Notice) from Trustor to Beneficiary, shall obtain, at Beneficiary's expense, and file any lost instrument bond required by Trustee or pay the cost thereof to affect the release of this Deed of Trust.

20. **Waiver of Exemptions**. Trustor hereby waives all right of homestead and any other exemption in the Property under state or federal law presently existing or hereafter enacted.

21. **Transfer of the Property; Assumption**. The following events shall be referred to herein as a "Transfer": (i) a transfer or conveyance of title (or any portion thereof, legal or equitable) of the Property (or any part thereof or interest therein); (ii) the execution of a contract or agreement creating a right to title (or any portion thereof, legal or equitable) in the Property (or any part thereof or interest therein); (iii) or an agreement granting a possessory right in the Property (or any portion thereof), in excess of 3 years; (iv) a sale or transfer of, or the execution of a contract or agreement creating a right to acquire or receive, more than fifty percent (50%) of the controlling interest or more than fifty percent (50%) of the beneficial interest in Trustor and (v) the reorganization, liquidation or dissolution of Trustor. Not to be included as a Transfer are the creation of a lien or encumbrance subordinate to this Deed of Trust, or an agreement with, or transfer to, the Colorado Water Conservation Board regarding the use of the Property for instream flow purposes.

At the election of Beneficiary, in the event of each and every Transfer:

(a) All sums secured by this Deed of Trust shall become immediately due and payable (Acceleration).

(b) If a Transfer occurs and should Beneficiary not exercise Beneficiary's option pursuant to this §21 to Accelerate, Transferee shall be deemed to have assumed all of the obligations of Trustor under this Deed of Trust including all sums secured hereby whether or not the instrument evidencing such conveyance, contract or grant expressly so provides. This covenant shall run with the Property and remain in full force and effect until said sums are paid in full. Beneficiary may without notice to Trustor deal with Transferee in the same manner as with Trustor with reference to said sums including the payment or credit to Transferee of undisbursed reserve Funds on payment in full of said sums, without in any way altering or discharging Trustor's liability hereunder for the obligations hereby secured.

(c) Should Beneficiary not elect to Accelerate upon the occurrence of such Transfer then, subject to §21(b) above, the mere fact of a lapse of time or the acceptance of payment subsequent to any of such events, whether or not Beneficiary had actual or constructive notice of such Transfer, shall not be deemed a waiver of Beneficiary's right to make such election nor shall Beneficiary be estopped therefrom by virtue thereof. The issuance on behalf of Beneficiary of a routine statement showing the status of the loan, whether or not Beneficiary had actual or constructive notice of such Transfer, shall not be a waiver or estoppel of Beneficiary's said rights.

22. **Trustor's Copy**. Trustor acknowledges receipt of a copy of the Note and this Deed of Trust.

[signature page follows]

EXECUTED BY TRUSTOR as of the date first stated above:

TRUSTOR:

COLORADO RIVER WATER CONSERVATION DISTRICT,
a political subdivision of the State of Colorado

By: _____
Andrew A. Mueller, Secretary/General Manager

By: _____
Kathy Chandler-Henry, CRWCD Board President

STATE OF COLORADO)
)ss.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ____ day of _____, 20___, by Andrew A. Mueller, Secretary/General Manager, and Kathy Chandler-Henry, Board President of the Colorado River Water Conservation District, a political subdivision of the State of Colorado.

Witness my hand and official seal.

My commission expires: _____

_____
Notary Public

MEMORANDUM – DRAFT – SUBJECT TO REVISION

To: Colorado River District Staff and Counsel
From: Hydros Consulting, Inc.
Subject: Shoshone Power Plant Water Rights Yield Assessment
Date: September 11, 2024

Summary

The Colorado River District (River District) asked Hydros Consulting, Inc. (Hydros) to provide technical assistance in quantifying the yield or "pull" of the water rights associated with the Shoshone Power Plant (Shoshone), with the goal of understanding the impact of the Shoshone water rights on flows through the "15-Mile Reach"[1] near Palisade, Colorado and at the Colorado-Utah state line. To perform this analysis, Hydros used the State of Colorado's StateMod water allocation and accounting model to assess impacts to river flows both with and without the Shoshone water rights being utilized. Notwithstanding the foregoing, this analysis is not intended to serve as an analysis of the historical use of the Shoshone water rights with respect to any proceeding in water court for a change in type of use for the Shoshone water rights. Instead, this analysis is provided to demonstrate the benefits of the Shoshone water rights on flows through the 15-Mile Reach.

The analysis indicates that continued exercise of the Shoshone water rights will result in significant benefits to the Colorado River through the 15-Mile Reach to the Colorado-Utah state line, and abandonment or disuse of those rights would dramatically reduce flows, particularly in drier years. Assuming full use of the Shoshone water rights, and continued growth of demands for consumptive uses in the upper mainstem Colorado River, the net annual benefit of the Shoshone call could be more than 80,000 acre-feet of water to the 15-Mile Reach in dry years. The benefit is even more pronounced during critically dry months when the Shoshone water rights are fully utilized. As shown in Table 7, flows in these critically dry months are as much as 29% higher (approximately 140 cfs) on average when the Shoshone water rights are being fully utilized. The benefits of continued exercise of the Shoshone water rights are not limited to critically dry periods, and an *average* flow increase of 6% - 9% (equal to approximately 78 cfs to 96 cfs) is expected across the driest 50% of *all* simulated monthly flows compared to flows without Shoshone.

This report first provides a background of the Shoshone water rights and the importance of the administration of those water rights on the Colorado River. Next, this report describes

[1] See, for example: https://coloradowatertrust.org/project/15-mile-reach.

the methodologies used to quantify the yield of the Shoshone water rights. Finally, a description of the various scenarios used to compare model runs with and without the Shoshone water rights and the results of those models are presented.

Background

The Shoshone Power Plant is a run-of-river hydroelectric power plant located on the Colorado River approximately nine miles east of Glenwood Springs, Colorado. The power plant has been in operation since the early 1900s and utilizes two water rights as described in Table 1. Together, the water rights total 1,408 cubic feet per second (cfs). As a run-of-river operation, the Shoshone hydroelectric plant has no consumptive use and no immediately identifiable impact on the river, other than a small forebay and reduced flows through a short section of Glenwood Canyon. The power plant's broader impact on the river, however, is at times significant. The Shoshone Call[2] will often limit the ability of junior users upstream of the power plant to divert water or will force those users to provide replacement water to offset their depletions. The beneficial effect of the Shoshone Call to river flows is also felt downstream of the power plant, as all of the water diverted through the plant's penstocks returns to the Colorado River and continues downstream, where it is available for diversion by other water users.

Table 1: Shoshone Power Plant Water Rights.

Water Right	Amount [cfs]
Adjudication Date 12/9/1907; Admin. No.: 20427.18999	1,250
Adjudication Date 2/7/1956; Admin. No.: 33023.28989	158

The River District is interested in acquiring the Shoshone water rights from Public Service Company of Colorado (PSCo). Model results demonstrate that protecting the Shoshone water rights would benefit flows through the 15-Mile Reach, which is critical habitat for endangered warm-water fish species. The River District and west slope water users have a number of operating agreements, leases, and other mechanisms in place to ensure that critical flows are maintained through the 15-Mile Reach.[3] Failure to maintain these flows could lead to non-compliance with the Programmatic Biological Opinion and Record of Decision (PBO) regarding endangered fish species in the Colorado River basin. As with most western rivers, critically low flows are often associated with particularly dry hydrologic years, and with late summer and early fall months in *most* years, when demands are at their highest and the river is returning to baseflow conditions after the snowmelt runoff.

[2] Unless stated otherwise, "Shoshone Call" in this report refers to the full 1,408 cfs junior + senior call
[3] See, for example: https://www.usbr.gov/gp/ecao/10825_final_ea_fonsi.pdf

Without active diversions of the Shoshone water rights, the impacts to the river in the future could be even greater. Growth of both transmountain diversions (TMDs) and in-basin uses by junior water users would likely result in additional reduction to river flows absent the Shoshone water rights being exercised.

Between 1975 and 2020, the Shoshone Power Plant diverted an annual average of approximately 668,000 acre-feet/year, according to State records on Colorado's Decision Support System (CDSS) website. Figure 1 below shows the average monthly diversions (1975-2020) as reported by the State of Colorado via CDSS (https://dwr.state.co.us/Tools/Structures/5300584). These average monthly values are shown in comparison to the monthly volumes *if the Shoshone water rights were being met 100% of the time*.[4] Natural hydrologic shortages, particularly during winter months, will often prohibit Shoshone from realizing those full diversion amounts, even if they are calling for their full decreed amounts. Shoshone's diversions are non-consumptive, and the Shoshone water rights are senior to many upstream diversions for consumptive uses. As a result, the Shoshone Call has historically resulted in increased flows in the Colorado River above and below the Shoshone Power Plant.

[4] The CDSS records are based on an equation relating power generation to flow through the turbine. It is believed these records may underestimate the actual volume of water delivered to and through the Shoshone powerplant due to rating curve discrepancies, system losses, and other factors. If historical diversions are in fact greater than reported through CDSS, we expect the benefit from continued use of the Shoshone Rights to increase. Water availability, particularly during fall and winter months, will often limit how much water Shoshone can actually divert.

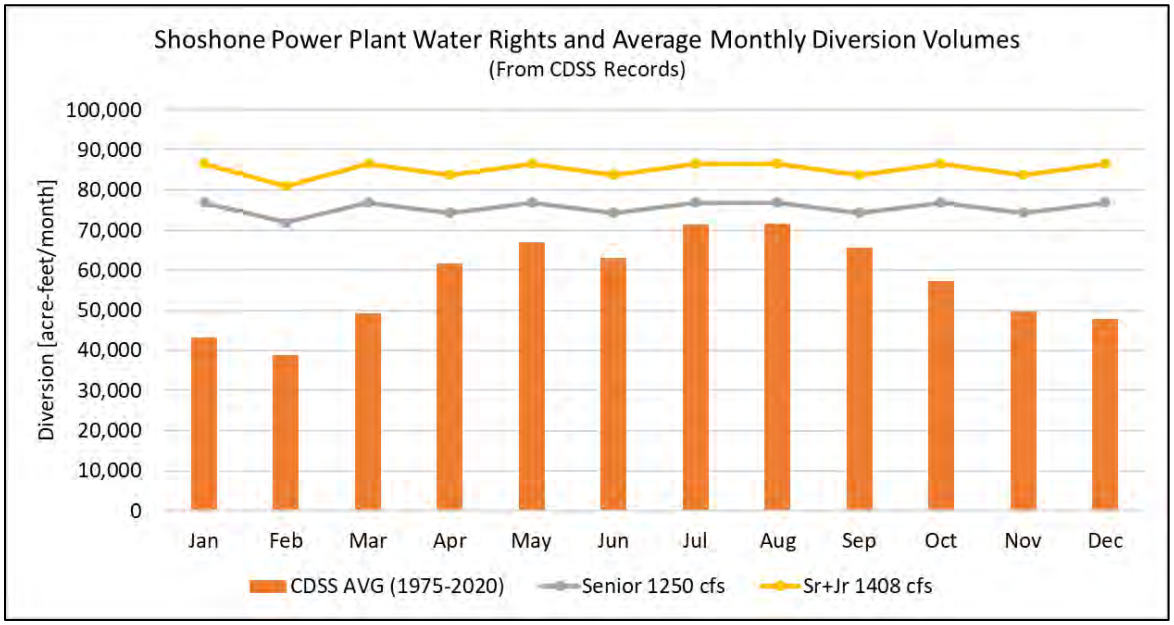


Figure 1: CDSS Shoshone Power Plant Average Monthly Diversions (1975-2020) and Maximum Decreed Diversion Rates.

Methodology

StateMod is a water rights administration and accounting model that simulates priority administration of Colorado water rights and operating protocols such as diversions to storage, releases, exchanges, and augmentation. It is often used to evaluate water availability for new water rights, or to evaluate potential impacts from changes in use of existing water rights. StateMod can simulate changes in diversions, releases, and other basin-wide water operations by senior and junior water rights both upstream and downstream of the Shoshone Power Plant if the exercise of the Shoshone water rights is modified. Of particular interest to this analysis are major downstream water rights such as the Grand Valley Project and Grand Valley Canal diversions, commonly referred to collectively as the "Cameo Call" diversions, and environmental flows through the 15-Mile Reach. The interaction between the Cameo Call and the Shoshone water rights is discussed in detail in Appendix C.

Using the Baseline model from the State of Colorado's 2015 release of the Upper Colorado River Basin StateMod model (cm2015B[5]) with updates made as part of the Phase IV Risk Study (Hydros, 2023)[6], Hydros evaluated the Shoshone water rights by performing a series of analyses comparing model runs with and without the Shoshone water rights active[7]. In addition to a "No Shoshone Call" scenario, several other scenarios were developed in which Shoshone's water rights were active at different levels of demand. Using this modeling approach, the difference in model results between the activated and deactivated runs are used to illustrate the impact of the Shoshone water rights.

Scenario Descriptions

For this analysis, we compare four Shoshone operating policies together with both current and estimated future basin-wide demands. Analysis of results focuses on the "Stress-Test Period"[8] (water years 1988-2013)[9] as this includes several critically dry periods, particularly during the late 1980s, 2002-2005, and 2012-2013. Unique characteristics that

[5] Obtained on 4/7/2022 from: https://cdss.colorado.gov/software/statemod
[6] Technical Appendices A and B of the Phase IV Risk Study Report describe these modifications in detail. The purpose of the modifications was to enhance accuracy of simulation for the structures in the model that simulate the aggregated operations of numerous smaller diversions from tributaries, which is described in Appendix A, and to represent future incremental development of transmountain diversions and other demands to represent future conditions, which is described in Appendix B.
[7] This analysis uses the publicly available version of StateMod simulating on a monthly timestep. The CWCB is currently developing a daily version of the mainstem Colorado River model in StateMod.
[8] The "Stress Test" hydrology concept has been used extensively in Colorado River Basin planning efforts such as the Drought Contingency Plan (DCP) and other planning studies. The use of this period as the period of focus in this study should not be construed as a representative study period of the historical exercise of the Shoshone water rights for evaluation of the proposed change of use.
[9] Water years start October 1st of the prior year and continue through September 30 of the year identified.

define each scenario include the demands assumed for Shoshone, the demands assumed for other water users in the basin, and whether a reduction in the Shoshone Call based upon a "call relaxation" agreement with Xcel (Xcel, 2007) is applied. The assumptions for each scenario are listed in Table 2.

Table 2. Scenario Definitions.

Scenario	Shoshone Demands	Basin-Wide Demands	Call Relaxation
Zero Shoshone Current	Zero[1]	Current[2]	None
Zero Shoshone Future	Zero	Future[3]	None
Senior Current	Senior[4]	Current	None
Senior Future	Senior	Future	None
Max Current	Maximum[5]	Current	None
Max Future	Maximum	Future	None
Senior Current w/ Relaxation Agreement	Senior	Current	3-year[6]
Senior Future w/ Relaxation Agreement	Senior	Future	3-year
Max Current w/ Relaxation Agreement	Maximum	Current	3-year
Max Future w/ Relaxation Agreement	Maximum	Future	3-year

1) Scenarios with Zero demands for Shoshone are used to quantify the impact on river flows if the Shoshone water rights were abandoned or not exercised. This is the "worst case" scenario for river flows.
2) "Current" basin-wide demands apply to all water users other than Shoshone, and are the demands used in the CM2015B Baseline StateMod model of the Upper Colorado.
3) "Future" basin-wide demands apply to all water users other than Shoshone, and are the demands developed to represent future conditions identified in the Phase III Risk Study
4) "Senior" demands for Shoshone are based on only the senior diversion right of 1,250 cfs, totaling approximately 906,000 acre-feet per year.
5) "Maximum" demands for Shoshone assume full use of all decreed water rights for Shoshone, totaling approximately 1,019,000 acre-feet per year. These demands are used to estimate upper bounds on the impact of the Shoshone call (see Figure 1)
6) "3-year" Xcel Call Reduction scenarios apply the Call Relaxation in 2003, 2004, and 2013. 2003 and 2013 were years when the reduction historically occurred, and although not historically a call reduction year, Shoshone was not physically able to divert for part of 2004 so it is included here to mimic that historical reduction in demand.

Call Relaxation Agreement Background

In 2007, the City and County of Denver's Board of Water Commissions and Xcel Energy entered into an agreement (2007 Agreement) to "relax" the Shoshone Call in years when the NRCS and Colorado River Basin Forecast Center predict that the April - July flow of the Colorado River at the Kremmling gage will be less than or equal to 85% of average (other requirements to trigger the call relaxation, including projections of defined storage content within Denver's system, also apply, see 2007 Xcel Call Reduction [Xcel, 2007]). When the conditions for a "Call Relaxation" are met, Xcel will reduce the Shoshone Call

to a senior water right call of 704 cfs during the period of March 14th – May 20th (inclusive). 704 cfs is exactly half of the total decreed rate of 1,408 cfs diversion for the plant and represents the use of just one of the two turbines in the plant (see Table 1). A similar agreement was previously entered in 2003 (Xcel, 2003). Because the 2007 agreement is the most recent agreement, the terms of the 2007 Agreement are applied in this analysis for any year that includes a Call Relaxation. This agreement allows Denver Water and other junior water users to refill reservoirs and/or divert water through trans-basin or in-basin diversions during the pre-runoff period in exceedingly dry years when Shoshone would otherwise place an administrative call on those rights.

To simulate Call Relaxation under the 2007 Agreement, Hydros conducted model runs where the monthly demands in the Maximum Current and Maximum Future demand scenarios were reduced for the months of March, April, and May. To do this, the monthly diversion volumes were converted to a daily flow rate (assuming a uniform distribution for each month) and diversions for the period of March 14th - May 20th were limited to 704 cfs. The resulting reduction in demand is shown below in Figure 2. The daily diversion rates were then aggregated back to monthly volumes for use in the model (Table 3). The Call Relaxation scenarios were evaluated to determine incremental impacts from Call Relaxation under the 2007 Agreement during very dry years. For this analysis, we assume that the call reduction would occur in 2003, 2004, and 2013.[10]

[10] 2003 and 2013 were years when the reduction historically occurred. The Shoshone Power Plant was not physically able to divert for part of 2004 due to infrastructure maintenance issues.

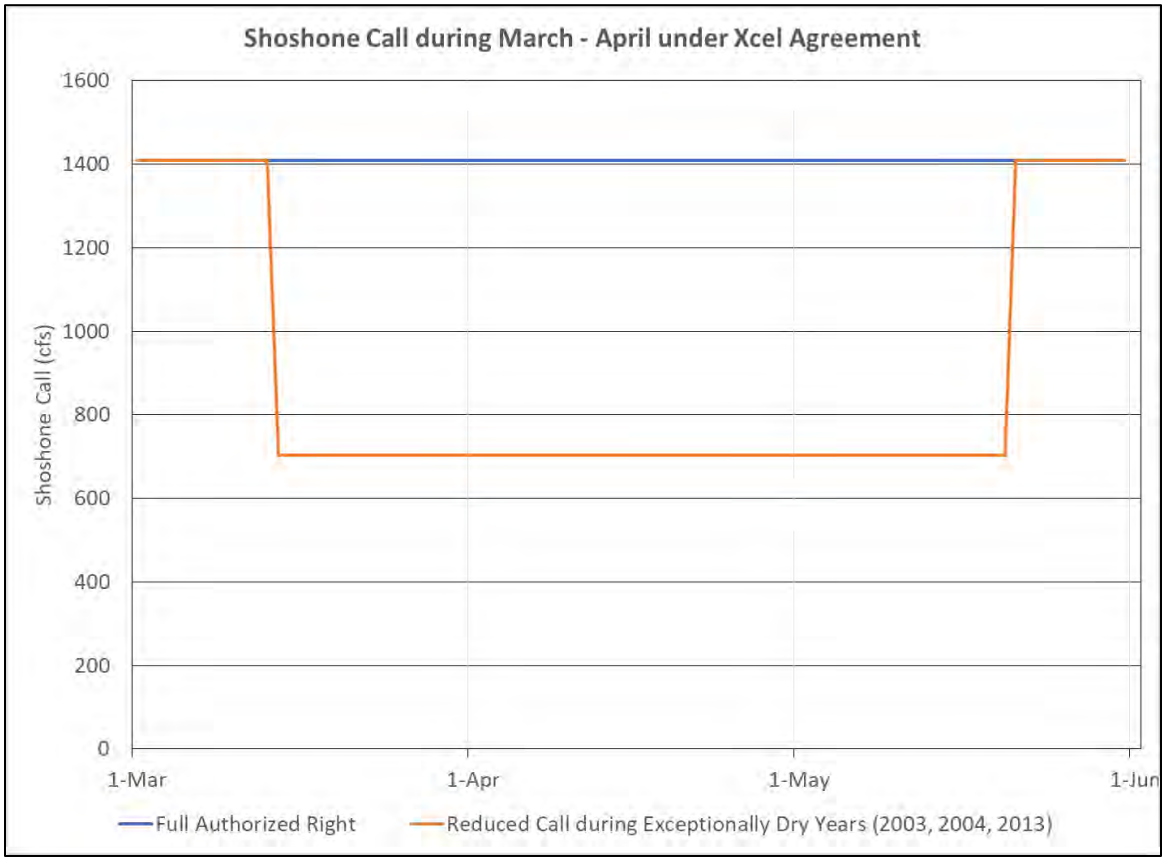


Figure 2: Demands with Call Relaxation applied to full use of both Shoshone rights.

Table 3: Change in Modeled Monthly Shoshone Call Volume (Demand) under the Call Relaxation Agreement.[11]

Monthly Volumes	Full Use (AF)	Call Relaxation (AF)
March	86,576	61,441
April	83,783	41,892
May	86,576	58,648

Results

The following section provides a summary of results for the scenarios described above. Results focus on the Stress Test period of 1988-2013. Flows at both the Colorado-Utah state line and in the 15-Mile Reach were evaluated for each scenario, both as timeseries and via statistical analysis. Although some differences between impacts to the 15-Mile Reach and the state line were evident, the two locations had similar outcomes when comparing scenarios. As a result, and to simplify the discussion, the following summary

[11] Note that the relaxation agreement represents a change in demand (call) from Shoshone and the volumes shown would only be realized if water supply and river administrative conditions permit.

focuses on impacts in the 15-Mile Reach. In the following discussion of results, "yield" or "benefit" means the expected additional flow resulting from the Shoshone Power Plant and Call actively calling its decreed rights compared to expected changes in river flows without any active calls attributable to the Shoshone water rights.

The 15-Mile Reach is critical habitat for two threatened and two endangered warm-water fish species.[12] Flow recommendations have been developed by the U.S. Fish and Wildlife Service (USFWS) as part of the Programmatic EIS for the 15-Mile Reach. USFWS identified a minimum flow target of 810 cfs for dry hydrologic years for the months August-October. This is equivalent to approximately 50,000 acre-feet per month.

We examine the benefits of the Shoshone Call in two ways: first, we evaluate three example years to understand how the Shoshone Call impacts annual flow volumes in dry, average, and wet years; second, we look specifically at very low flow periods (months) in the 15-Mile Reach, to better understand how some of the most significant benefits of the Shoshone water rights are realized during times of critically low flows in this reach.

Appendix B to this report outlines the monthly distribution of yields in more detail and includes both quantifications of the typical variation in yields by month of the year. Appendix C describes the administrative conditions and operational mechanisms that lead to increased 15-Mile Reach flows during late-summer months.

Annual Examples

Antecedent conditions from one year to the next can cause significant differences in reservoir storage across scenarios with different administrative regimes or user demands. Varying levels of low initial storage between scenarios can distort or obscure the actual impacts of the Shoshone Call in the year of interest, particularly when comparing results across scenarios and multiple years. Wet, dry, and average example years were chosen based on having wet antecedent conditions in order to minimize differences between model scenarios caused by impacts of prior year drawdown in storage by junior water rights.

A table of annual results from the stress-test period (1988-2013) is attached in Appendix A as Table A-1. As shown in Table A-1, the example years are not necessarily the years with the highest yield within a particular hydrologic category. For example, we use 2010 as a typical average year. However, 1994 (another average year) has a simulated yield that is more than twice as large as 2010. Although the yield in 1994 is much larger than 2010,

[12] See https://coloradoriverrecovery.org

2010 is considered to be more representative of yields in an average hydrologic year due to a longer period of wet antecedent conditions leading up to that year.

Wet Year Example

1998 was chosen as the example year to represent wet conditions due to flows exceeding the 1988-2013 average by 33%, and due to antecedent conditions being wet or average for the prior 7 years. Yields for each scenario are tabulated in Table 4, where the yields for the scenarios with Call Relaxation under the 2007 Agreement are omitted due to the Call Relaxation not being active in the example year:

Table 4. Wet Year (1998) Example Yields.

Scenario	15-Mile Reach Yield (AF)
Senior Current	3,107
Senior Future	13,028
Max Current	13,359
Max Future	27,273

Average Year Example

2010 was chosen as the example year to represent average conditions, due to flows being within 4% of the 1988-2013 average, and due to antecedent conditions being wet or average for the prior 5 years. Yields for each scenario are tabulated in Table 5, where the yields for the scenarios with Call Relaxation under the 2007 Agreement are omitted due to the Call Relaxation not being active in the example year.

Table 5. Average Year (2010) Example Yields.

Scenario	15-Mile Reach Yield (AF)
Senior Current	5,376
Senior Future	22,608
Max Current	9,823
Max Future	27,324

Dry Year Example

2012 was chosen as the example year to represent dry conditions, due to flows being 48% below the 1988-2013 average, and due to antecedent conditions being wet or average for the prior 7 years. Yields for each scenario are tabulated in Table 6, where the yields for the scenarios with Call Relaxation under the 2007 Agreement are omitted due to the Call Relaxation not being active in the example year.

Table 6. Dry Year (2012) Example Yields.

Scenario	15-Mile Reach Yield (AF)
Senior Current	41,184
Senior Future	55,080
Max Current	69,580
Max Future	86,143

Annual Examples Summary

The wet, average, and dry year examples above all show a net benefit from maintenance of the Shoshone Call. These examples include both the senior (1,250 cfs) and maximum (1,408 cfs) calls for the Shoshone water rights, as well as current and future basin demands. A few obvious trends are apparent from the results:

1. There is generally a larger benefit to flows through the 15-Mile Reach in dry years as compared to wet years. This benefit is magnified when considering that the years with the highest volumetric yield are generally also the years with the lowest total annual flows to begin with.
2. Fully exercising both the senior and junior Shoshone water rights results in larger yields, meaning the junior water right provides additional value in contributing flows to the 15-Mile Reach.
3. The benefit of maintaining the Shoshone Call will increase with time, as additional upstream junior rights are developed or are more fully exercised. The Shoshone Call will be an important "backstop" to protect flows through the 15-Mile Reach as those junior rights are fully utilized.

Monthly Flow Impacts

A second analysis of the results focuses on monthly flow volumes during the Stress Test period (1988-2013), and in particular on very low flow months in which the minimum flow targets for the 15-Mile Reach are not met. Under the "No Shoshone Call" StateMod run with current basin-wide demands, approximately 15% (46 of 312 months) of *all months* since 1988 would fail to meet the late irrigation season minimum flow target of 50,000 acre-feet per month. Of these 46 months, 30 are in the August-October period (the others include 8 Aprils, 1 May, 2 Junes, and 5 Julys). Table 7 below illustrates the *average* increase in flow under the Shoshone Call during these 46 critically dry months. Table 7 includes results under both current and forecasted future Upper Colorado basin demands across the four Shoshone Call scenarios outlined in Table 2.

Under current basin demands and full exercise of the Shoshone water rights, average flows during these critically dry months are 23% higher than flows with no Shoshone Call. Assuming an increment of future growth by both TMDs and in-basin uses, the benefit of the continued exercise of Shoshone water rights results in 29% more flow on average in these critically dry months. In some instances, the monthly flows with the Shoshone Call active *more than double* the expected flow through the 15-Mile Reach under a no-call scenario. The 2007 agreement for Call Relaxation has a relatively minor impact on the critically dry months' results in the 15-Mile Reach, because the agreement is only active in certain spring conditions, and most of the critical low-flow months are in the late summer and early fall.

Table 7. Increase in flow through the 15-Mile Reach during months with less than 50,000 acre-feet of water in the 1988-2013 simulation period. Increases are shown as monthly average flow and percent increase above flows modeled in the "No Shoshone Call" scenario.

Average Monthly Flow Increase (cfs, %) 1988-2013 (Months < 50,000 AF)				
Basin Demand Level	Senior Shoshone Right 1,250 cfs	Senior Shoshone Right 1,250 cfs w/ Relaxation	Max Shoshone Call 1,408 cfs	Max Shoshone Call 1,408 cfs w/ Relaxation
Current	93 (18 %)	90 (18 %)	118 (23 %)	115 (22 %)
Future	123 (25 %)	120 (25 %)	140 (29 %)	127 (26 %)

The benefits of the Shoshone water rights are not limited to just the driest months. Table 8 shows the expected benefit in the driest quarter (25%) of all months in the 1988-2013 simulation period. While the average benefit across all these months is somewhat less than in the very driest of months, there is still a significant increase in average flow. Even considering the driest half of all the monthly flows in the simulation period (Table 9), there is a clear benefit from continued operation of the Shoshone water rights.

Table 8. Increase in flow through the 15-Mile Reach during the driest 25% of months in the 1988-2013 simulation period. Increases are shown as monthly average flow and percent increase over flows in the "No Shoshone Call" scenario.

Average Monthly Flow Increase (cfs, %) 1988-2013 (Driest 25% of Months)				
Basin Demand Level	Senior Shoshone Right 1,250 cfs	Senior Shoshone Right 1,250 cfs w/ Relaxation	Max Shoshone Call 1,408 cfs	Max Shoshone Call 1,408 cfs w/ Relaxation
Current	88 (12 %)	81 (11 %)	121 (16 %)	114 (15 %)
Future	119 (17 %)	114 (16 %)	147 (21 %)	136 (20 %)

Table 9. Increase in flow through the 15-Mile Reach during the driest half (50%) of months in the 1988-2013 simulation period. Increases are shown as monthly average flow and percent increase above flows modeled in the "No Shoshone Call" scenario.

Average Monthly Flow Increase (cfs, %) 1988-2013 (Driest 50% of Months)				
Basin Demand Level	Senior Shoshone Right 1,250 cfs	Senior Shoshone Right 1,250 cfs w/ Relaxation	Max Shoshone Call 1,408 cfs	Max Shoshone Call 1,408 cfs w/ Relaxation
Current	49 (4 %)	45 (4 %)	70 (6 %)	67 (6 %)
Future	76 (7 %)	73 (7 %)	97 (9 %)	88 (8 %)

Conclusions

This analysis of the Shoshone water rights indicates that abandonment or lack of enforcement of the water rights would have a significant detrimental effect on flows through the 15-Mile Reach of the Colorado River and likely would result in reduced flows at the Colorado-Utah state line. The impact of the Shoshone Call is particularly significant during dry years, such as in 2012, when the 15-Mile Reach would suffer a loss of approximately 41,000-86,000 acre-feet per year if the Shoshone water rights were no longer administered against upstream juniors.

This existing benefit of the Shoshone Call is critical to the continued success of the 15-Mile Reach PBO. If the Shoshone water rights were not exercised in the future, this would likely result in the further inability to satisfy the 15-Mile Reach PBO minimum target flows. Furthermore, the benefit of the Shoshone water rights is not only seen during these critical dry years. In average and wet years, flows in the 15-Mile Reach would be as much as 27,000 acre-feet lower (per year) without continued exercise of the Shoshone Water rights.

Of equal importance to the overall increase in annual flows through the 15-Mile Reach is the significant benefit to flows seen during late summer and early fall months, particularly in dry years, when the river is typically at its lowest. During these months, the Shoshone Call can double the monthly flow compared to flows without a Shoshone Call, and when averaged across all of the critically dry months, the Shoshone Call increases the monthly flows by 18% - 26% under the Senior Current and Future Max scenarios, respectively.

Future Work

As of early September 2024, the Colorado Water Conservation Board is working on an updated version of the Upper Colorado River Basin StateMod Model. This updated model will include revisions to operating rules, as well as a daily timestep version of the model. While that model was not publicly available when this analysis was performed, this memo will be updated *if warranted* after that model is made public.

References

Hydros, 2023. Colorado River Risk Study Phase IV Draft Report. Prepared for the Colorado River District and the Southwestern Water Conservation District.

Xcel, 2003. Agreement Concerning Proposed Operation of the Shoshone Power Call. Agreement between the City and County of Denver, acting by and through its Board of Water Commissioners, and the Colorado River Water Conservation District.

Xcel, 2007. Agreement Concerning Reduction of Shoshone Call. Agreement between the City and County of Denver, acting by and through its Board of Water Commissioners, and Public Service Company of Colorado d/b/a Xcel Energy.

Appendix A: Increases inflow (aka "yield") attributed to the Shoshone Call.

Table A-1. 15-Mile Reach Yields for Each Year in All Scenarios

		Future Development Yield* (AF)				Current Development Yield* (AF)			
Year	**Hydrology**	**Senior**	**Senior-**	**Max**	**Max-Relaxation**	**Senior**	**Senior-**	**Max**	**Max-**
1988	Average	20,708	20,708	20,986	20,986	3,407	3,407	-	-
1989	Dry	28,262	28,262	30,325	30,325	-	-	2,109	2,109
1990	Dry	51,330	51,330	50,386	50,386	18,267	18,267	42,655	42,655
1991	Average	35,394	35,394	33,374	33,374	38,505	38,505	19,770	19,770
1992	Average	32,442	32,442	41,387	41,387	15,995	15,995	18,658	18,658
1993	Wet		-	-	-	-	-	-	-
1994	Average	50,013	50,013	63,986	63,986	19,169	19,169	39,451	39,451
1995	Wet		-	-	-	-	-	-	-
1996	Wet		-	-	-	1,745	1,745	-	-
1997	Wet		-	-	-	-	-	-	-
1998	**Wet**	**13,028**	**13,028**	**27,273**	**27,273**	**3,107**	**3,107**	**13,359**	**13,359**
1999	Average	16,551	16,551	4,310	4,310	5,197	5,197	-	-
2000	Average		9,644	18,427	18,427	1,604	1,604	2,723	2,723
2001	Dry	48,552	48,552	59,162	59,162	27,086	27,086	30,354	30,354
2002	Dry	53,552	53,552	54,837	54,837	36,204	36,204	39,351	39,351
2003	Dry	32,060	25,699	43,610	12,703	22,834	17,318	24,549	19,031
2004	Dry	68,408	42,649	72,176	15,334	54,538	33,620	61,151	40,394
2005	Average	29,034	39,894	28,914	59,250	2,423	4,606	7,556	10,179
2006	Average	13,374	13,228	25,755	23,528	-	-	6,157	5,911
2007	Average		-	13,016	12,948	-	-	-	-
2008	Wet		-	-	-	-	-	-	-
2009	Wet	11,523	11,521	21,762	21,723	-	-	-	-
2010	**Average**	**22,608**	**22,611**	**27,324**	**27,328**	**5,376**	**5,374**	**9,823**	**9,821**
2011	Wet		-	-	-	-	-	-	-
2012	**Dry**	**55,080**	**55,083**	**86,143**	**86,294**	**41,184**	**41,183**	**69,580**	**69,580**
2013	Dry	20,429	5,926	22,192	-	5,419	-	7,213	-

**Yield is defined here as being necessarily greater than zero, because Shoshone's call does not directly result in reductions in flow. Differences in reservoir operations between scenarios can cause reductions in flow greater in magnitude than Shoshone's actual yield, resulting in zero apparent yield.*

Appendix B – Monthly Yield Analysis

This appendix provides a more detailed review of simulated monthly increases (yields) to the 15-Mile Reach than is provided in the main body of the report. Whereas the main body of the report contains results across all scenarios showing the annual yields, this appendix focuses on the Max-Relaxation scenarios[13] under both current and future demand levels. The Max-Relaxation scenarios have distributions of monthly yields similar to the other scenarios in most years but exhibit reductions in overall yield to the 15-Mile Reach during Call Relaxation periods when compared to the Max-Relaxation scenarios, which do not include the 2007 Agreement. This appendix reviews the simulated patterns of monthly yields under the Max-Relaxation scenarios, followed by an illustration of the amount of 15-Mile Reach flows attributable to the Shoshone Call. As additional background information, Appendix C provides an overview of the operational mechanisms at Cameo (OMID Power Canal, Check Structure, and GVC operations) together with a more detailed explanation of how the exercise of the Shoshone water rights can increase flows in the 15-Mile Reach even when a Cameo Call is active.

Simulated Patterns of Monthly Yield – Magnitude and Frequency

Magnitude

The patterns of monthly yield to the 15-Mile Reach due to utilization of the Shoshone call are similar for both Current and Future demand levels. Figure 3 depicts the average amount of additional daily flow by month when full utilization of the Shoshone Call yields additional water to the 15-Mile Reach. Regardless of which demand set is used in the Max-Relaxation scenario, the pattern of monthly yields is similar, with the highest yields occurring in early spring – particularly April - and in the late summer months of August – October.

Additional flows in the 15-Mile Reach in months outside the irrigation season, such as in February and March, tend to result from changes in reservoir storage carryover from previous years, together with differing administrative regimes that can limit the amount of storable water[14]. The yields in those months typically result from reservoirs having to

[13] The Max-Relaxation scenario assumes full use of the Shoshone water rights (1,408 cfs call) and implementation of a Call Relaxation under the 2007 Agreement, which is simulated to occur in this analysis in 2003, 2004, and 2013)

[14] These changes may be due to both increased releases to offset other depletions and decreased ability to store water in priority. This phenomenon is seen in many years and is particularly evident in dry years, such as in 2001. In February and March of 2001, in both the Current and Future scenarios, Williams Fork Reservoir gains storage each month if the Shoshone Call is not active and loses storage each month if the Shoshone Call is active. The increase in flow at the 15-Mile Reach due to the different administrative regime at Williams Fork Reservoir in February and March with the Shoshone call on is about 88 cfs in 2001. However, the difference in river administration with and without the Shoshone Call does not impact

bypass inflows that – absent a Shoshone call – would be storable under their more junior storage rights. The pronounced increase in April is due to both changes in the ability of upstream reservoirs to fill, coupled with early-season irrigators either being curtailed or required to release additional augmentation water from storage.

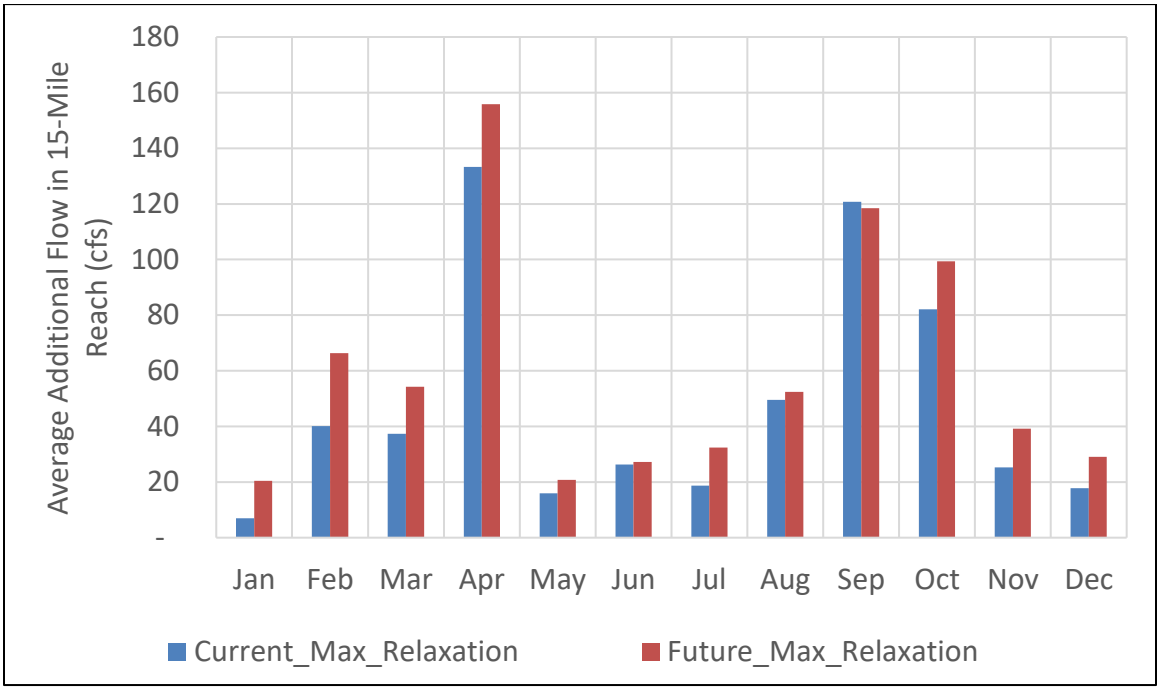


Figure 3. 1988-2013 Average Monthly Yield Magnitude Patterns - Current and Future Max Relaxation Scenarios

Frequency

In addition to increased flows during spring and late summer, the *frequency* of increased flows is also highest in these months. Table 10 illustrates expected frequency (likelihood) by month of increased 15-Mile Reach flows with the Shoshone Call active. The frequency shown is percentage of years over the 1988-2013 study period in which a given month saw increased flows.

Williams Fork Reservoir every year. Similarly, changes in storage at other reservoirs may exhibit different behavior in any given year due to the complexities of each reservoir's operational response to the presence or absence of a Shoshone Call, and this impact may persist over multiple years.

Table 10. Monthly Yield Frequency - Current and Future Max Relaxation Scenarios

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Current	27%	73%	69%	69%	12%	12%	15%	46%	88%	77%	46%	35%
Future	46%	92%	73%	77%	19%	12%	23%	54%	81%	85%	54%	54%

The monthly pattern of yield *frequency* is similar to the monthly pattern of yield *magnitude*, with the exception of the winter months (December through March). The four winter months show higher frequency of yield but a lower magnitude of yield, due to reduced natural flows in the winter and the lack of any substantial irrigation demands, including the Cameo Call, during this period.

PBO Comparison

Differences between these scenarios can also be evaluated against flow recommendations from the Upper Colorado River PBO.[15] Table 2 of the PBO is repeated here for reference:

[15] https://coloradoriverrecovery.org/uc/wp-content/uploads/sites/2/2021/09/FinalPBO.pdf

Table 11. (Table 2 from Upper Colorado River Programmatic Biologic Opinion)

Table 2. Recommended mean monthly flows for the top of the 15-Mile Reach in cubic feet per second. Rate is the percent of years recommended for identified flows based on winter snowpack levels. For example, in the wettest 25 percent of years, flows in June should average at least 15,660 cfs; stated another way, this recommendation should be met in 5 of every 20 years. During low-water years, June flows should average no less than 6,850 cfs, and such a minimum should occur at a rate of no more than 4 in 20 years (20 percent). Table from Osmundson et al. 1995.

Rate	25 percent	25 percent	30 percent	20 percent
Exceedance	25 percent	50 percent	80 percent	100 percent
JAN	1,630	1,630	1,630	1,240
FEB	1,630	1,630	1,630	1,240
MAR	1,630	1,630	1,630	1,240
APR	3,210	2,440	2,260	1,860
MAY	10,720	9,380	7,710	7,260
JUN	15,660	14,250	11,350	6,850
JUL	7,060	5,370	3,150	1,480
AUG	1,630	1,630	1,240	810
SEP	1,630	1,630	1,240	810
OCT	1,630	1,630	1,240	810
NOV	1,630	1,630	1,630	1,240
DEC	1,630	1,630	1,630	1,240

As noted in the inset table caption, PBO recommendations for very low-flow years are listed in cfs in the far right column by month. From a fisheries-benefit perspective, those low-flow targets ideally would have an 80% exceedance (i.e., only 4 years out of 20 would see flows corresponding to the right-most monthly targets). Figure 4 and Figure 5 compare the frequency of meeting the recommended flow targets for the months of April and September across the scenarios.

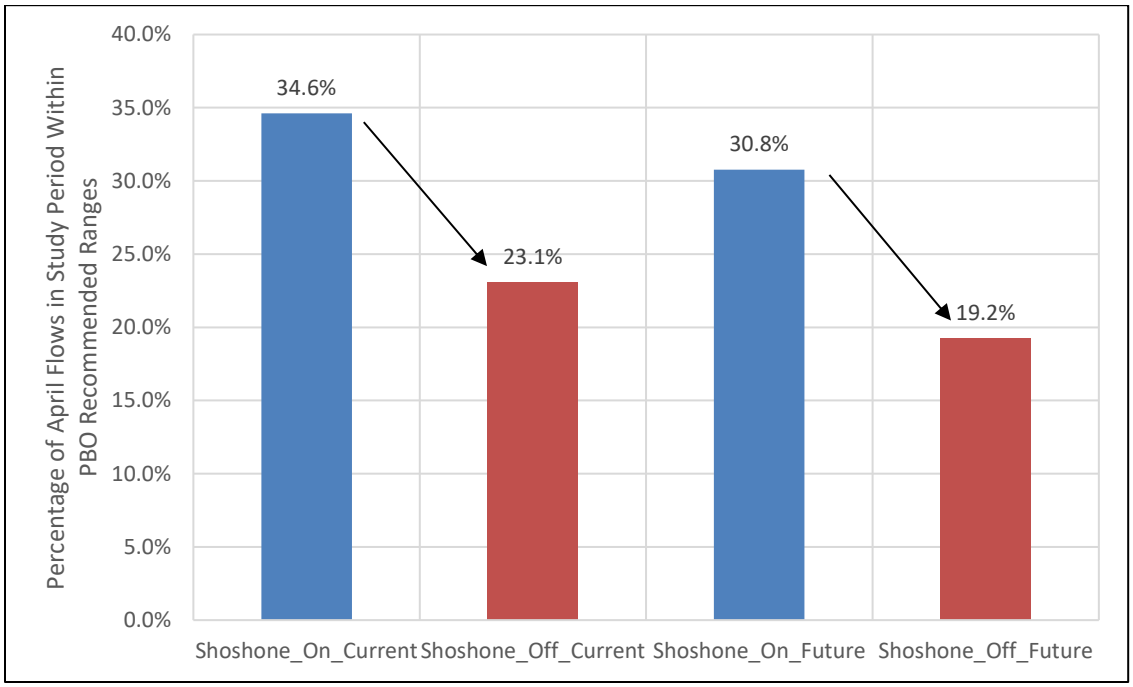


Figure 4. Frequency of April Flows meeting the Lowest PBO Recommended Range *(Shoshone On Scenario is Max w/ Relaxation).*

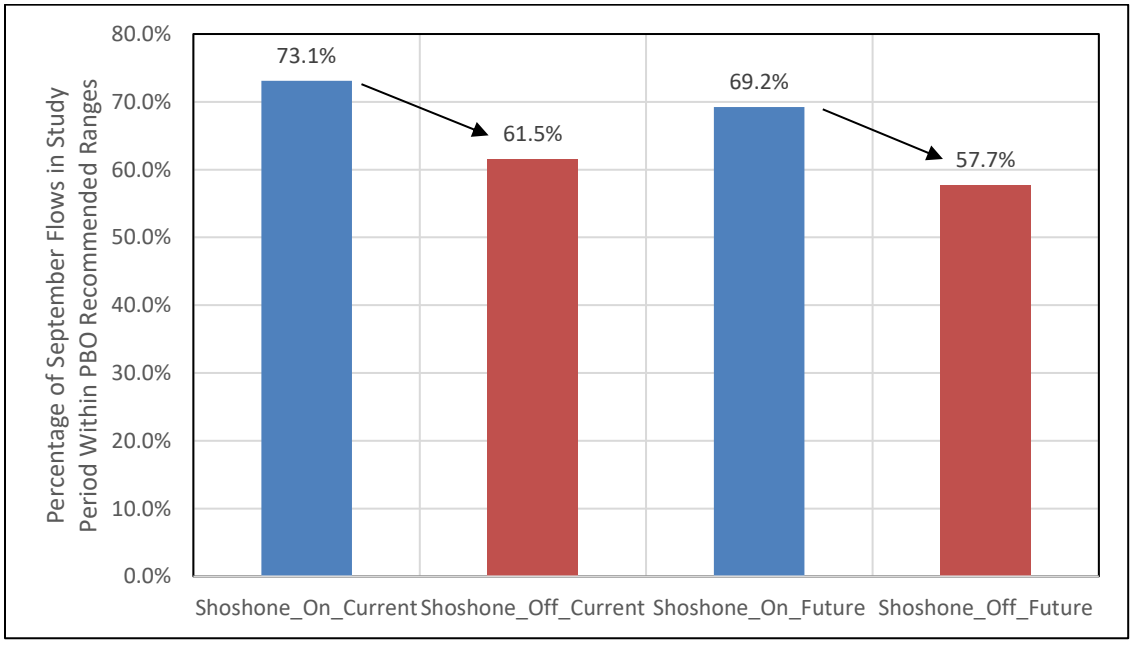


Figure 5. Frequency of September Flows meeting the Lowest PBO Recommended Range *(Shoshone On Scenario is Max w/ Relaxation).*

Notably, there is a significant *decrease* in the frequency of meeting the PBO recommendations when the Shoshone Call is *off*. While having the Shoshone Call active does not by itself meet all desired flow targets for the 15-Mile Reach, its absence would result in significant reductions in PBO target flow compliance rates.

Summary of Late-Summer Benefits

The increase in flows in August-October are of particular interest, because generally lower natural flow conditions—combined with upstream diversions that are often being fully utilized during late summer—tend to negatively impact flows, and hence endangered species, in the 15-Mile Reach. Despite having the lowest monthly flow target (810 cfs), flows in August-October meet that target just 72% of the time during the simulation period. The contribution of the Shoshone Call to flows in the 15-Mile Reach is significant, particularly in critically dry periods.

Model results indicate that when average flows in the 15-Mile reach are less than 810 cfs, the Shoshone Call is responsible for 22% (on average) of that flow, and in some months as much as 50% of the flow (Figure 6).

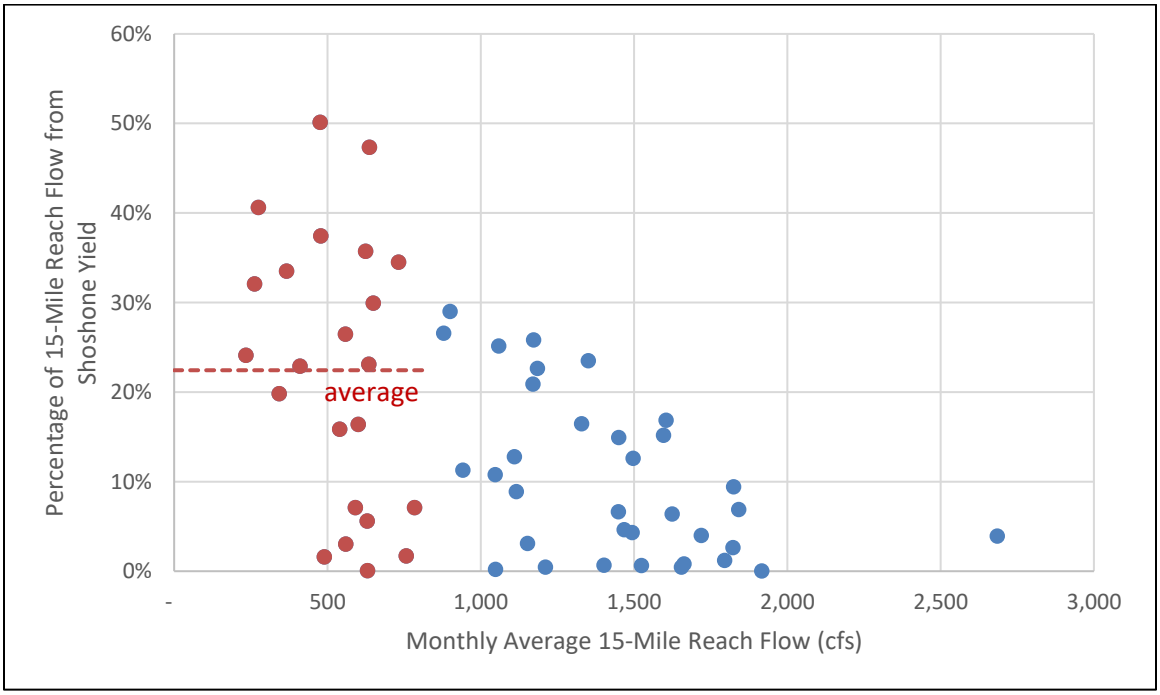


Figure 6. Relationship Between Monthly Average Flow and the Percentage of Flow Resulting from Shoshone's Call - Aug-Oct, Future Max Relaxation Scenarios.

Summary of Monthly Yield Analysis

The analysis presented in Appendix B illustrates several key benefits of the Shoshone Call to the 15-Mile Reach, including:

1. Increases in monthly flows through the 15-Mile Reach year-round, with the highest flow increases in early spring (February – April) and late summer (August – October).
2. The *frequency* of increased flows is also generally highest during the early spring and late summer months. Approximately 4 out of 5 years see some amount of increased flows in September and October (Table 10).
3. The benefits accruing to the 15-Mile Reach are particularly significant during the months with the lowest flows in the driest years. The likelihood of meeting the PBO recommended flow minimums increases across all scenarios when the Shoshone Call is on (Figures 4 and 5).
4. During critically dry (<810 cfs) months, the Shoshone Call contributes *on average* 22% of the flow in the 15-Mile Reach, and as much as 50% of the flow.

Appendix C: Dissecting the Cameo Calls – How Shoshone Contributes to the 15-Mile Reach in Late-Summer

This appendix is being provided in response to comments received during review of this report and associated presentations. The appendix provides additional details as to the mechanisms that result in additional flows to the 15-Mile Reach during months in which a Cameo Call may typically be active. The Cameo Call is a generic term that describes an administrative call for water placed by either the Grand Valley Project's Government Highline Canal or the Grand Valley Canal, both of which are directly upstream of the 15-Mile Reach and both of which have relatively senior water rights in the basin (although the most senior Cameo water rights are junior to Shoshone's senior water right). StateMod results indicate that having Shoshone active has a meaningful impact to the 15-Mile Reach. However, StateMod is somewhat limited in its ability to tease out details of how the Shoshone and Cameo calls interact, particularly over sub-monthly time periods. Examination of historical river administration records can be used to validate these conclusions.

Mechanisms that benefit 15-Mile Reach flows include:

1. Delayed Onset of the Cameo Call: A Shoshone Call brings additional water downstream, which delays and shortens the duration of the Cameo Call. This additional flow is the result of increased curtailment and/or release of larger volumes of augmentation water by junior users upstream of Shoshone.
2. Reduced Need for Recovery Program Flow Releases: A Shoshone Call reduces the need for Recovery Program supplemental releases by increasing flows past Cameo into the 15-Mile Reach. This reduces the need for releases from "fish water"[16] storage accounts during certain times and allows for increased flexibility in providing flow augmentation releases during late summer months.
3. Operation of the OMID Check Dam during a Cameo Call: Efficient operation of the OMID Power Plant and Pump Turbine often results in only partial operation of the Check Dam. This enables more efficient power production and results in water bypassing the Check Dam and returning to the river at the head of the 15-Mile Reach.

Each of these is discussed in more detail below.

1. Delayed Onset of Cameo Call

Historically, the Cameo Call is the controlling call on the river during the late summer months of August through October. In the absence of a Shoshone Call, it is likely that the

[16] "Fish Water" refers to releases from upstream reservoirs make specifically to benefit flows in the 15-Mile Reach. These releases are shepherded past the Cameo diverters for the benefit of the Endangered Fish.

Cameo Call would be initiated even earlier in the year, as the runoff peak ends and the river returns to a baseflow condition. Under an assumed full utilization of the Shoshone Call, the need for a Cameo Call is pushed later in the summer and may be eliminated altogether.

An example of the effect that the Shoshone Call has in delaying the Cameo Call can be seen in CDSS administrative data from August and September of 2019. The Shoshone junior call was first placed on 8/23/2019. The senior Shoshone call was then placed on 8/28/2019 with the swing right at CBT's 8/1/1935 priority. As Administrative Flows[17] continued to fall, the swing right was adjusted to the Moffat Tunnel (7/9/1934) priority on 8/30, and finally to the Shoshone Priority (12/5/1905) on 9/2/2019. Although Shoshone was calling throughout September, the gradual reduction of mainstem and tributary inflows pushed the natural flow of the river low enough that by 9/25/2019, a Cameo Call was necessary at the 8/3/1934 priority of the Grand Valley Project.

In analyzing this historical sequence of calls, it is reasonable to conclude that absent the Shoshone Call, a Cameo Call would have been placed much earlier in September. In this example, the Shoshone Call likely delayed the onset of the Cameo Call by 3 or 4 weeks. Regardless of how much Administrative Flow was in the river over and above the Cameo diverters' demands, the lack of a Cameo Call during this period indicates that the Shoshone Call resulted in water in excess of the Cameo diverters' needs passing into the 15-Mile Reach. Absent the Shoshone Call, it is likely that the Cameo Call would have started weeks earlier and there would have been less water in the 15-Mile Reach. Delaying the onset of the Cameo Call by making the Shoshone Call permanent will result in additional flows into the 15-Mile Reach.

Sources of Water

The Senior Shoshone Call is administered under a 1905 priority and is approximately seven years senior to the senior Cameo Call, which is administered at a 1912 priority. Differences in the administrative dates and volume of the two calls impacts water users upstream of Shoshone. In general, the more senior Shoshone Call will force junior rights upstream to either provide additional augmentation water or curtail their uses.

To the extent that there was a swing call on one of the junior rights above Shoshone, exercising the Shoshone call over the Cameo call would increase that user's required offset, or would shift the swing to another user. Regardless, delaying or preventing a Cameo Call through continued utilization of the Shoshone rights will result in longer periods of flows

[17] In general terms, the "Administrative Flow" equals the measured flow at the Dotsero Gage minus shepherded reservoir release water, including "fish water" that has been bypassed or released from upstream storage and is shepherded past other diversions in order to supplement flows in the 15-Mile Reach

at Cameo in excess of diversion demands, and result in more water being bypassed into the 15-Mile Reach.

2. ***Enhanced Flexibility of Recovery Program Releases***

As previously discussed in the main body of this report, modeling results indicate a reduction in flows in the 15-Mile Reach during late summer months without Shoshone actively calling. However, when the Shoshone Call is active, average 15-Mile Reach flows increase, particularly during critically dry months and years.[18] StateMod currently does not simulate changes to "fish water" releases that might result from changes to Shoshone operations. However, it is clear that having additional flows in the 15-Mile Reach by virtue of the Shoshone Call increases the likelihood of meeting PBO flow targets (See Figures 4 and 5) and will allow for greater flexibility in utilizing the various environmental pools to make releases to benefit the endangered fish populations in that reach.

3. ***Operation of OMID Check Dam during a Cameo Call***

The existence of a Shoshone call does not guarantee that there will not be a Cameo call, although it does reduce the likelihood and delay the onset. During periods when both Cameo and Shoshone are calling, there can still be benefits to the 15-Mile Reach as compared to river conditions without a Shoshone Call.

Figure 7 presents a simplified schematic of the diversion infrastructure at Cameo that is useful in understanding how water moves through that system.[19] The Orchard Mesa Irrigation District (OMID) diverts part of the flow of the Government Highline Canal into the OMID Power Canal. Tailwater from the OMID power plant and pump turbine are regulated by a Check Dam which can be operated to deliver water upstream through the bypass channel for diversion by the GVIC into the Grand Valley Canal. If the Check Dam is only partially closed, the portion of water not delivered back to GVIC is returned to the river just below the GVIC canal, at the head of the 15-Mile Reach.

OMID operates the Check Dam when flows available to meet the Cameo Call are at or below 1,950 cfs, thereby enabling power generation and deliveries to OMID without injuring the senior GVIC rights (see Figure 7). However, checking flows into the bypass channel at a rate greater than 100 cfs results in decreased power production due to a reduction in hydraulic head caused by pooling of the power and pumping plant tailwater. Thus, the Check Dam does not always redirect all the OMID Power Canal return flow water upstream to the GVIC diversion dam. Often, the Check operates only partially or not

[18] See Figures 3-5.
[19] This schematic is taken from a report by Paul Calder dated July 12, 1993 entitled "Orchard Mesa Irrigation District Operation of the 'Check'".

at all – even when a Cameo Call is in effect. Water not checked back into the bypass channel accrues to the 15-Mile Reach.

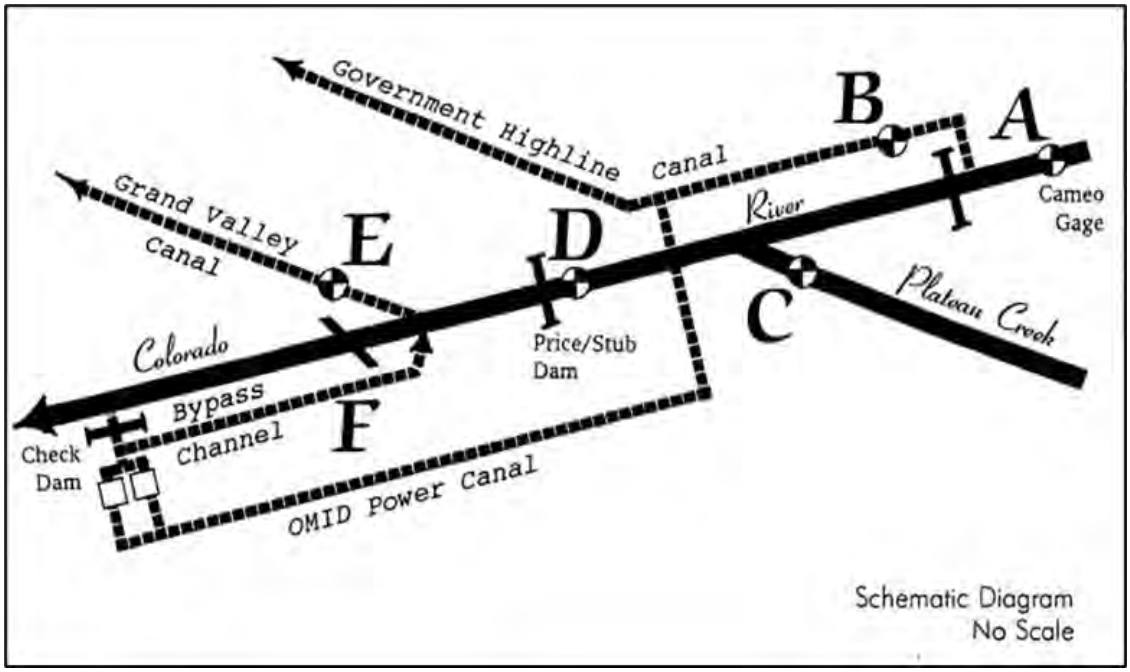


Figure 7. Schematic Diagram of Cameo Diversions.

Historical Example

Historical flows in the 15-Mile Reach were evaluated during periods when Shoshone was calling. The full set of data required for this assessment is available beginning in 2012, which was a year where infrastructure issues prevented full exercise of the Shoshone water rights. Figure 8 shows the period from July-October of that year when the senior Cameo Call was active, and how the Check Dam and the OMID power plant were operated in tandem during that time. In the figure, the "check structure" line represents flows delivered back to the river via the bypass channel to ensure GVIC's demand is met. The difference in flow between the two lines represents—at a minimum—the amount of water entering the 15-Mile Reach. If GVIC is not diverting 100% of the flow at its headgate, additional water will arrive at the 15-Mile Reach as it passes the GVIC diversion dam.

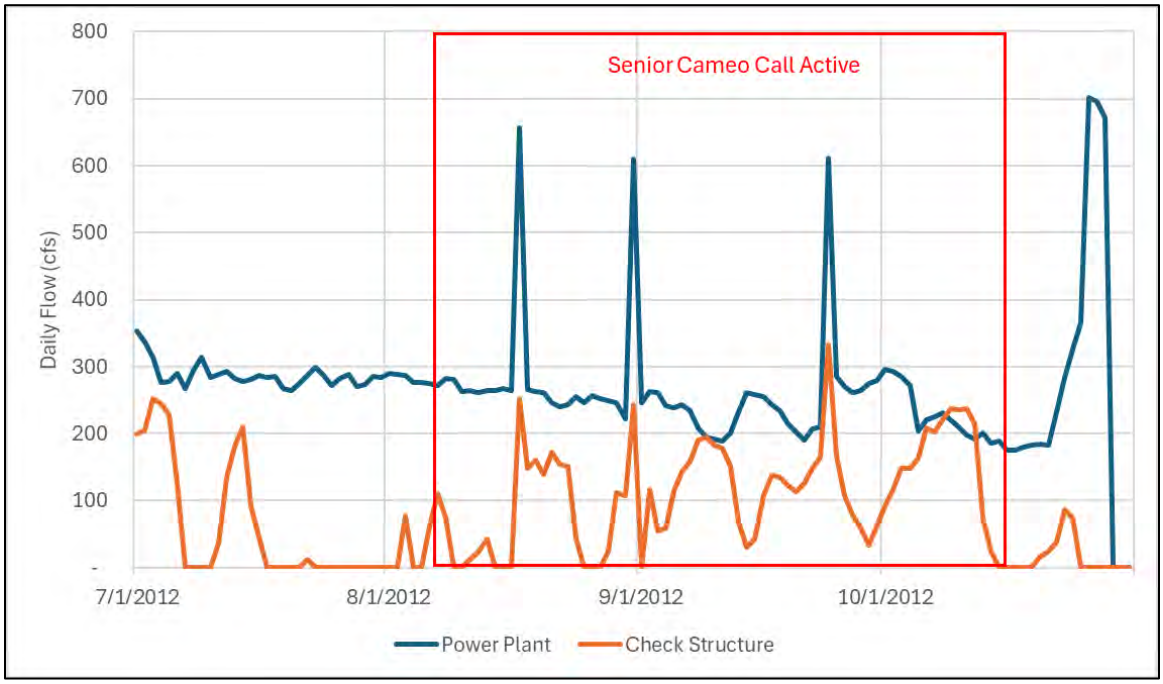


Figure 8. Historical Observed Power Plant Diversions and Checked Flow, 2012.

A portion of the difference in flow between the lines showing the OMID power plant and Check Dam usage corresponds to "Fish Water" that was released from upstream storage and is intended to supplement flow in the 15-Mile Reach. These deliveries are NOT subject to a Cameo Call, are often routed through the OMID power plant, would not be checked back into the bypass channel, and would be released into the river at the head of the 15-Mile Reach. Not all of the water represented by the difference between the two lines is "Fish Water". Periods during which this additional flow accrues to the river below GVIC represent instances where calls from the Cameo water rights have been met, and any additional flows from upstream would accrue to the 15-Mile Reach. Had the senior Shoshone Call been in place during these times, there are upstream diversions junior to Shoshone but senior to Cameo that would have been called out, and the additional yield from their curtailment (or associated replacement water released from storage) would have accrued to the 15-Mile Reach.

DRAFT

TO: Colorado River District Staff and Counsel
FROM: Hydros Consulting, Inc.
SUBJECT: Addendum to September 11, 2024, Shoshone Power Plant Water Rights Yield Assessment
DATE: November 7, 2024

This memo is being provided as an addendum (Addendum) to the September 11, 2024 memo "Shoshone Power Plant Water Rights Yield Assessment" from Hydros Consulting to the River District. On September 18, 2024, a new version of the Upper Colorado River Basin Model (UCRM) and Baseline Data Set was released to the public by the Colorado Water Conservation Board (CWCB). The updated version of the UCRM can be run using either monthly or daily timesteps. A summary of the significant changes made to the 2015 version of the UCRM is provided in a memo from the State's modeling contractor (herein "WWG Memo") from Erin Wilson (Wilson Water Group) to Brian Macpherson (CWCB) dated September 16, 2024.[1]

This Addendum provides a summary of additional analyses conducted using the daily timestep version of the new UCRM and addresses comments raised by organizations reviewing the original analysis. Like the original September 11, 2024, memo, the analysis presented in this Addendum is not intended to quantify the historical use of the Shoshone water rights.

Background

The daily timestep model provides an opportunity to more precisely analyze the effects of the proposed Shoshone water rights on stream flow and revisit the analysis of the impacts to Colorado River flow if the Shoshone water rights were eventually abandoned or otherwise not exercised. However, because the daily UCRM has yet to undergo any formal vetting process, the daily UCRM outputs are likely less accurate than what would occur under real-time conditions. [2]

[1] https://dnrftp.state.co.us/CDSS/ModelFiles/StateMod/Shoshone_StateMod_Baseline_9-26-2024.zip

[2] Note that this daily model was not calibrated to daily or monthly flows or operational data, and only generally approximates actual patterns of daily water user demands. It also does not reflect the reality of multi-day travel times when making reservoir releases or administering water rights. As such, the daily UCRM will tend to allocate water more precisely, but possibly less accurately, than would occur in reality.

For purposes of this Addendum, three different Shoshone water rights[3] operation scenarios were evaluated:

1. The "Baseline" model as provided by CWCB, representing the current conditions in the basin;
2. A "Zero Shoshone" scenario, which simply sets the Shoshone demand to zero; and
3. A "Max Shoshone" scenario, which assumes a Shoshone demand of 1,408 cubic feet per second (cfs) year-round, subject to reduction as discussed below.

In both the Baseline and Max Shoshone scenarios, the years 2003 and 2013 are simulated using the Public Service Company/Denver Water Relaxation Agreement demands for the Shoshone water rights. Thus, the "Max Shoshone" scenario is comparable to the "Max with Relaxation" scenarios from the September 11, 2024, Hydros memo. These three Shoshone scenarios are combined with two sets of basin-wide user demands, representing "Current Conditions" (i.e., users other than Shoshone unadjusted from the "Baseline"), and "Future Conditions," which approximate the increment of consumptive use allowed under the 15-Mile Reach Programmatic Biological Opinion (PBO).[4]

Impacts to Reclamation Projects and Associated Water Deliveries

Following release of the September 11, 2024, Hydros report which utilized the 2015 monthly UCRM, some water users expressed a desire for additional analyses of potential impacts, if any, the proposed "Shoshone Permanency" approach would have on Reclamation's project operations, including reservoir storage and water deliveries.

As stated in the WWG Memo, the Baseline model represents current demands, infrastructure, and administration, and "*can be used as the basis against which to compare a simulation that includes a new use or operation*." (WWG Memo, page 1). Given this intended use, and to address the questions raised with respect to impacts on other users, the Baseline model results were compared to a simulation of basin conditions under a "Max Shoshone" scenario in which a year-round demand of 1,408 cfs was assumed for the Shoshone Power Plant.

[3] Unless otherwise noted, the use of "Shoshone" when referring to operational scenarios and model results generally refers to the demands placed by, and exercise of, the Shoshone water rights.

[4] The PBO allows for 120,000 acre-feet of additional depletions in the Colorado River above its confluence with the Gunnison River. The updated UCRM Baseline demands are approximately 50,000 acre-feet more than the 2015 UCRM Baseline demand data. Thus, the Future Conditions demand dataset used in this Addendum targets an additional 70,000 acre-feet of demands. The depletions resulting from these demands increase by approximately 105,000 acre-feet on average due to shortages in some years.

In the Baseline scenario, Shoshone's water rights demands vary between 704 cfs and 1,408 cfs depending on the season, assumptions about outages at the Shoshone Power Plant, and implementation of call relaxation in 2003 and 2013. In order to assess the possibility that the impact of the Shoshone Call[5] might change in the future as basin-wide development increases, the daily UCRM under Baseline and Max Shoshone scenarios is simulated under both Current Conditions and Future Conditions for basin-wide demands. Since the objective of this analysis is to understand more about the impact and importance of the Shoshone Call, and not to assess the impacts of other development in the basin, comparisons here focus on differences between Baseline and Max Shoshone scenarios (as opposed to comparing the Max Shoshone scenario under Current and Future demand conditions).

Colorado – Big Thompson Project (C-BT) and Frying Pan – Arkansas (Fry-Ark) Storage

The Baseline and Max Shoshone scenarios produce almost identical results for storage in Granby Reservoir, Green Mountain Reservoir, and Ruedi Reservoir when minimum, average, or maximum storages are compared at a given level of basin-wide development. Table 1 presents a comparison of storage in units of thousands of acre-feet (KAF), where the largest difference resulting from Shoshone Max versus Baseline is the 0.1 KAF difference in average storage for Granby Reservoir. For reference, results for the "Zero Shoshone" scenarios are also presented in Table 1.

Table 1. C-BT and Fry-Ark Storage Comparison (units of KAF)

Scenario		Granby			Green Mountain			Ruedi		
		Min	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
Current Conditions	**Baseline**	74.4	332.8	539.7	48.6	95.9	154.6	52.0	83.6	102.4
	Max	74.4	332.8	539.7	48.6	95.9	154.6	52.0	83.6	102.4
	Zero	76.1	337.3	539.7	57.9	100.3	154.6	52.0	83.2	102.4
Future Conditions	**Baseline**	74.3	279.2	539.7	48.5	93.4	154.6	52.0	83.6	102.4
	Max	74.3	279.1	539.7	48.5	93.4	154.6	52.0	83.6	102.4
	Zero	73.6	282.4	539.7	57.6	97.4	154.6	52.0	83.1	102.4

There is no appreciable difference in simulated storages between the Baseline and Max Shoshone scenarios. There are differences, however, between those two scenarios and the Zero Shoshone scenario, which exhibits higher average storage levels for reservoirs upstream of the Shoshone Power Plant (Granby and Green Mountain Reservoirs), The

[5] For purposes of this Addendum and the September 11, 2024, memo, the "Shoshone Call" means the historical administration of the 1,408 cfs attributable to the junior and senior priorities under the Shoshone water rights.

decrease in average storage at Ruedi Reservoir without the Shoshone Call occurs because administration of the Shoshone Call tends to prevent calls from Grand Valley water users that would impact Ruedi Reservoir. The differences in minimum and average storage levels in Granby Reservoir and Green Mountain Reservoir are due to changes in the timing of drawdown and refill of those facilities under the different scenarios.

Reclamation and Other Major Trans-Mountain Diversions (TMDs)

C-BT (Adams Tunnel) and Fry-Ark Project (Boustead Tunnel) deliveries to the East Slope are largely unaffected by Shoshone's operations, when Baseline and Max Shoshone scenarios are compared to each other, similar to the impacts noted for project storage. There are also significant amounts of Colorado River water diverted for municipal and other uses for Front Range communities through the Homestake, Twin Lakes, Roberts, and Moffat Tunnels. None of these uses experience any appreciable reduction in their supplies between the Baseline and Max Shoshone scenarios as illustrated in Table 2:

Table 2. Major Trans-Mountain Diversions Average Annual Diversions (units of KAF)

Scenario		Adams Tunnel	Boustead Tunnel	Homestake Tunnel	Twin Lakes Tunnel	Moffat Tunnel	Roberts Tunnel
Current Conditions	**Baseline**	242.4	48.0	26.3	40.8	53.2	75.5
	Max	242.4	48.0	26.3	40.8	53.2	75.5
	Zero	242.7	47.8	26.7	40.7	53.5	75.5
Future Conditions	**Baseline**	254.4	48.0	28.7	40.8	60.2	96.6
	Max	254.4	48.0	28.7	40.8	60.2	96.6
	Zero	255.3	47.8	32.0	40.7	60.7	96.6

Grand Valley Project

Reclamation's Grand Valley Project delivers water to the Grand Valley Water Users Association (GVWUA), Orchard Mesa Irrigation District (OMID), and Vinelands Hydropower Plant (Vinelands). Diversions to these water users are unchanged when comparing the Baseline, Max Shoshone, and Zero Shoshone scenarios under both Current and Future Conditions (the maximum difference is 0.02%, less than one acre-foot). The Grand Valley Project water users do not see increased demands under Future Conditions, and their water rights are senior enough not to be impacted by changes to Shoshone operations.

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Recovery Program Storage

While the Shoshone demands are different between the Baseline and Max Shoshone scenarios, the outcome of the modeling is nearly identical under these two scenarios. These results are not unexpected, because physical water supply limits water availability for large periods of time when Shoshone is typically calling for water.[6] In many periods, especially during winter months, regardless of whether Shoshone is calling for 900 cfs, 1,250 cfs, or 1,408 cfs, there is often not enough water to fully satisfy the Shoshone Call.

The UCRM tracks the use of the various user pools in each reservoir, so evaluation of impacts to specific user accounts is possible. One group of reservoir accounts of particular interest in this analysis are the "fish pool" accounts for the Upper Colorado River Recovery Program that store water for subsequent release to benefit threatened and endangered fish in the 15-Mile Reach. To address the possibility that the Max Shoshone scenario might negatively impact the fish pool accounts, combined storage in the fish pool accounts was evaluated and compared to the Baseline scenario. *Figure 1* presents the combined storage in the fish pool accounts in Ruedi, Wolford Mountain, and Granby Reservoirs under Current Conditions demands. Although the time series are not identical for each reservoir, as evident during the lowest drawdowns in some years, the average storage differs by less than 10 acre-feet (less than 0.1%).

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[6] Previous versions of the UCRM utilized average monthly state-recorded *diversions, which are calculated using a constant turbine efficiency at the Shoshone Power Plant,* as the basis for Shoshone water rights' demands. This assumption underestimated Shoshone water rights' actual *demand* for water and artificially limited the power plant's ability to divert water for power production during times when the amount of water available for diversion exceeded the long-term average.

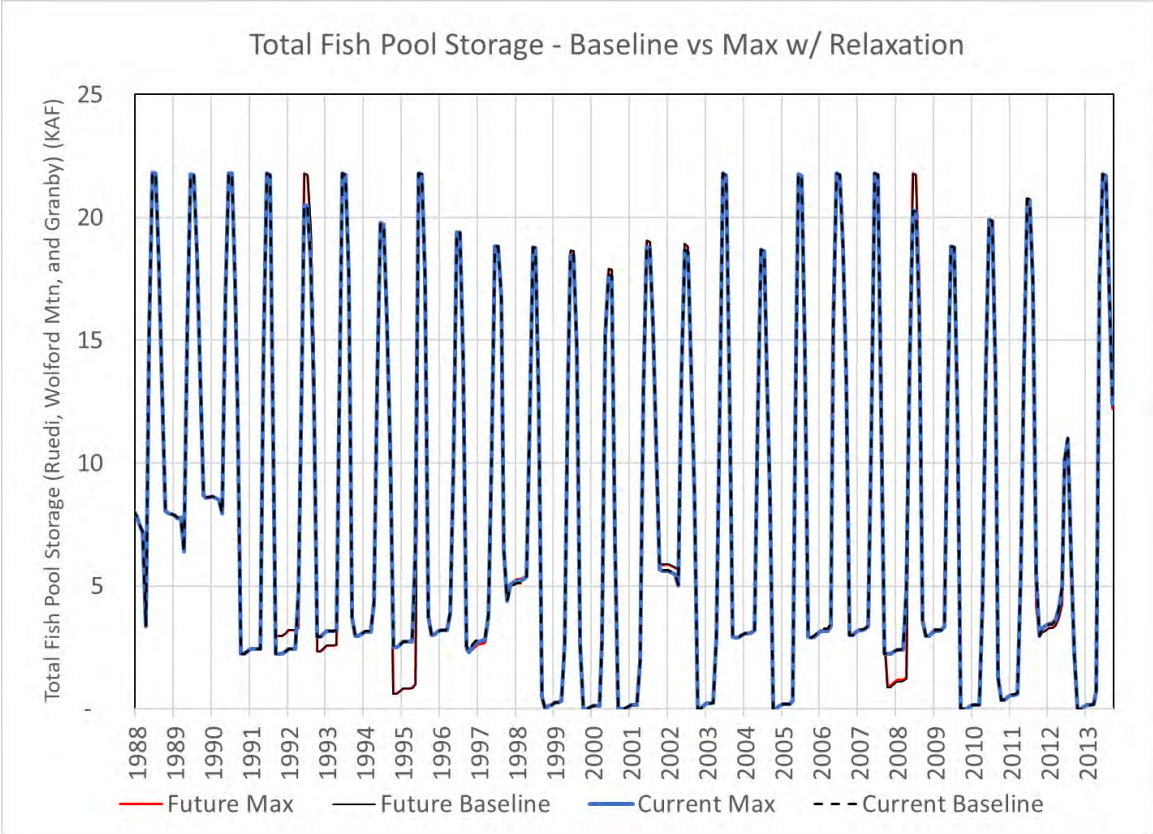


Figure 1. Total Fish Pool Storage - Baseline vs Max w/ Relaxation. The differences in minimum storage are so small as to be difficult to discern on this graph, except for some minimum storage values when Current and Future Conditions are compared.

Benefits to the 15-Mile Reach

Analysis of impacts to the 15-Mile Reach includes simulation of the Max Shoshone and Zero Shoshone scenarios under both Current Conditions and Future Conditions in the daily timestep version of the UCRM.

Summary: Results from this daily modeling analysis confirm the conclusions from the original Hydros yields assessment memo (September 11, 2024) using the monthly UCRM. Shoshone has a significant benefit to flows in the 15-Mile Reach, and the timing of that benefit is well aligned with the objectives of the Endangered Fish Recovery Program. The timing of the Shoshone call and the resulting benefits to the 15-Mile Reach are greatest during dry years, and in all years during the lowest flow months of August – October, when fish flow targets are most difficult to meet.

Based on outputs from the Baseline model, the Shoshone water rights are actively calling 62% - 64% of the time during the 1988-2013 period of simulation, under Current Conditions and Future Conditions, respectively. Absent the continued exercise and

administration of the Shoshone water rights, flows through the 15-Mile Reach would be reduced by an annual average of 24.2 KAF under Current Conditions and 26.9 KAF under Future Conditions.[7] Importantly, 68% - 76% of that flow reduction would occur during the critical low-flow months of August through October. These results are shown in Table 4,[8] which presents the expected annual and August-October benefits to the 15-Mile Reach due to Shoshone Permanency under both Current and Future Conditions. The maximum benefit to the 15-Mile reach in a single year is 41.9 KAF under Current Conditions and 56.0 KAF under Future Conditions. Maximum benefits to the 15-Mile Reach during August-October of a single year are 38.7 KAF and 33.8 KAF for Current and Future Conditions, respectively.

Table 4. Summary of Baseline Model Flow Benefit in the 15-Mile Reach attributable to ongoing exercise of the Shoshone water rights.

Basin-Wide Development	Average Annual Increase (KAF)	Average August-October Increase (KAF)	Increase occurring during August-October (% of Total Annual Increase)
Current Conditions	24.2	18.5	76%
Future Conditions	26.9	18.2	68%

Table 5 provides a breakdown of the benefits by year type for both Current and Future Conditions scenarios. The Shoshone water rights contribute a higher percentage of the total flow through the 15-Mile Reach during the period extending from August through October in dry years than in wet years, although the total volumes are similar. The average increase in daily flow attributable to continued exercise of the Shoshone water rights for Current and Future Conditions during August – October over the 1988-2013 period is approximately 100 cfs.

[7] The "available flow" data from the Shoshone node in the daily UCRM is used to identify the days in the simulation period during which Shoshone water rights are actively calling. If there is no "available flow" at that node, it means that the Shoshone water rights are calling out upstream juniors and/or forcing them to provide replacement water for any depletions. All comparative results presented for the 15-Mile Reach are evaluated during periods that Shoshone water rights are calling under the Baseline scenario.

[8] Results for the August-October summary statistics shown in Table 4 are for the calendar years 1988-2012. Using calendar years instead of water years allows continuity when computing results statistics over the August-October period. The difference in simulated annual average benefit between 1988-2013 water years and 1988-2012 calendar years is less than 1%. The model simulation ends in September 2013 (the end of the 2013 water year), so calendar year 2013 data are incomplete and not included in the annual summary results that include August-October, such as Table 4 and Table 5.

Table 5. Benefit of Shoshone Call on flows through the 15-Mile Reach by year type under the Baseline scenario. Both annual average and August-October average values are shown.

Hydrologic Condition	Current Conditions			Future Conditions		
	Average Annual Benefit (KAF)	Average August-October Benefit (KAF)	Aug-Oct Benefit (% of total flow in those months)	Average Annual Benefit (KAF)	Average August-October Benefit (KAF)	Aug-Oct Benefit (% of total flow in those months)
Dry	33.1	14.9	15%	36.8	15.0	17%
Average	22.6	20.0	12%	24.9	18.7	12%
Wet	18.3	19.6	7%	20.9	20.4	8%

Delaying the Cameo Call[9]

The September 11, 2024, Hydros memo compared monthly results to historical data from the CWCB's CDSS website and concluded that the utilization of the Shoshone water rights impacts the "Cameo Call" by delaying the administration of junior rights to satisfy that call. Results from the daily timestep version of the UCRM confirm this finding.

In the Baseline scenario with Current Conditions, the Cameo Call is on for 1,041 days during the 1988-2013 simulation period. In comparison, the Cameo Call is on for 1,340 days in the Zero Shoshone scenario, a 29% increase in calling days over the Baseline scenario. The Future Conditions results also show a 29% increase in calling days, from 1,108 to 1,429, resulting from the removal of the Shoshone call. Minimizing the frequency of the Cameo Call is significant for the 15-Mile Reach. Every day that Cameo is not calling indicates that there is flow in the river in excess of the Cameo diverters' needs, and that water will flow past those diverters and into the 15-Mile Reach.

Monthly Results

In the September 11, 2024, Hydros memo, Appendix B discusses monthly distributions of yield, and changes in frequency of flows meeting PBO-recommendations. The qualitative results from that analysis are generally unchanged when similar evaluations are carried out with 2024 UCRM results. Figure 2 presents the average increase in flows by month for periods when the Shoshone water rights are actively calling. These results are consistent with the monthly pattern of benefits seen in the 2015 UCRM results, with

[9] "Cameo Call" is a generic term that describes an administrative call for water placed by either the Grand Valley Project's Government Highline Canal or the Grand Valley Canal, both of which are directly upstream of the 15-Mile Reach and both of which have relatively senior water rights in the basin (although the most senior Cameo water rights are junior to Shoshone's senior water right).

the most significant benefits in the early spring and late summer months. While the magnitude of yields in May and June for the 2024 UCRM is larger than the similar results from the 2015 UCRM, the frequency of yields (i.e., number of days of benefits) in those months is lower.

Another important monthly result that is similar to the 2024 UCRM's daily results is the expected reduction in flows during September under the Zero Shoshone scenario that meet PBO-recommendations (a minimum flow of 810 cfs). Figure 3 presents the comparison of days within the recommended flow range in September across Current Conditions and Future Conditions for the Baseline Shoshone scenario versus the Zero Shoshone scenario. There is a greater decrease in flows meeting the 15-Mile Reach PBO targets under the 2024 UCRM compared to the 2015 UCRM, when comparing the Zero Shoshone scenario to the Baseline, which is likely the result of the 2024 UCRM's ability to evaluate flows on a daily basis.

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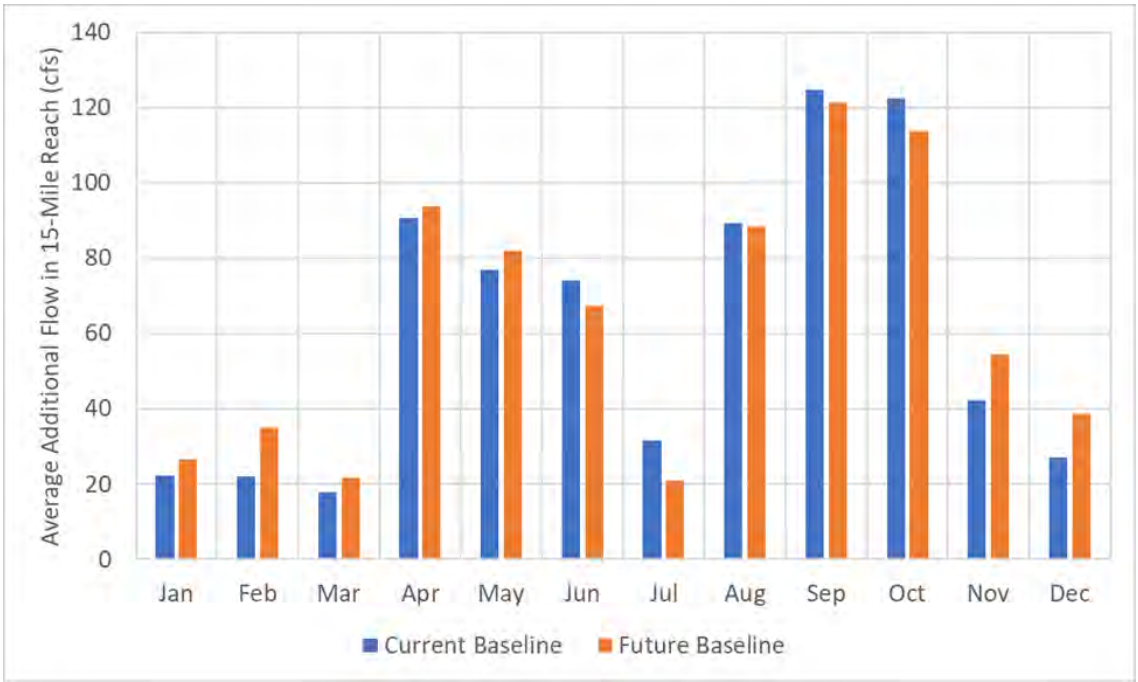


Figure 2. Monthly Distribution of 15Mile Reach Yield - 2024 UCRM

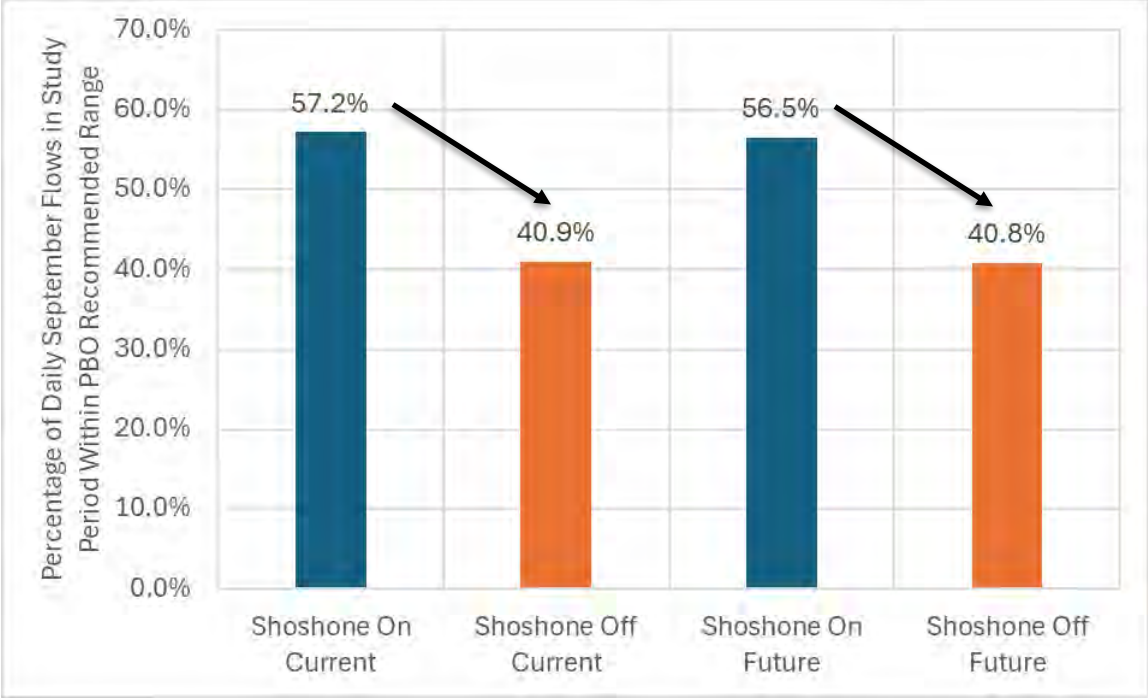


Figure 3. Decrease in Frequency in September Flows within PBO-Recommended Range without Shoshone Permanency

15-Mile Reach Discussion

Benefits to the 15-Mile Reach occur more uniformly across the different year types in the daily UCRM compared to the results from the monthly 2015 version of the UCRM, but still show the greatest benefit during dry (i.e., drought) years.

As expected, and consistent with the results presented in the September 11, 2024, memo, the benefit of Shoshone Permanency to the 15-Mile Reach is magnified when evaluating the Future Conditions scenarios. Results from those scenarios further illustrate the benefit that the Shoshone water rights have in limiting the impact of future growth in consumptive uses on flows through the 15-Mile Reach. As was noted in the original September 11, 2024, Hydros memo, and confirmed again here, the greatest benefit to the 15-Mile Reach, as a percentage of flow attributable to the Shoshone Call, is seen during the driest years and during the low-flow months of August, September, and October.

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Conclusions

This Addendum presents analyses using the recently released daily timestep version of the CWCB's 2024 UCRM. This Addendum addresses specific questions raised by interested parties regarding potential impacts to existing projects and to flows in the 15-Mile Reach, which are critical to the success of the Upper Colorado River Endangered Fish Recovery Program. The Addendum also provides a point of comparison between the results presented previously, as shown in Table 5, which presents annual and dry year yields across various versions of the model that have been used to assess yield.

Table 5. Comparison of benefits of continued exercise of the Shoshone water rights on flows through the 15-Mile Reach across model versions and scenarios.

Model + Scenario	**Annual Benefit, All Years (KAF)**	**Annual Benefit, Dry Years (KAF)**
2015 Monthly Model ***Max w/ Relaxation - Current***	14.0	30.4
2024 Daily Model ***Max w/ Relaxation - Current***	24.0	32.8
2015 Monthly Model ***Max w/ Relaxation - Future***	25.5	38.6
2024 Daily Model ***Max w/ Relaxation - Future***	26.8	36.6
2024 Daily Model ***Baseline - Current***	24.2	33.1
2024 Daily Model ***Baseline - Future***	26.9	36.8

The results presented in this Addendum reaffirm the benefit of the Shoshone Call under both Baseline and Max Shoshone scenarios, particularly during dry years, in keeping additional water in the 15-Mile Reach when compared to river conditions absent utilization of the Shoshone water rights. Results indicate that full use of the Shoshone water rights does not negatively impact Reclamation projects when compared to the Baseline scenario, nor does it impact the water users that benefit from and/or provide water in support of those federal projects. Also notable is the similarity between the Baseline and Max with Relaxation results for the 2024 daily UCRM, which further validates the use of the Max with Relaxation scenario yields in the original analysis.

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COLORADO RIVER DISTRICT

PROTECTING WESTERN COLORADO WATER SINCE 1937

MEMORANDUM

TO: PETER C. FLEMING, GENERAL COUNSEL
JASON TURNER, DEPUTY GENERAL COUNSEL
BRUCE WALTERS, ASSOCIATE COUNSEL

FROM: RAQUEL FLINKER, SENIOR WATER RESOURCES ENGINEER/ PROJECT MANAGER
BRENDON LANGENHUIZEN, DIRECTOR OF TECHNICAL ADVOCACY

SUBJECT: SHOSHONE WATER RIGHTS ANALYSIS ON DECREED INSTREAM FLOW REACHES IN THE COLORADO RIVER WATERSHED

DATE: APRIL 30, 2025

The Shoshone Hydroelectric Power Plant (the "Shoshone Power Plant") has two of the largest and most senior non-consumptive-use water rights on the mainstem of the Upper Colorado River. These water rights include the 1905 senior Shoshone Water Right in the amount of 1,250 cubic feet per second ("cfs") and the 1940 junior Shoshone Water Right in the amount of 158 cfs (together, the "Shoshone Water Rights"). The exercise of the Shoshone Water Rights results in an influential "pull" of water down the mainstem of the Colorado River, including through several significant tributaries, which helps to maintain flows both upstream and downstream of the Shoshone Power Plant. To satisfy an administrative call placed under the Shoshone Water Rights, upstream junior water rights are curtailed or are required to provide replacement releases from upstream reservoirs.

The State of Colorado has approximately 350 decreed instream flow ("ISF(s)") water rights on the Colorado River upstream of the Shoshone Power Plant (*see* Figure 1), and over 120 ISF water rights located downstream of the Shoshone Power Plant, including those on tributaries to the Colorado River. River District staff carried out the following analysis to evaluate the benefits that the exercise and administration of the Shoshone Water Rights have on these existing decreed ISF reaches. Representative ISFs located upstream and downstream of the Shoshone Power Plant were selected to better understand how the Shoshone Permanency Project is expected to help protect the identified ISFs. The selected ISFs reviewed in this memorandum that are located upstream of the Shoshone Power Plant include one of the three ISF water rights within the Upper Colorado River Wild and Scenic eligible reaches and one on the mainstem of the Eagle River. The selected ISFs located downstream of the Shoshone Power Plant include two ISFs on the Roaring Fork River. The ISFs studied herein include major and minor tributaries as well as the mainstem Colorado River and were selected to be representative of the range of influence of the Shoshone Call across

the basin. Overall, the exercise of the Shoshone Water Rights has been found to support upstream ISF reaches in meeting target flows, especially in dry years and in critical months during the late irrigation season, while having minimal impact on tributaries downstream of the Shoshone Power Plant, including on the Roaring Fork River.

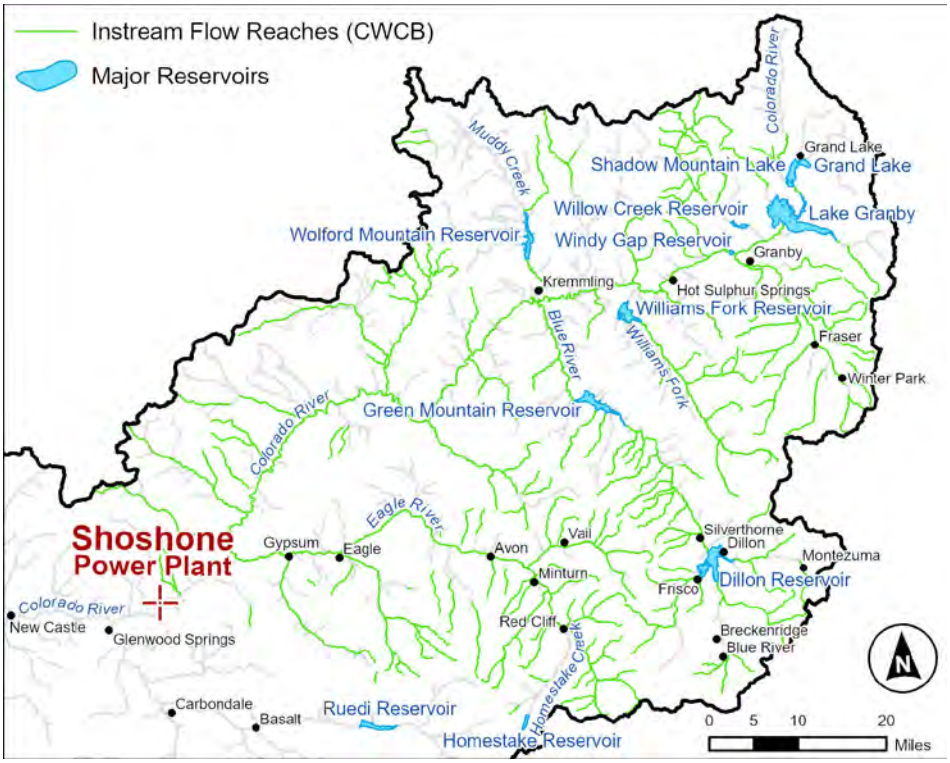


Figure 1 – ISF reaches upstream of the Shoshone Power Plant

The analysis described herein is based on modeled daily average flows from January 1988 to September 2013 at specific locations using the State of Colorado's StateMod 2024 Upper Colorado River Basin Model (the "2024 UCRM"). These average daily flows were modeled by Hydros Consulting, Inc. ("Hydros")[1] in four scenarios: 1) "Shoshone On Current" – Shoshone baseline demands with current basin water demands, [2] 2) "Shoshone Off Current" – Shoshone Water Rights are not active with current basin water demands,[3] 3) "Shoshone On Future" – Shoshone baseline demands with projected future basin water demands,[4] and 4) "Shoshone Off Future" – Shoshone Water Rights are not active with projected future basin water demands.[5] In the first and third

[1]Additional outputs were developed from Hydros' modeling efforts as described in their November 7, 2024, "Shoshone Power Plant Water Rights Yield Assessment – Addendum" and were provided to the Colorado River District in two documents named "CurrentConditions_GageFlows_updated.xlsx" and "FutureConditions_GageFlows_updated.xlsx".

[2] This is equivalent to the "Baseline" current conditions Hydros scenario.

[3] This is equivalent to the "Zero Shoshone" current conditions Hydros scenario.

[4] This is equivalent to the "Baseline" future conditions Hydros scenario. The future water demand scenarios assumed 120,000 acre-feet ("AF") of development including 85,000 AF of transmountain diversions.

[5] This is equivalent to the "Zero Shoshone" future conditions Hydros scenario.

scenarios, when the Shoshone Water Rights are active, the Shoshone baseline demands were developed by the Colorado Water Conservation Board ("CWCB") in the published 2024 UCRM as a "Baseline" scenario to simulate current operations. These demands fluctuate based on daily historical records with demands ranging from 704 cfs (one turbine use as contemplated under the Agreement Concerning Reduction of Shoshone Call effective January 1, 2007 [the "2007 Call Relaxation Agreement"]) to 1,408 cfs.[6] As noted in the Hydros November 2024 *Shoshone Power Plant Water Rights Yield Assessment – Addendum* memorandum, it is important to highlight that the 2024 UCRM has not undergone a formal vetting process, and the outputs are likely less accurate than what would occur under real-time conditions.

The first part of the analysis evaluated the impact of the Shoshone Water Rights on average flows within the identified ISF reaches (such as an increase or decrease in cfs), while the second part of the analysis assessed the impact in meeting the ISFs at each location (number of days the ISF is met). This analysis was done for the current demand comparison (i.e., "Shoshone Off Current" scenario minus "Shoshone On Current" scenario) and the future demand comparison (i.e., "Shoshone Off Future" scenario minus "Shoshone On Future" scenario). It is important to note that the initial part of the analysis focused on average flows over the modeled period to represent the impacts of the Shoshone Water Rights: however, modeled daily flows vary significantly from these averages.

The analysis was limited to days when the Shoshone Water Rights were calling and therefore having an impact on river flows. Thus, the analysis excluded periods such as peak runoff when flows naturally remain above the 1,408 cfs demand of the Shoshone Water Rights. As seen in Figure 2, the Shoshone Call[7] is on more frequently in dry years and during the months of August, September, and October when natural river flows are low. Interestingly, in dry years, the Shoshone Call is on for nearly the entirety of every month from August through December. Therefore, this analysis focused on the dry calendar years of 1989, 1990, 2001, 2002, 2003, 2004, 2012, and 2013,[8] and particularly in the months of August, September, and October during those years, when flows are important to meet minimum ISFs. There is a total of 2,156 dry-year days when the Shoshone Water Rights are calling in the current scenarios and 2,189 days in the future scenarios.

[6] This is equivalent to the "Baseline" scenario in the November 2024 Shoshone Power Plant Water Rights Yield Assessment - Addendum memorandum prepared by Hydros. The scenarios where the Shoshone Call is off are referred to as "Zero Shoshone".

[7] For purposes of the analyses set forth in this memorandum, and unless otherwise defined or limited herein, the "Shoshone Call" means the in-priority demand for administration of water available under the senior and junior priorities for the Shoshone Water Rights (i.e., 1,408 cfs).

[8] The dry calendar year classification is the same as what was utilized by Hydros Consulting Inc. in their November 7, 2024, "Shoshone Power Plant Water Rights Yield Assessment – Addendum".

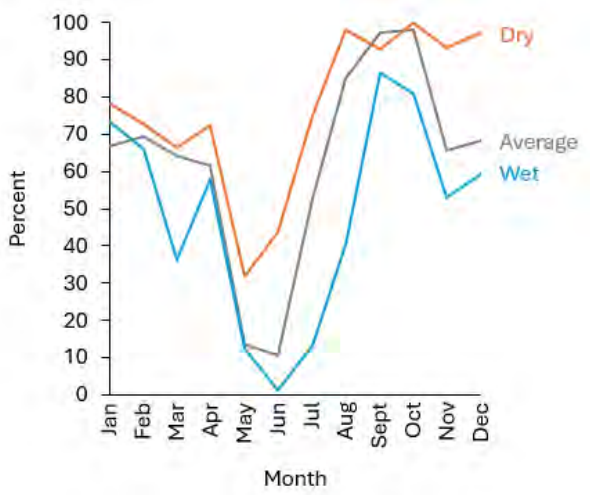


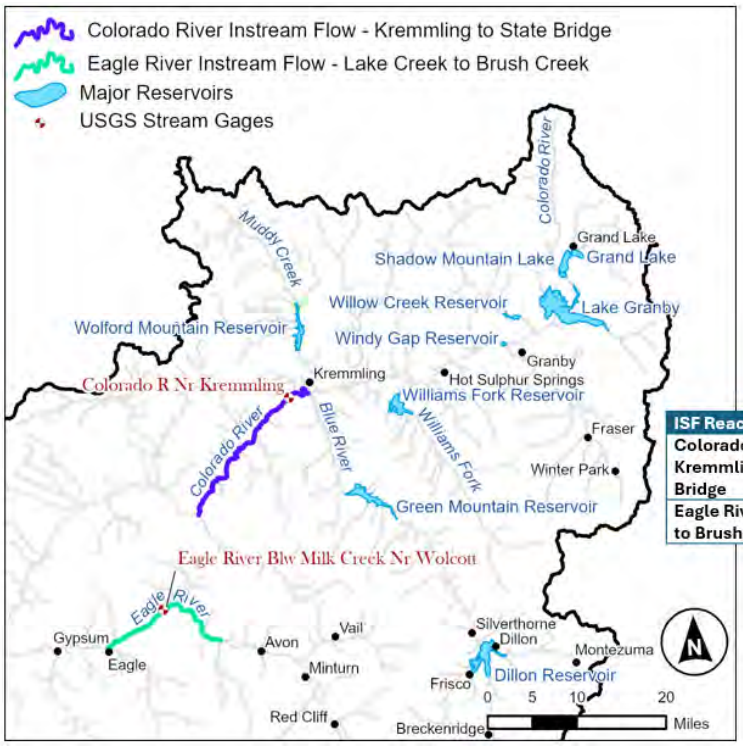
Figure 2 – Percent of modeled days per month when the Shoshone Call was on during dry, average, and wet years under current water demands (January 1988 through September 2013).

ISF Reaches Upstream of the Shoshone Power Plant

The following ISF reaches (Table 1) upstream of the Shoshone Power Plant were selected to better understand the benefits of the Shoshone Water Rights in protecting existing ISF flows. Flows were analyzed at the locations within the ISF reaches identified in Figure 3, below.

Table 1 – Analyzed ISF Reaches Upstream of the Shoshone Power Plant

ISF Reaches	ISF (CFS)	Start Date	End Date	Miles	Appropriation Date	Case Number
Colorado River – Kremmling to State Bridge	500	16-Sep	14-May	23.74	7/12/2011	5-11CW159
	600	15-May	31-Jul			
	750	1-Aug	15-Sep			
Eagle River – Lake Creek to Brush Creek	45	1-Oct	30-Apr	17.64	3/17/1980	5-80CW126
	110	1-May	30-Sep			



ISF Reach	Gage Name	USGS Gage ID
Colorado River – Kremmling to State Bridge	Colorado River at Kremmling	9058000
Eagle River – Lake Creek to Brush Creek	Eagle River near Wolcott	394220106431500

Figure 3 – Upstream ISF Reaches and the Associated USGS Gage Analyzed

Colorado River – Kremmling to State Bridge

The Colorado River – Kremmling to State Bridge ISF reach is located within the Upper Colorado River Wild and Scenic eligible sections. It is one of three ISF appropriations that were pursued as long-term protection measures of the Outstandingly Remarkable Values ("ORVs"). The Amended and Restated Upper Colorado River Wild & Scenic Stakeholder Group Management Plan (the "Management Plant")[9] lists the continuation of the Shoshone Water Rights as a long-term protection measure of the streamflow-influenced ORVs. The Management Plan states that the administration of the Shoshone Call generally results in higher streamflow through the upper Colorado River stream segments.

Several major reservoirs and transmountain diversion projects are located upstream of the Colorado River – Kremmling to State Bridge ISF reach, including but not limited to: the Colorado Big-Thompson Project (Adams Tunnel, Granby Reservoir, Willow Creek Reservoir, Green Mountain Reservoir); the Windy Gap Project (Windy Gap Reservoir and Pumps); the Moffat Collection System, Williams Fork Reservoir, Blue River Project (Dillon Reservoir, Roberts Tunnel); the Continental-Hoosier Project; and Wolford Mountain Reservoir. All of these reservoirs and transmountain diversion projects are junior in priority to the senior Shoshone Water Right and are subject to either curtailment or replacement (releases of water stored in reservoirs to allow continued out-of-priority diversions) to satisfy the senior Shoshone Call. Therefore, if the senior

[9] *See* Amended and Restated Upper Colorado River Wild & Scenic Stakeholder Group Management Plan, https://www.upcowildandscenic.com/uploads/1/3/5/3/135388668/amended_and_restated_sg_plan_july_2024.pdf

Shoshone Water Right was no longer exercised, lower flows would be expected throughout this ISF reach as the normal curtailment or replacement releases from reservoirs would be reduced.

Average flows in the Colorado River – Kremmling to State Bridge ISF reach (*see* Figure 4), analyzed at the Colorado River at Kremmling Gage (USGS gage ID 9058000), would be impacted the most in the Dry Years, Aug-Oct when flows would be reduced by 11% or 80 cfs if the Shoshone Water Rights were not exercised in both the current and future demand comparisons. This is equivalent to a reduction in the average flow volume of approximately 4,550 AF/month.

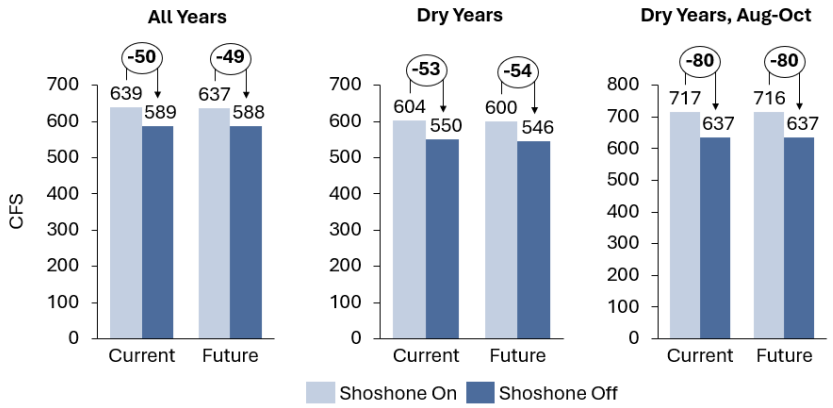


Figure 4 – Average flows at the Colorado River at Kremmling Gage

The reduction in flow in the absence of a Shoshone Call would also translate to fewer days when the ISF is met (*see* Figure 5). The impact to the ISF is highlighted during the Dry Years, Aug-Oct months, when the days the ISF is met are reduced by 31% in both the current and future demand comparisons.

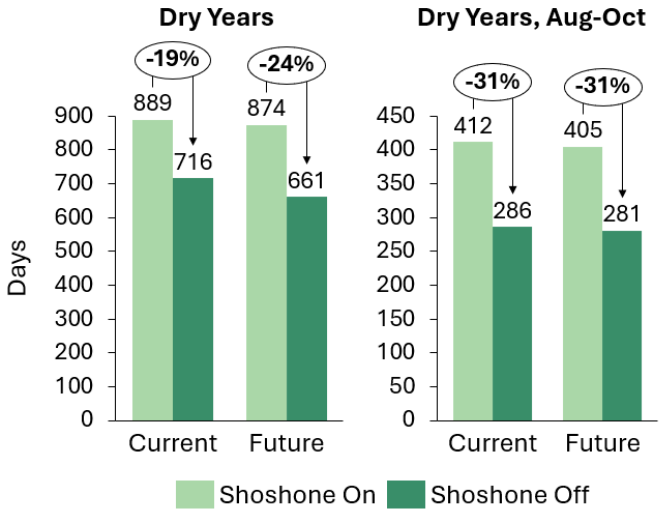


Figure 5 – Minimum ISF exceedance days at the Colorado River at Kremmling Gage

Eagle River – Lake Creek to Brush Creek

As described earlier, the exercise and administration of the Shoshone Water Rights results in an influential "pull" of water down the Colorado River, including through significant tributaries. The Eagle River is one such tributary and it has seven decreed ISFs that span nearly 50 miles. Average flows in this reach (*see* Figure 6), analyzed at the Eagle River near Wolcott Gage (USGS gage ID 394220106431500), would see the most significant average impacts if the Shoshone Water Rights were not exercised in Dry Years where flows would be reduced by 6 to 7 cfs (4% to 5% of the average annual flow) depending on the water demand. This is equivalent to an average reduction in flow volume of approximately 160 AF/month under both the current and future demand comparisons.

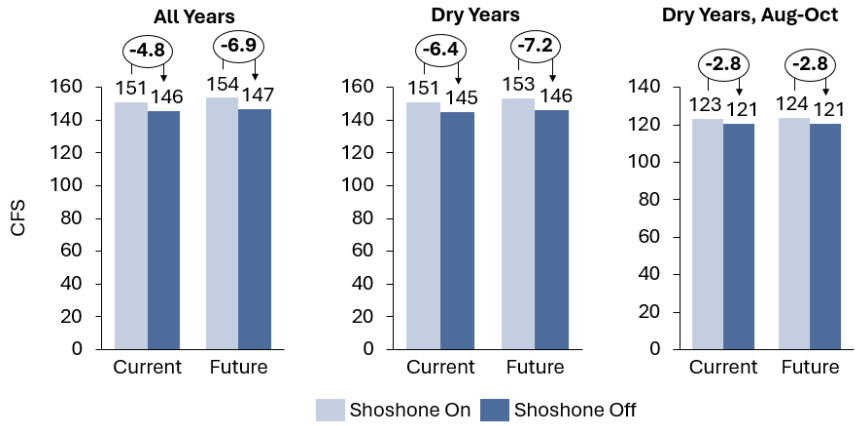


Figure 6 – Average flows at the Eagle River near Wolcott Gage

The reduction in flows from the absence of the Shoshone Call would not significantly impact the number of days the ISF is met and equates to a reduction of three days across the full eight years included in the Dry Years (*see* Figure 7). The ISF at this location is relatively small compared to measured flows. This is illustrated by the fact that in Dry Years, the ISF is met 88% of the time in the current and future demand scenarios.

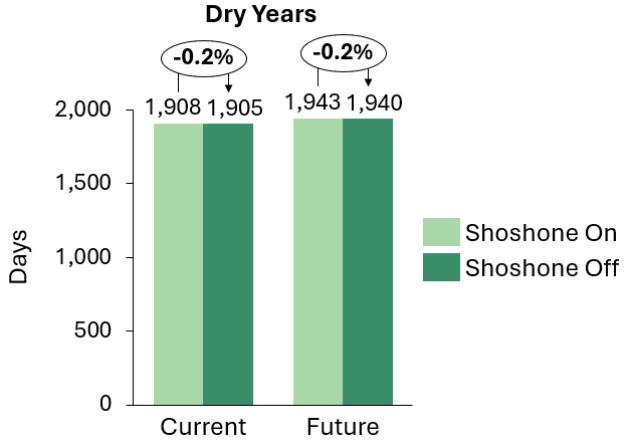


Figure 7 – Minimum ISF exceedance days at the Eagle River near Wolcott Gage

Summary of Upstream ISF Findings

Both upstream ISF reaches evaluated above experienced reduced flows when the Shoshone Water Rights were not exercised. The Colorado River from Kremmling to State Bridge reach saw losses of approximately 80 cfs in August through October in Dry Years, equating to a reduction in days that met the ISF by approximately 31% under current and future demand comparisons. On the Eagle River near Wolcott, the ISF was most impacted across Dry Years with reduced average flows of 6.4 and 7.2 cfs under current and future demand comparisons, respectively. Both reaches see significant responses to the loss of a Shoshone Call as shown in Figure 8 where each reach is shown to have a greater than 75% response in number of days with a realized reduced flow during the Dry Years, Aug-Oct months under current demands.

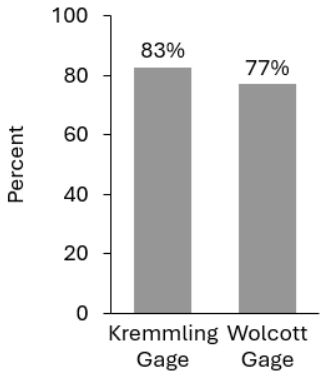


Figure 8 – Percent of August – October Dry Year days when flows are lower if the Shoshone Water Rights are not exercised, under current water demands

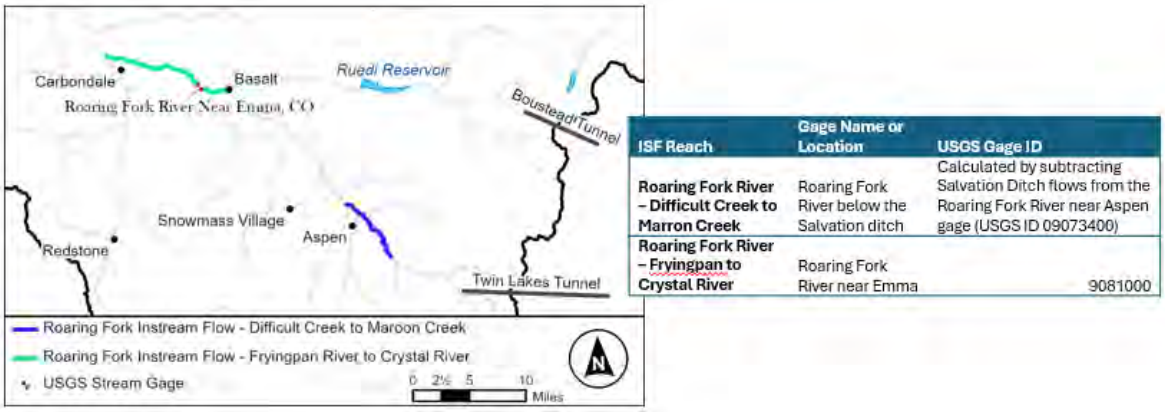
ISF Reaches Downstream of the Shoshone Power Plant – Roaring Fork River

This analysis also considered the impact (or lack thereof) that the absence of a Shoshone Call might have on the Roaring Fork River watershed. The absence of a Shoshone Call could cause the downstream "Cameo Call,"[10] to come on earlier and more often, thereby causing earlier administration of tributaries above Cameo including the Roaring Fork watershed. The increased Cameo Call would prompt curtailing transmountain diversions typically only subject to the Cameo Call such as relatively junior water rights including the Fry-Ark Project (Ruedi Reservoir and Boustead Tunnel) and occasionally even relatively senior rights like the Independence Pass Transmountain Diversion System ("Twin Lakes Tunnel"), as well as other West Slope water rights. To evaluate the impact of this occurrence, River District staff carried out a similar ISF analysis on two ISF reaches in the Roaring Fork watershed as detailed in Table 2 and shown in Figure 9.

[10] A conglomerate of significant and senior irrigation rights which divert from the Colorado River in the Grand Valley near Palisade, Colorado.

Table 2 – Analyzed ISF Reaches in the Roaring Fork River Watershed

ISF Reaches	ISF (CFS)	Start Date	End Date	Miles	Appropriation Date	Case Number
Roaring Fork River – Difficult Creek to Maroon Creek	32	1-Jan	31-Jul	8.67	1/14/1976	5-76W2948
Roaring Fork River – Frying Pan to Crystal River	75	1-Oct	31-Mar	13.46	11/8/1985	5-85CW639
	145	1-Apr	30-sept			



ISF Reach	Gage Name or Location	USGS Gage ID
Roaring Fork River – Difficult Creek to Marron Creek	Roaring Fork River below the Salvation ditch	Calculated by subtracting Salvation Ditch flows from the Roaring Fork River near Aspen gage (USGS ID 09073400)
Roaring Fork River – Fryingpan to Crystal River	Roaring Fork River near Emma	9081000

Figure 9 – Roaring Fork Watershed ISF Reaches, and the Associated USGS Gages/Locations Analyzed

Roaring Fork River – Difficult Creek to Maroon Creek

The Roaring Fork River – Difficult Creek to Maroon Creek ISF reach was selected because it is located on the Roaring Fork River immediately below the Salvation Ditch (WDID 3800981), where flows are frequently below the minimum ISF. At this location, if the Shoshone Water Rights were no longer exercised, average flows would increase slightly. During the Dry Years, Aug-Oct months, this increase would be the most impactful but would still be limited to approximately 0.5 cfs or 1% of total flow (*see* Figure 10) in both the current and future demand comparisons. This is equivalent to an average increase in flow volume of approximately 25 AF/month under both comparisons. It is important to highlight that during Dry Years, Aug-Oct months, most days (92%) would have the same flow regardless of whether the Shoshone Water Rights were calling. Interestingly, there would also be times when flows in the ISF would decrease if the Shoshone Water Rights were not exercised.

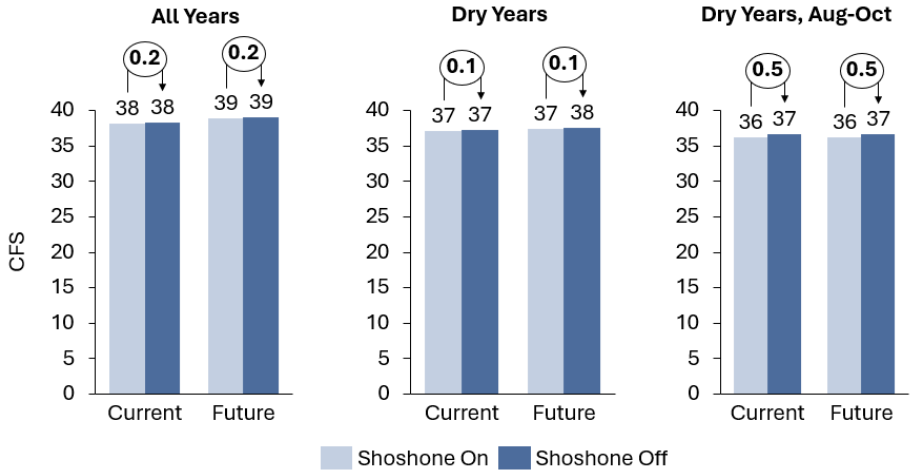


Figure 10 – Average flows at the Roaring Fork River below the Salvation Ditch location

The slight flow increases that are observed if the Shoshone Water Rights were not calling would only lead to an addition of 7 days (current demand comparison) and 6 days (future demand comparison) when the ISF is met across the eight years included in Dry Years, Aug-Oct months (*see* Figure 11). This is equivalent to an increase of approximately 1.5-1.7% of days when the ISF is met. Therefore, if the Shoshone Water Rights were no longer exercised, this reach would see, on average, a slight flow increase during a limited number of days, with only a few additional days when the ISF is met. This is because the Twin Lakes Tunnel is relatively senior in the system and would seldom be impacted by a Cameo Call beyond the administration already in place by the Cameo Call. Importantly, while the complete absence (e.g., future abandonment) of the Shoshone Water Rights could result in a small, modeled increase of 0.5 cfs of flow in the Upper Roaring Fork River, the maintenance of the historical Shoshone Call regime would not result in any change from existing conditions.

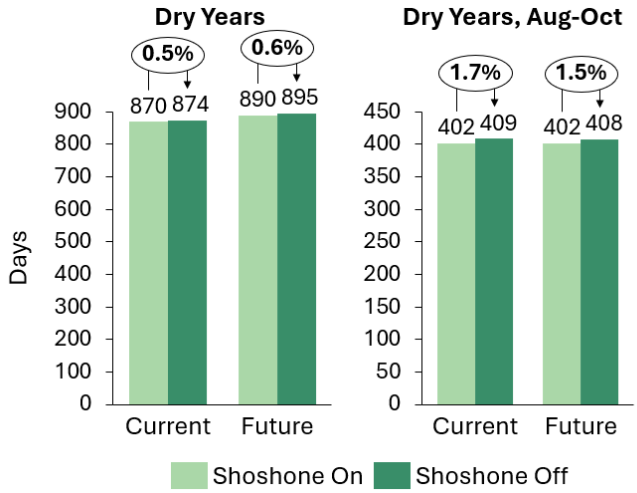


Figure 11 – Minimum ISF exceedance days at the Roaring Fork River below the Salvation Ditch

Roaring Fork River – Fryingpan River to Crystal River

The Roaring Fork River – Fryingpan River to Crystal River ISF reach was selected to capture impacts on the Roaring Fork River from the Fryingpan River where the Fry-Ark Project is mostly located. At this location, if the Shoshone Water Rights were no longer exercised, flows would increase on average by less than 1% (3 cfs) in Dry Years under both the current and future demand comparisons (*see* Figure 12). This is equivalent to an increase in average flow volume of approximately 80 AF/month across Dry Years in the current and future demand comparisons. Although the average flows would slightly increase in Dry Years with the Shoshone Call offline, only 27% of the days were shown to have higher flows in the current demand comparison and 25% in the future demand comparison. Most days (approximately 67% in both comparisons) realized lower flows when the Shoshone Water Rights were not calling.

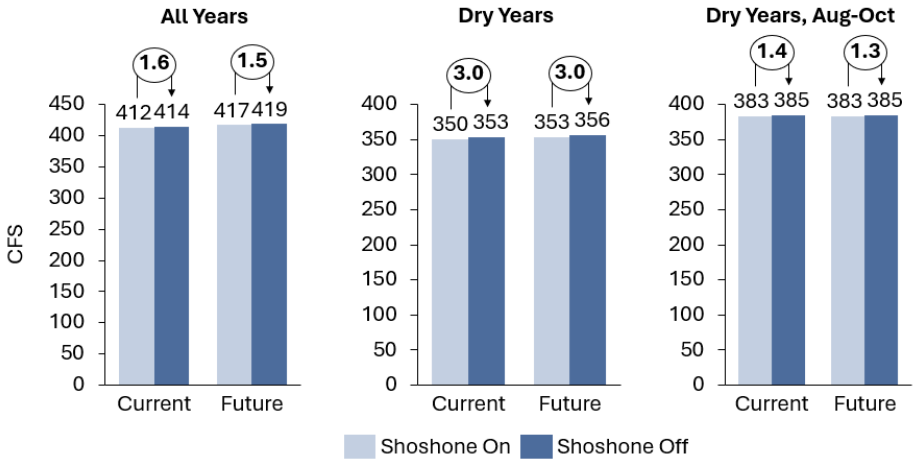


Figure 12 – Average flows at the Roaring Fork River near Emma gage

The average flow increases from the removal of the Shoshone Call would have no impact on the days the ISF is met as seen in Figure 13. The ISF at this location is relatively small compared to typical flows such that the ISF has never been the source of an administrative call on the river. This is illustrated by the fact that in Dry Years, the ISF is modeled to be met 99% of the time in the current and future scenarios.

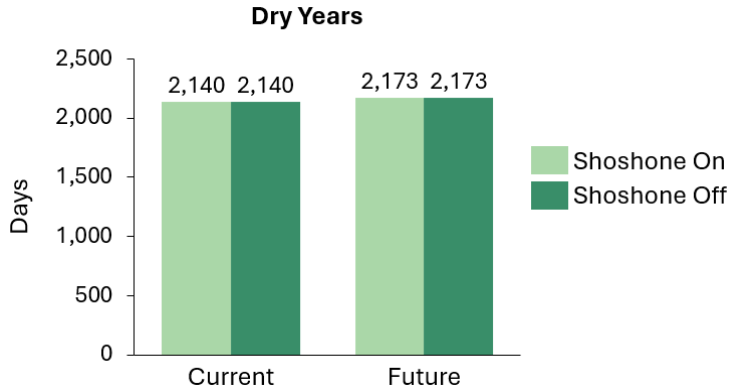


Figure 13 – Minimum ISF exceedance days at the Roaring Fork River near Emma gage

Therefore, while there would be a small increase in flow in the Roaring Fork Watershed if the Shoshone Water Rights were no longer exercised, the increases would be minor. In fact, at the Roaring Fork River - Fryingpan to Crystal River ISF reach, most dry days would see a decrease in river flows.

ISF Reaches Downstream of the Shoshone Power Plant –15-Mile Reach

The benefits of maintaining the Shoshone Water Rights are documented in the November 7, 2024, "Shoshone Power Plant Water Rights Yield Assessment – Addendum" memorandum prepared by Hydros.

Downstream ISF Summary Findings

Without the Shoshone Call, tributaries such as the Roaring Fork River are modeled to see increased impacts from the Cameo Call, which are shown to have variable effects. In the upper reach of the Roaring Fork River, below the Salvation Ditch, flows were shown to have limited increases in flow of less than 0.5 cfs which leads to 6 to 7 additional days of meeting the ISF in Dry Years, Aug-Oct. Similar results were found along the Roaring Fork in the Fryingpan to Crystal River ISF reach with limited increases in flow of up to 3 cfs (less than 1% of total flow) with no associated increase in number of days the ISF is met. Modeling at both sites found variable results with some results finding reduced flows without the Shoshone Call on.

Conclusion

Four separate ISF reaches were evaluated in this memorandum to determine whether and how the Shoshone Call influences hydrology through the selected ISF reaches and how that impacts the number of days each ISF is met. The ISF reaches studied herein include tributaries as well as the mainstem Colorado River and are representative of the range of influence of the Shoshone Call across the basin. Both ISF reaches studied above the Shoshone Reach show average decreases in flow with the Shoshone Call offline, particularly in Dry Years and the late irrigation season months of August through October of Dry Years. For example, average monthly decreases in flows at the Colorado River below Kremmling were shown to be as much as 80 cfs or approximately 11% of the flow, corresponding to an average elimination of approximately 4,550 AF/month in the absence of the Shoshone Call. Findings at Eagle River had similar results, although with relatively smaller flow impacts.

Downstream ISF reaches evaluated focused on the Roaring Fork River at two locations: (1) a segment located near the headwaters below the Salvation Ditch, which runs through the City of Aspen, and (2) a segment located between the Fryingpan River and Crystal River confluence. Findings at these locations showed average increases in flows without the Shoshone Call due to the increased downstream Cameo Call. The analysis found that the Upper Roaring Fork River flows increased up to an average of 0.5 cfs (25 AF/month) and up to an average of 3.0 cfs (80 AF/month) at the Lower Roaring Fork River reach in the August-October months of Dry Years. Only the Upper Roaring Fork River ISF reach experienced additional days of meeting the ISF due to the increase in flows and that was limited to a handful of days across the August through October months of the eight Dry Years evaluated. Much larger and more consistent impacts downstream

of the Shoshone Power Plant through the 15-Mile Reach ISF were examined in the technical report prepared by Hydros.

Overall, the Shoshone Call has been found to support both upstream ISF reaches in meeting the target flows, especially in dry years and in critical months during the late irrigation season while having minimal influence on tributaries downstream of the Shoshone Power Plant such as on the Roaring Fork River.

DISTRICT COURT, WATER DIVISION 5, COLORADO Garfield County Courthouse 109 8th Street, Suite 104 Glenwood Springs, CO 81601 (970) 947-3861	
CONCERNING THE APPLICATION FOR WATER RIGHTS OF THE COLORADO WATER CONSERVATION BOARD, PUBLIC SERVICE COMPANY OF COLORADO, and THE COLORADO RIVER WATER CONSERVATION DISTRICT. In GARFIELD AND EAGLE COUNTIES, COLORADO.	▲ COURT USE ONLY ▲
Attorney for Colorado Water Conservation Board: PHILIP J. WEISER, Attorney General JENNIFER L. MELE, Reg. No. 30720* Natural Resources and Environment Section Colorado Department of Law 1300 Broadway, 10th Floor Denver, Colorado 80203 Phone: (720) 508-6282 Email: jennifer.mele@coag.gov *Attorneys for Public Service Company of Colorado:* Carolyn F. Burr, Reg. No. 25978 Jim M. Noble, Reg. No. 36716 WELBORN SULLIVAN MECK & TOOLEY, P.C. 1401 Lawrence Street, Suite 1800, Denver, Colorado 80202 Phone: (303) 830-2500 E-mail: cburr@wsmtlaw.com jnoble@wsmtlaw.com *Attorneys for Colorado River Water Conservation District*: Names: Peter C. Fleming, Reg. No. 20805 Jason V. Turner, Reg. No. 35665 Bruce C. Walters, Reg. No. 50235 Address: 201 Centennial Street, Suite 200 Glenwood Springs, CO 81601 Phone: (970) 945-8522 E-mail: pfleming@crwcd.org jturner@crwcd.org bwalters@crwcd.org	Case Number: Div.: Ctrm:
APPLICATION FOR CHANGE OF WATER RIGHTS	

PRELIMINARY DRAFT

1. Names, mailing addresses, e-mail addresses, and telephone numbers of Co-Applicants.

Colorado Water Conservation Board (the "CWCB")
Attn: Director
1313 Sherman Street, Room 721
Denver, Colorado 80203
(303) 866-3441

Public Service Company of Colorado, a Colorado Corporation ("PSCo")
Jeff West, Senior Director, Environmental Services
3500 Blake Street, CO1453-03-MCB
Denver, CO 80205
(303) 571-2762

Colorado River Water Conservation District (the "River District")
Attn: Secretary/General Manager
201 Centennial Street, Suite 200
Glenwood Springs, CO 81601
(970) 945-8522

The above-listed parties shall be collectively referred to herein as "Co-Applicants."

Please send all copies of pleadings and correspondence to:

Jennifer L. Mele, Esq.
Natural Resources and Environment Section
Colorado Department of Law
1300 Broadway, 10th Floor
Denver, Colorado 80203
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WELBORN SULLIVAN MECK & TOOLEY, P.C.
1401 Lawrence Street, Suite 1800
Denver, Colorado 80202
(Attorneys for PSCo)

Peter C. Fleming, Esq.
Jason V. Turner, Esq.
Bruce C. Walters, Esq.
201 Centennial Street, Suite 200
Glenwood Springs, CO 81601
(Attorneys for River District)

PRELIMINARY DRAFT

1. Summary of Application.

The CWCB is an agency of the State of Colorado created to aid in the protection and development of the waters of the state for the benefit of its present and future inhabitants. Pursuant to section 37-92-102(3), C.R.S., the CWCB is authorized to acquire, by grant, purchase, donation, lease, or other contractual agreement, such water, water rights, and interests in water that are not on the abandonment list in such amount as the CWCB determines is appropriate for stream flows to preserve and/or improve the natural environment to a reasonable degree. The River District is a political subdivision of the State of Colorado charged with, among other duties, promoting the health and general welfare of the inhabitants of the River District by the conservation, use, and development of the water resources of the Colorado River and its principal tributaries. *See* §§ 37-46-101, C.R.S., *et seq*. PSCo is a Colorado corporation and is the owner and operator of the Shoshone hydroelectric power plant ("Shoshone Power Plant") located on the mainstem of the Colorado River in Glenwood Canyon, approximately six miles upstream of the City of Glenwood Springs.

The Shoshone Power Plant produces hydroelectric energy by means of PSCo's diversion of the Shoshone Water Rights, which are more particularly described in paragraph 2 below. Pursuant to the January 1, 2024 Purchase and Sale Agreement between the River District and PSCo (the "PSA"), the River District is the contract purchaser of the Shoshone Water Rights. The "PSA" (including all exhibits) is attached and incorporated hereto as **Exhibit 1.**

At its bi-monthly meeting on September ____, 2025, the CWCB determined that acquiring from the River District the exclusive right to use the Shoshone Water Rights for instream flow purposes in the reach of the Colorado River described in paragraph 3.2., below, is appropriate to preserve and improve the natural environment to a reasonable degree pursuant to section 37-92-102(3), C.R.S. Co-Applicants entered into a Water Rights Dedication and Instream Flow Agreement with the CWCB on September ____, 2025 (the "ISF Agreement," attached and incorporated hereto as **Exhibit 2**). The ISF Agreement grants to the CWCB the exclusive right to use the Shoshone Water Rights to preserve and improve the natural environment within the approximately 2.4 mile-reach of the Colorado River that extends between the Shoshone Diversion Dam and the Shoshone Power Plant's discharge outlets (the "Shoshone Reach"). The PSA provides that PSCo, or its successors and assigns is entitled to a leasehold interest in the Shoshone Water Rights for continued use of those rights for hydropower generation at the Shoshone Power Plant so long as the plant is operating.

By this Application, Co-Applicants seek to add instream flow use by the CWCB to the decreed uses of the Shoshone Water Rights. The change of water rights decree shall confirm that water attributable to the historical exercise of the Shoshone Water Rights for hydropower generation will remain in the stream to preserve and improve the natural environment to a reasonable degree within the Shoshone Reach up to the full decreed rate of the Shoshone Water Rights of available "Natural Flow". For the purposes of this Application, the "Natural Flow" is the amount of water in the Colorado River measured at the streamflow gauge (USGS 09070500) on

PRELIMINARY DRAFT

the Colorado River near Dotsero, Colorado, located in Eagle County (the "Dotsero Gage"), including the amount of water usable by the Shoshone Water Rights when those water rights are in priority, except that the "Natural Flow" does not include any water released from storage and conducted into the Colorado River upstream of the Dotsero Gage (accounting for evaporation and transit loss), which water is intended for delivery for use downstream of the discharge outlets for the Shoshone Power Plant.

2. Decreed water rights for which change is sought and structures associated with the decreed water rights.

2.1. Glenwood Power Canal and Pipeline ("Senior Shoshone Water Right").

2.1.1. Previous Decrees. Civil Action No. 466, Eagle County District Court, decreed December 9, 1907, for a conditional water right, which was made absolute on February 27, 1911, in Civil Action No. 553.

2.1.2. Decreed Point of Diversion. The Shoshone Diversion Dam and Tunnel ("Point of Diversion") located on the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

2.1.3. Source. Colorado River.

2.1.4. Appropriation Date: January 7, 1902.

2.1.5. Decreed Uses. Power, mining, milling, manufacturing, lighting, heating, and traction purposes.

2.1.6. Amount. 1,250 cubic feet per second ("c.f.s.").

2.2. Shoshone Hydro Plant Diversion No. 2 ("Junior Shoshone Water Right").[1]

2.2.1. Previous Decrees. Civil Action No. 1123, Eagle County District Court, decreed absolute on February 7, 1956.

2.2.2. Decreed Point of Diversion. *See* ¶ 2.1.2. above.

2.2.3. Source. Colorado River.

2.2.4. Appropriation Date. May 15, 1929.

[1] The Senior Shoshone Water Right and Junior Shoshone Water Right are collectively referred to herein as the "Shoshone Water Rights" for a total combined rate of 1,408 c.f.s.

PRELIMINARY DRAFT

2.2.5. Decreed Uses. Manufacturing and generation of electrical energy.

2.2.6. Amount. 158 c.f.s.

2.3. Priorities, appropriation dates, total decreed amounts and rates of flow, and amounts Co-Applicants intend to change.

2.3.1. Co-Applicants seek to continue to use the full 1,408 c.f.s. decreed to the combined Shoshone Water Rights for the changed use for instream flow purposes, subject to terms and conditions preventing injury to other decreed water rights.

Shoshone Water Rights (all amounts are absolute and are in c.f.s.)			
Priority Date	**Appropriation Date**	**Adjudication Date**	**Total Decreed Rate of Diversion and Diversion Rate Co-Applicants Intend to Change**
December 5, 1905	January 7, 1902	December 9, 1907	1,250 c.f.s.
May 31, 1940	May 15, 1929	February 7, 1956	158 c.f.s.
TOTAL			**1,408 c.f.s.**

3. Detailed Description of Proposed Change of Water Right.

3.1. Addition of Instream Flow Use. In addition to the existing decreed hydropower generation use, Co-Applicants seek water court approval to add instream flow use of the Shoshone Water Rights exclusively by the CWCB pursuant to section 37-92-102(3), C.R.S., and the terms of the ISF Agreement (**Exhibit 2**), to preserve and improve the natural environment of the Shoshone Reach to a reasonable degree at flow rates up to 1,408 c.f.s. of Natural Flow, under their individual priorities, as measured and administered at the Dotsero Gage. Co-Applicants intend for the CWCB to use the Shoshone Water Rights for instream flow purposes to the extent that the Shoshone Water Rights are not being used by PSCo for hydropower generation at the Shoshone Power Plant. Subject to the terms and conditions of the ISF Agreement and the change of water rights decree requested herein, the CWCB shall exercise the Shoshone Water Rights for instream flow purposes to the extent that the water rights are not being exercised by PSCo for hydropower generation at the Shoshone Power Plant.

3.2. Shoshone Reach. The CWCB's instream flow use will occur in the following stream reach of the Colorado River ("the Shoshone Reach"), which is approximately 2.4 miles in length between the upstream and downstream termini. The Shoshone Reach is more particularly described below and is depicted on **Exhibit 3** attached hereto.

PRELIMINARY DRAFT

3.2.1. Upstream Terminus – Shoshone Power Plant Diversion Dam and Tunnel.

3.2.1.1. On the right bank, being the northerly bank, of the Colorado River whence the North quarter corner of Section Thirty (30), Township Five (5) South, Range Eighty-Seven (87) West of the 6th Principal Meridian bears North 23° 48'20" East 2,414.64 feet, in Garfield County, Colorado.

3.2.1.2. UTM Zone 13 NAD83; Easting: _____; Northing_____.

3.2.2. Downstream Terminus – Shoshone Power Plant Discharge Outlets.

3.2.2.1. On the right bank, being the northerly bank, of the Colorado River whence the Southeast corner of Section Thirty-five (35), Township Five (5) South, Range Eighty-Eight (88) West of the 6th Principal Meridian bears South 29° 24' 14" East, 1,771 feet, in Garfield County, Colorado.

3.2.2.2. UTM Zone 13 NAD83; Easting: _____; Northing _____.

3.2.3. Maximum Rate of Flow. The maximum rate of flow for the instream flow use of the Shoshone Water Rights will be their combined decreed rate of 1,408 c.f.s. of Natural Flow, under their individual priorities, for the purpose of preserving and improving the natural environment of the Shoshone Reach to a reasonable degree, subject to the terms and conditions of the change of water rights decree requested herein.

4. Quantification of Historical Exercise of the Shoshone Water Rights.

Co-Applicants will determine the historical use of the Shoshone Water Rights over a representative study period that includes wet years, dry years, and average years.

4.1. Historical Use.

4.1.1. The Shoshone Water Rights have been historically administered by the State Engineer and the Division Engineer for Water Division No. 5 (the "Engineers") at the Dotsero Gage, located approximately 8.5 miles upstream of the Shoshone Diversion Dam. The Shoshone Water Rights have historically been diverted by PSCo at the Shoshone Diversion Dam, as described in paragraph 3.2.1. above. The historical use of water attributable to the Shoshone Water Rights has been non-consumptive. The water historically diverted at the Shoshone Diversion Dam and run through the Shoshone Tunnel for delivery to the plant turbines was returned to the Colorado River at the outfall (i.e., discharge outlets) of the Shoshone Power Plant approximately 2.4 miles downstream of the Point of Diversion. *See* **Exhibit 3**. Notwithstanding the foregoing, the practice of diverting water attributable to the Shoshone Water Rights from the Colorado River and

PRELIMINARY DRAFT

into the Shoshone Tunnel for delivery to the Shoshone Power Plant means that the historical exercise of the Shoshone Water Rights has been depletive to the Shoshone Reach before the diversions are returned to the Colorado River at the Shoshone Power Plant Discharge Outlets (i.e., the Downstream Terminus described in ¶ 3.2.2. above).

4.1.2. [ ]

4.1.3. [ ]

5. Maintenance of Historical Return Flows.

5.1. Co-Applicants will maintain historical return flows by ensuring that any future use of the Shoshone Water Rights is consistent with the historical exercise of the Shoshone Water Rights, so that water will continue to be available in the stream at the same time, location, and amount at the Downstream Terminus. This maintenance of the historical return flow pattern will prevent injury to downstream water rights. Upon entry of the change of water rights decree requested herein, Co-Applicants shall maintain the return flows that historically accrued to the Colorado River at the location of the Downstream Terminus.

6. Name(s) and address(es) of owners of land on which structures are located.

6.1. _____.

WHEREFORE, the CWCB, PSCo, and the River District request the Water Court to award a change of water rights decree for the Shoshone Water Rights to confirm the addition of instream flow use by the CWCB, pursuant to section 37-92-102(3), C.R.S., to preserve and improve the natural environment to a reasonable degree in the Shoshone Reach, in the amounts and up to the full decreed 1,408 c.f.s. of Natural Flow, as set forth in this application.

Respectfully submitted this ____ day of _____, 2025.

PRELIMINARY DRAFT

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PRELIMINARY DRAFT

VERIFICATION

I, _____, state that I have read the foregoing Application for Change of Water Rights and verify its content. I declare under penalty of perjury under the laws of the State of Colorado that the foregoing is true and correct.

_____ _____

Printed Name **Signature**

PRELIMINARY DRAFT

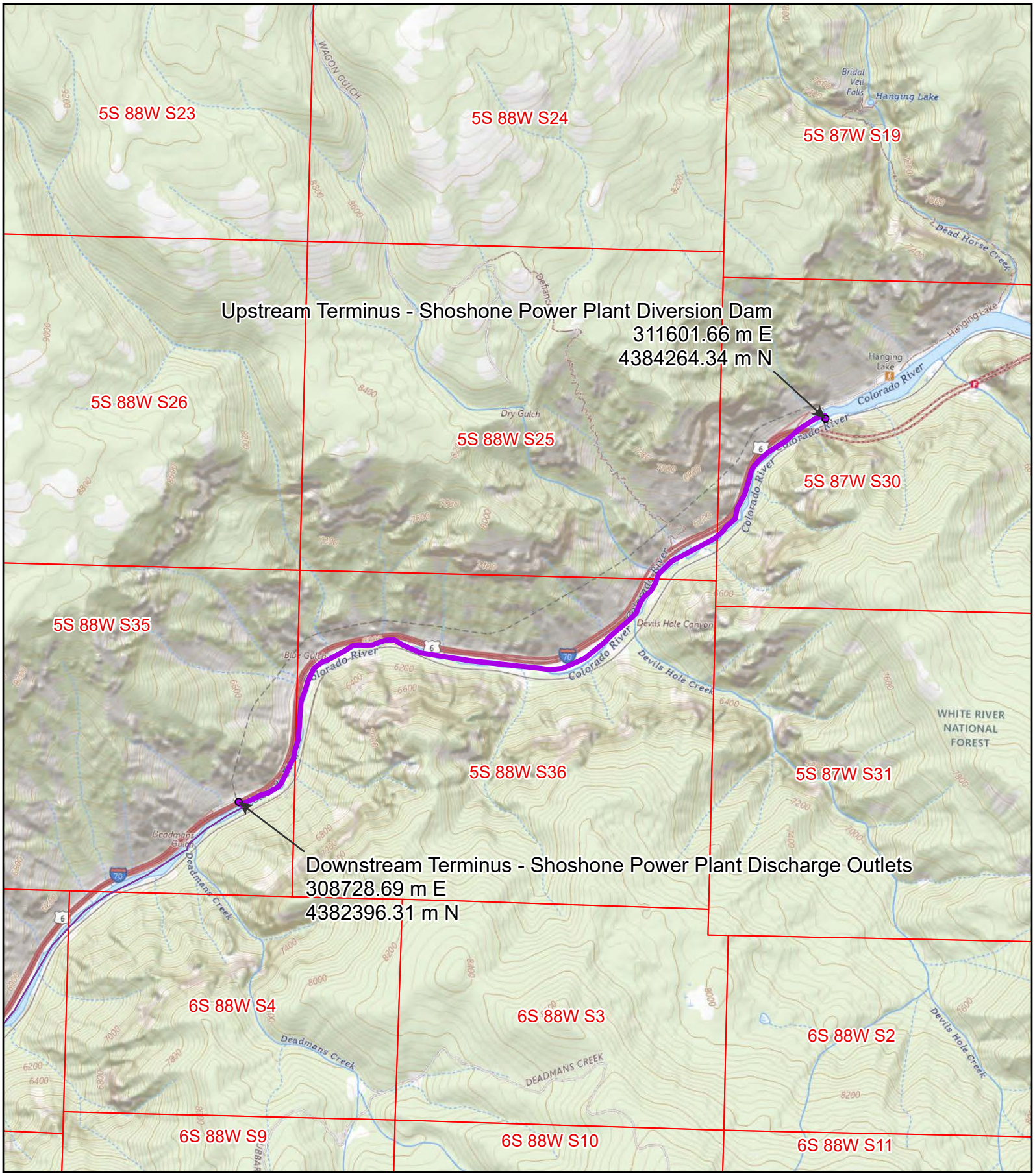


EXHIBIT 3

Garfield County, CO
DWR Division 5

Shoshone Reach

TRUE-NORTH
MAGNETIC-NORTH

Scale: 1:24,000
0 ¼ ½ 1
Miles

DWR Division 5

COLORADO RIVER DISTRICT

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GEI Consultants

Consulting Engineers and Scientists

Review of the Effects of Flow on Biology and Stream Processes, Glenwood Canyon

April 2025

Enclosure G
Agenda Item 10d
CWCB Board Meeting
May 21-22, 2025





Review of the Effects of Flow on Biology and Stream Processes, Glenwood Canyon

GEI Consultants

Consulting Engineers and Scientists



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April 2025

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Table of Contents

1. **Introduction** **1-1**

2. **Fish** **2-1**
2.1 Fish Species Accounts 2-2
2.1.1 Cutthroat Trout (Oncorhynchus clarki pleuriticus) 2-2
2.1.2 Speckled Dace (Rhinichthys osculus) 2-2
2.1.3 Native Sculpin (Cottus punctulatus, C. annae) 2-3
2.1.4 Bluehead Sucker (Catostomus discobolus) 2-3
2.1.5 Flannelmouth Sucker (Catostomus latipinnis) 2-4
2.1.6 Roundtail Chub (Gila robusta) 2-4
2.1.7 Mountain Whitefish (Prosopium williamsoni) 2-5
2.2 Current Fishery Conditions in the Study Reach 2-5
2.3 Instream Flow Benefits to Fish 2-11

3. **Macroinvertebrates** **3-1**
3.1 Macroinvertebrate Assemblages in the Study Reach 3-1
3.2 Instream Flow Benefits to Macroinvertebrates 3-5

4. **Flow and Food Webs** **4-1**
4.1 Consistent Base Flows Benefit Stream Food Webs 4-1
4.2 Periodic High Flows Benefit Stream Food Webs 4-2
4.3 Intermittent Flow Causes High Unpredictability in Aquatic Food Webs 4-3

5. **Flow, Sediment, and Temperature** **5-1**
5.1 Flow Effects on Sediment Regimes in Rivers 5-1
5.2 Flows Can Stabilize Temperatures in the Study Reach 5-5

6. **Flow and Aquatic Habitat** **6-1**
6.1 Native Fish Utilize Canyon Habitat 6-1
6.2 Instream Flows Maintain Interstitial Habitat 6-3
6.3 Instream Flows Maintain Longitudinal Habitat Connectivity 6-4
6.4 Instream Flows Control Fish and Macroinvertebrate Drift 6-5
6.5 High Flows Maintain Canyon Habitat 6-7

7. **Conclusion** **7-1**

8. **References** **8-1**

List of Figures

Figure 2-1.—Map of fish sampling sites on the Colorado River, within and upstream of the Study Reach. 2-1
Figure 2-2.—Average relative abundance of fish species in the Colorado River #4B reach upstream of the confluence with the Eagle River. Sampling occurred in 2010, 2013, 2015, 2016, 2018, 2021, and 2022. Species without bars had average relative abundances less than 0.1%. 2-7
Figure 2-3.—Average relative abundance of fish species in the Eagle River #1 reach upstream of the confluence with the Colorado River. Sampling occurred in 2010, 2014, 2016, 2021, and 2023. Species without bars had relative abundances of less than 0.1%. 2-7
Figure 2-4.—Average relative abundance of fish species in the Colorado River #4A (at Grindstone Creek) downstream of the confluence of the Eagle River near Glenwood Springs, Colorado. Sampling occurred in 2021, 2023, and 2024. Species without bars had relative abundances of less than 0.1%. 2-9
Figure 2-5.—Average relative abundance of fish species in the Colorado River #4A (Shoshone) downstream of the Shoshone Dam and upstream of the Shoshone Hydroelectric Station (referred to as the Study Reach in this report). Sampling occurred in 2024. 2-9
Figure 2-6.—Density and biomass of fish populations in the three Colorado River sites and the Eagle River site from 2010 to 2024. 2-10
Figure 3-1.—Map of macroinvertebrate sampling sites on the Colorado River, within and upstream of the Study Reach. 3-2
Figure 5-1.-- *Figure 1 of Yarnell et al. (2015) exemplifies the ecological and geomorphic significance of a range of flows.* 5-2
Figure 5-2.—*Cinderelli and Cluer (1998)'s Figure 12 provides a schematic of recirculation currents and eddy bars associated with sediment inputs at tributary junctions in canyon reaches (top). In Glenwood Canyon, these habitats are located upstream and downstream of steep tributary inputs (bottom).* 5-4
Figure 5-3.—*Daily maximum temperatures from Dotsero and Glenwood USFS stream gages on the Colorado River.* 5-7
Figure 5-4.—Weekly *average temperature with MWAT standard temperature thresholds for Dotsero and Upstream of Glenwood USGS gages (Gages 09070500 and 09071750). The average weekly temperatures are calculated with continuous 15-minute temperature data.* 5-7
Figure 6-1.—*Vertical drop in Upper Death Rapid that would likely be more passable at higher flows.* 6-5
Figure 6-2.—*Modeled surface of Upper Death Rapid, below Shoshone Dam.* 6-8

List of Tables

Table 3-1.—Summary of macroinvertebrate metrics for the samples collected from the Colorado River within and upstream of the Study Reach. Data are presented from upstream to downstream. NC = not calculated. 3-3
Table 5-1.—*Temperature standards for the Study Reach.* 5-6

1. Introduction

This report details the benefits of instream flow for the reach of the Colorado River between the Shoshone Dam and the return at the Shoshone Power Plant (referred to hereafter as the Study Reach). The Study Reach is located in Glenwood Canyon and is characterized by steep gradients, limited floodplains, and large boulder substrate. Under moderate to high flow conditions, deep, turbulent, high-velocity flows are typical. This reach is also affected by water withdrawals by the power plant and often experiences flows that are lower than they would be under natural conditions. During the low flow season (i.e., in the months outside of spring runoff), the Study Reach can experience flows that are not continuous in time or space (intermittent flow) or fully dewatered conditions. The goal of this report is to discuss the effects of flow regime on the following: fish and macroinvertebrate populations, food webs, sediment and temperature regimes, and aquatic habitat. Because each of these are profoundly affected by flow, their relative health and function are discussed in the context of intermittent flow, consistent base flow, and higher flows (i.e., those approximating spring runoff).

This report was completed through a three-step process. First, available fish and macroinvertebrate data were reviewed and used to summarize existing biological conditions in the Study Reach. Second, the scientific literature was reviewed to determine the effects of flow on fish and macroinvertebrates, food webs, sediment and temperature regimes, and aquatic habitat. Third, this literature was synthesized with existing conditions to explain the implications of intermittency and the benefits of consistent base flows and higher seasonal flows for the Study Reach.

2. Fish

This section of the report contains species accounts for native fishes expected in the Study Reach, followed by a description of the existing fish assemblages in the Study Reach. Because fishery surveys are not common in the Study Reach, additional data were used to describe the fish assemblage present in this portion of the Upper Colorado River Drainage. A data request was submitted to Colorado Parks and Wildlife; the area covered in the query extended into the Eagle River in the vicinity of Gypsum, CO and into the Colorado River in the vicinity of Lyons Gulch on the upstream end and to the City of Glenwood Springs on the downstream end. The Study Reach is near the downstream end of the area covered by the query (Figure 2-1). This section concludes with a discussion of the potential benefits of increased instream flow for the resident fish assemblage in the Study Reach.

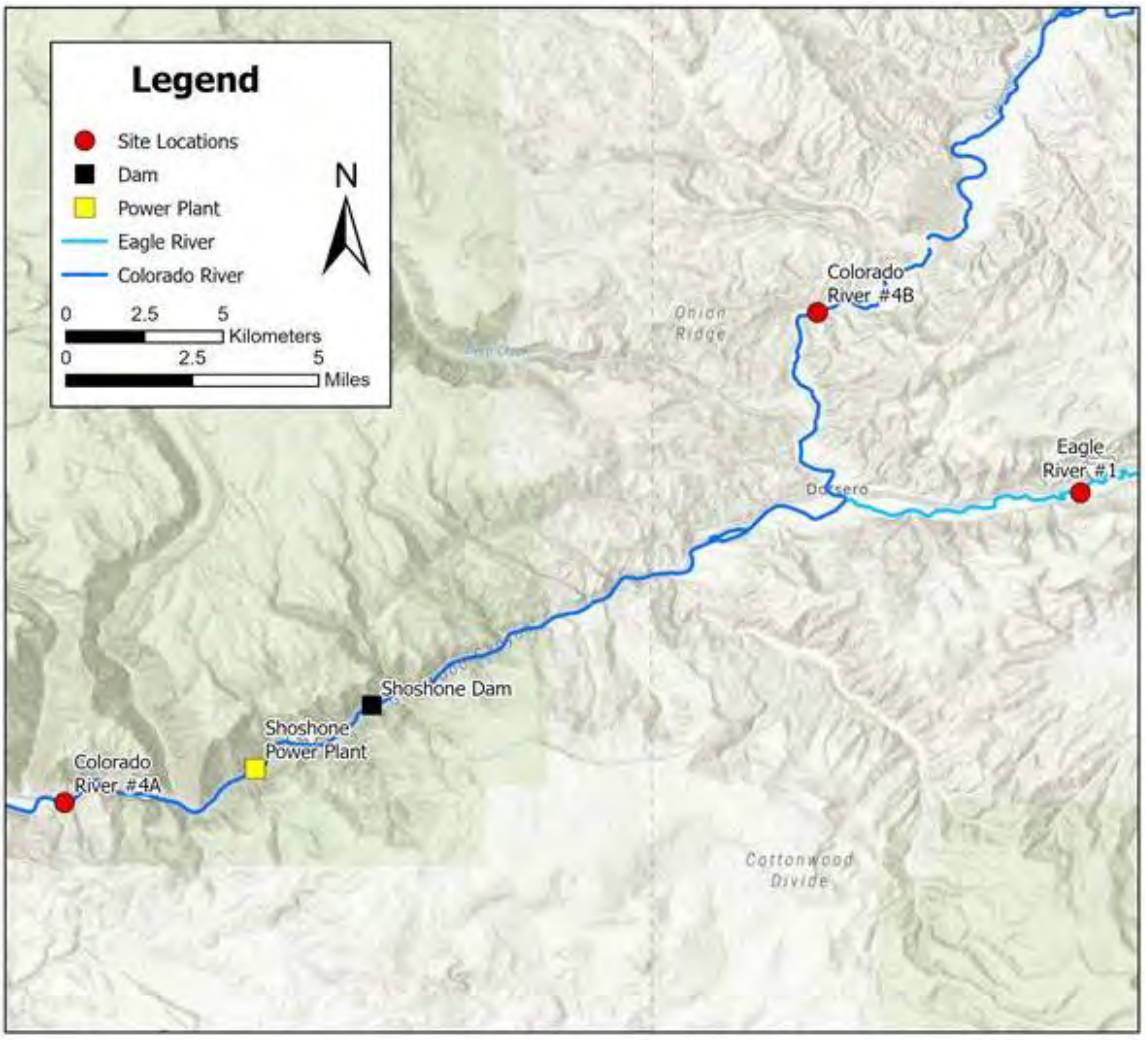


Figure 2-1.—Map of fish sampling sites on the Colorado River, within and upstream of the Study Reach.

2.1 Fish Species Accounts

2.1.1 Cutthroat Trout (Oncorhynchus clarki pleuriticus)

In Colorado, Colorado River Cutthroat Trout (CRCT) are primarily distributed in the colder waters of the Colorado River basin (Young 2008; Western Native Trout Status 2020). Current distribution of the CRCT is limited to isolated populations, and distribution of this species has declined to 1-13% of their historic range since the mid 1800's due to introductions of non-native salmonids and habitat alteration (Young, 2008, Olsen 2013). Hybridization with other Cutthroat Trout species and with Rainbow Trout (*Oncorhynchus mykiss*) has occurred to differing extents in native populations (Baxter and Stone 1995), further reducing CRCT distribution and probability of persistence. Even though Cutthroat Trout are relatively uncommon in the Study Reach, this species was chosen as a representative trout species in the Study Reach for two reasons. First, they are a native species and have been present in the Study Reach. Second, this species has similar habitat to Rainbow Trout and Brown Trout (*Salmo trutta*). However, they prefer lower temperatures than Brown Trout and Rainbow Trout and serve as the basis for the temperature regulations that apply to the Study Reach (See Section 5.2 for temperature criteria).

The average summer thermal temperature preference of CRCT is typically below 16°C along the western slope of the Rocky Mountains (Young 2008). CRCT prefer high gradient streams, but this may be because high gradient streams are not suitable habitat for many nonnative fish species (Young 2008). Like most salmonids, CRCT prefer pools in both summer and winter months to minimize bioenergetic expenditures (Young 2008).

CRCT mature at approximately two or three years of age and spawn from early spring to early July (Baxter and Stone 1995) after spring runoff flows have peaked (Young 1995). Adults can migrate long distances for preferential spawning habitat where they utilize clean gravel substrate for redds (Young 1995). Emergence of fry from the substrate is dependent on water temperature but generally occurs in late summer (Young 1995). Aquatic and terrestrial invertebrates comprise the majority of the CRCT diet (Baxter and Stone 1995, Young 1995), and CRCT forage primarily during daytime (Young 1995).

2.1.2 Speckled Dace (Rhinichthys osculus)

The known distribution of Speckled Dace is reported to be the western region of the United States (USFWS 2023), this species is native and widespread west of the Continental Divide (Baxter and Stone 1995, Woodling 1985). Speckled Dace distribution is largely defined by its tolerances of both high and low temperatures, but this species tolerates a broad thermal range (Batty 2010, Center for Biological Diversity 2020).

Habitat requirements of the Speckled Dace include but are not limited to shallow habitat in riffles, runs and pools, creeks, and small to medium rivers with a mostly rocky substrate (NatureServe 2025). This species can occupy moderately swift water habitat (Wallace and

Zaroban 2013) but is uncommon in water depths greater than three feet (Sigler and Sigler 1987). Speckled Dace are active during day and night, but they are more closely associated with the substrate at night. (Wallace and Zaroban 2013). They are found in shoals, or loose groups.

Speckled Dace mature at approximately two years of age (Sigler and Sigler 1987) spawn from early spring to summer and can spawn more than once in a year (Baxter and Stone 1995). Peak spawning activity occurs at a water temperature near 18°C. In the Yampa River, spawning occurred at temperatures between 15 and 22° C (Bestgen and Zelensky 2004). Spawning occurs beneath rocks and eggs are deposited and adhered to substrate (Baxter and Stone 1995, Sigler and Sigler 1987). Eggs hatch about 6 days after deposition, and fry emerge from gravel after an additional seven to eight days (Sigler and Sigler 1987). Speckled Dace are omnivorous, feeding on invertebrates, plant matter, and zooplankton (Baxter and Stone 1995, Sigler and Sigler 1987).

2.1.3 Native Sculpin (Cottus punctulatus, C. annae)

Genetic research supports the existence of two distinct sculpin species in the Upper Colorado River basin: *C. annae* and/or *C. punctulatus* (Young et al. 2022). Because they co-occur in some drainages, both species may be present in the Study Reach. Despite taxonomic uncertainty prior to the 2022 publication by Young et al., previous literature has accurately described sculpin ecology in Colorado. A brief summary is included below.

Native sculpin inhabit clear, cold streams with rock and gravel substrate, preferring benthic substrate for refuge and foraging (Baxter and Stone 1995). This species can occur in moderate to rapid current (Wallace and Zaroban 2013) and can tolerate water temperatures above 20°C (Wallace and Zaroban 2013, Woodling 1985). Native sculpin are not usually found where sedimentation has occurred, and interstitial habitat is not present (Woodling 1985).

Native sculpin mature at approximately three years of age (Woodling 1985). Spawning occurs beneath rocky substrate or submerged objects; native sculpin are known to share nest sites and guard nests after egg deposition (Baxter and Stone 1995). Spawning occurs between February and June, when water temperatures approach 10° C (Baxter and Stone 1995, Woodling 1985). Native sculpin are more active at night, foraging among benthic substrate (Baxter and Stone 1995). Diet includes aquatic insects, crustaceans, and small fish (Baxter and Stone 1995; Wallace and Zaroban 2013).

2.1.4 Bluehead Sucker (Catostomus discobolus)

Bluehead Sucker are found in tributaries and in larger rivers in western Colorado, Arizona, Idaho, New Mexico, Utah, and Wyoming (Woodling 1985). Adult Bluehead Sucker grow to between 11 and 18 inches and have been reported to reach ages over 20 years (Minckley 1991). Bluehead Sucker occupy a variety of habitats and are typically found in runs or riffles

with rocky substrate and water with moderate to fast velocity (Woodling 1985, Bezzerides and Bestgen 2002). They spawn in spring or early summer (Ptacek et al. 2005). Spawning has been observed over a cleaned area in gravel substrate and at temperatures ranging from 18 to 25 ° C (Maddux and Kepner 1988). They are benthic omnivores, feeding on invertebrates and other material from stones and rocks (Woodling 1985). Bluehead Sucker hybridize with native Flannelmouth Sucker (*Catostomus latipinnis*) and Mountain Sucker (*C. platyrhynchus*) and with non-native White Sucker (*C. commersonii*, Bezzerides and Bestgen 2002) and Longnose Sucker (*C. catostomus*). Nonnative suckers are a primary threat to Bluehead Sucker due to hybridization.

Bluehead Sucker rely on long-range migration as part of their life history (Bottcher 2009; Fraser et al. 2017). Individuals have been documented as moving hundreds of kilometers to access a variety of habitats, including spawning sites (Thompson and Hooley-Underwood 2019). Therefore, fragmentation is also a major threat to the persistence of this species.

2.1.5 Flannelmouth Sucker (Catostomus latipinnis)

The native range of the Flannelmouth Sucker is similar to that of Bluehead Sucker (Baxter and Stone 1995), but they prefer habitat in medium to large streams (Woodling 1985). Flannelmouth Sucker inhabit multiple habitat types including riffles, runs, eddies, pools, and backwaters (Woodling 1985, Valdez and Muth 2005) and are known to migrate long distances (Bezzerides and Bestgen 2002). Flannelmouth Sucker prefer water temperatures ranging from 10 to 27° C (Sublette et al. 1990). Flannelmouth Sucker can reach lengths of 22 inches or more (Baxter and Stone 1995) and are known to reach a maximum age of approximately 30 years (Minckley 1991).

Flannelmouth Sucker are lithophilic spawners; eggs are broadcast over clean substrate and adhere to gravel or rock crevices (Snyder et al. 2004). Flannelmouth Sucker are benthic omnivores foraging mainly on macroinvertebrates and algae (Valdez and Muth 2005).

Flannelmouth Sucker populations have declined throughout much of their historic range (Bezzerides and Bestgen 2002) due to habitat loss and habitat fragmentation. As with Bluehead Sucker, Flannelmouth Sucker hybridize with other native sucker species and non-native White Sucker and Longnose Sucker. Like Bluehead Sucker, Flannelmouth Sucker also make long-distance migrations and are threatened by habitat fragmentation (Bottcher 2009; Fraser et al. 2017).

2.1.6 Roundtail Chub (Gila robusta)

Roundtail Chub is a cyprinid fish species that can grow up to 20 inches in length (Valdez and Muth 2005). Roundtail Chub live in warm streams and larger rivers and utilize pools with cover that are adjacent to fast moving water. This species also concentrates in relatively swift, swirling waters below rapids (Minckley 1973). Maximum temperatures measured in Roundtail Chub habitat were 26.5° C (Bestgen and Propst 1989).

The average lifespan of this species is approximately eight to ten years (Brouder et al. 2000). Individuals first reproduce between ages two and five and spawn in May and June, shortly after peak runoff (Valdez and Muth 2005). Adhesive eggs are scattered over cobble and gravel substrate (Valdez and Muth 2005) and hatch after about five days (Muth 1990). Roundtail Chub are omnivores and consume a variable diet of algae, aquatic plants, invertebrates, fish, and reptiles (Minckley 1973). This species is threatened by nonnative species introductions and habitat fragmentation and destruction (Valdez and Muth 2005). This species also relies on extensive movement to fulfill its life history and is threatened by fragmentation (Bottcher 2009; Fraser et al. 2017).

2.1.7 Mountain Whitefish (Prosopium williamsoni)

Mountain Whitefish have a large natural range extending along both sides of the Continental Divide among the Rocky Mountains in Canada and the United States; its range includes the Colorado River Basin (Baxter and Stone 1995). Mountain Whitefish historically occupied the White and Yampa River Drainages and were subsequently introduced into the Upper Colorado Drainage. This species prefers large, clear, cold rivers with deep and fast water (Baxter and Stone 1995). Mountain Whitefish are fast growing long-lived species reaching a maximum length of about 20 inches. They migrate for spawning, feeding, and overwintering, preferring summer feeding habitat with water temperatures less than 15° C. Overwintering habitat is known to consist of relatively shallow water with large substrate (Schmidt et al. 2019) and deeper pool habitat (Pettit and Wallace 2011).

Mountain Whitefish become sexually mature at a length of about 8 – 10 inches at an age of about three years (Wallace and Zaroban 2013). This species spawns nocturnally from September through November when water temperatures range from 0 to 11°C (Wallace and Zaroban 2013). They migrate into smaller tributaries for spawning, disperse their eggs in cobble and gravel riffles, and return downstream to overwintering habitat (Wallace and Zaroban 2013). Eggs hatch in late winter or early spring (Baxter and Stone 1995, Wallace and Zaroban 2013), and fry remain in their natal stream until late summer before migrating downstream (Wallace and Zaroban 2013). Mountain Whitefish are mainly benthic foragers, consuming macroinvertebrates, small crustaceans, and fish eggs (Laakso 1951).

2.2 Current Fishery Conditions in the Study Reach

GEI requested survey data for the Upper Colorado and Eagle River from Colorado Parks and Wildlife (CPW) from 2010 to 2024 and has summarized the status of the fish populations in the vicinity of the Study Reach. Of note, sampling methods and goals differ by survey, so datasets are not directly comparable. However, all available surveys provide information on species presence and relative abundances. Based on the data provided, multiple surveys of the Colorado River and Eagle River from reaches both upstream and downstream of the Study Reach were conducted from 2010 to 2024.

In the Colorado River upstream of the confluence of the Eagle River (Colorado River #4B), populations are prolific and diverse. Brown Trout and White Sucker were frequently the dominant species (Figure 2-2). Longnose Sucker, Rainbow Trout, Flannelmouth Sucker, Bluehead Sucker, native sculpin, Speckled Dace, and hybrid suckers were also commonly collected. Smaller numbers of Roundtail Chub, Common Carp (*Cyprinus carpio*), and Cutthroat Trout were found during the various sampling events. Four species collected within the reach including Bluehead Sucker, Colorado River Cutthroat Trout, Flannelmouth Sucker, and Roundtail Chub are categorized by CPW as Tier 1 Species of Greatest Conservation Need (SGCN-1). The most recent sampling event in the database occurred in 2022; Brown Trout, Rainbow Trout, White Sucker were the most abundant species. Naturalized trout and White Sucker dominate the reach, with small numbers of native Mountain Whitefish and Speckled Dace also present.

In the Eagle River upstream of the confluence with the Colorado River (Eagle River #1) White Sucker and Brown Trout were the dominant species and were collected in surveys from 2010 through 2023 (Figure 2-3). Rainbow Trout, Longnose Sucker, and Mountain Whitefish were also commonly collected. Smaller numbers of Fathead Minnow (*Pimephales promelas*), native sculpin, Speckled Dace, Flannelmouth Sucker, Bluehead Sucker, and hybrid suckers were found during the various sampling events. Two SGCN-1 species, Bluehead Sucker and Flannelmouth Sucker, were collected within this reach from 2010 to 2023. The most recent sampling event in the database occurred in 2023; Brown Trout, White Sucker, and Fathead Minnow were the dominant species, with smaller numbers of Mountain Whitefish, Rainbow Trout, Longnose Sucker, hybrid suckers, and Speckled Dace.

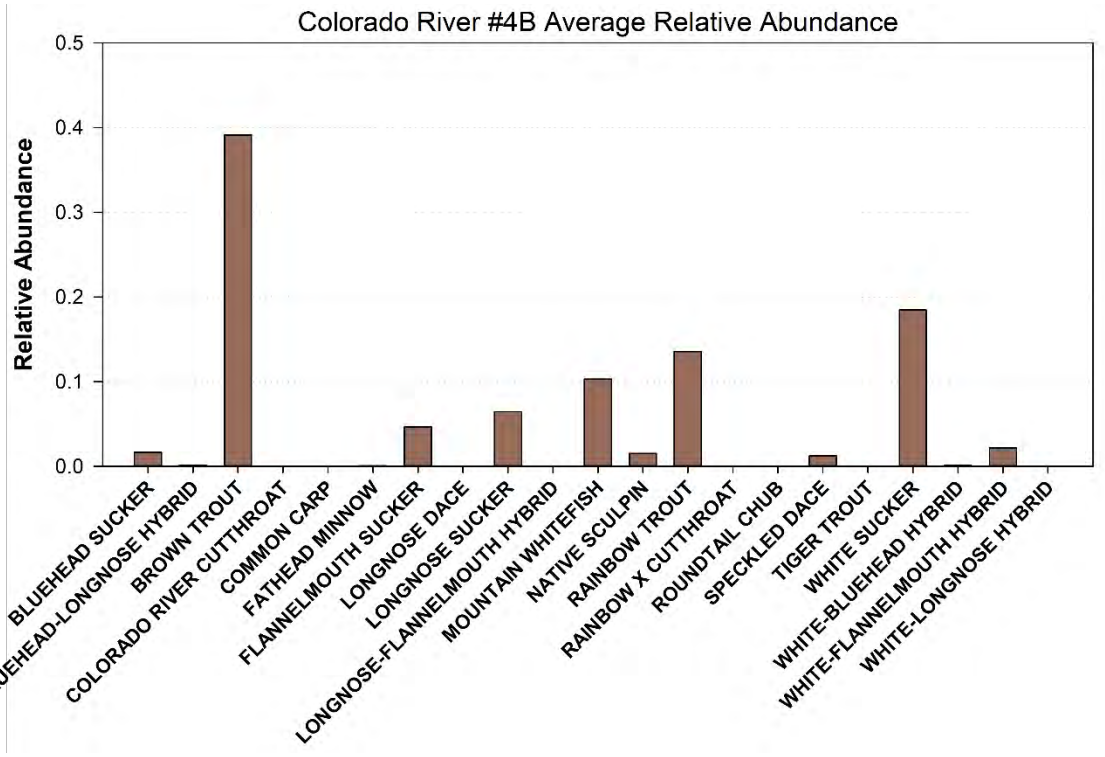


Figure 2-2.—Average relative abundance of fish species in the Colorado River #4B reach upstream of the confluence with the Eagle River. Sampling occurred in 2010, 2013, 2015, 2016, 2018, 2021, and 2022. Species without bars had average relative abundances less than 0.1%.

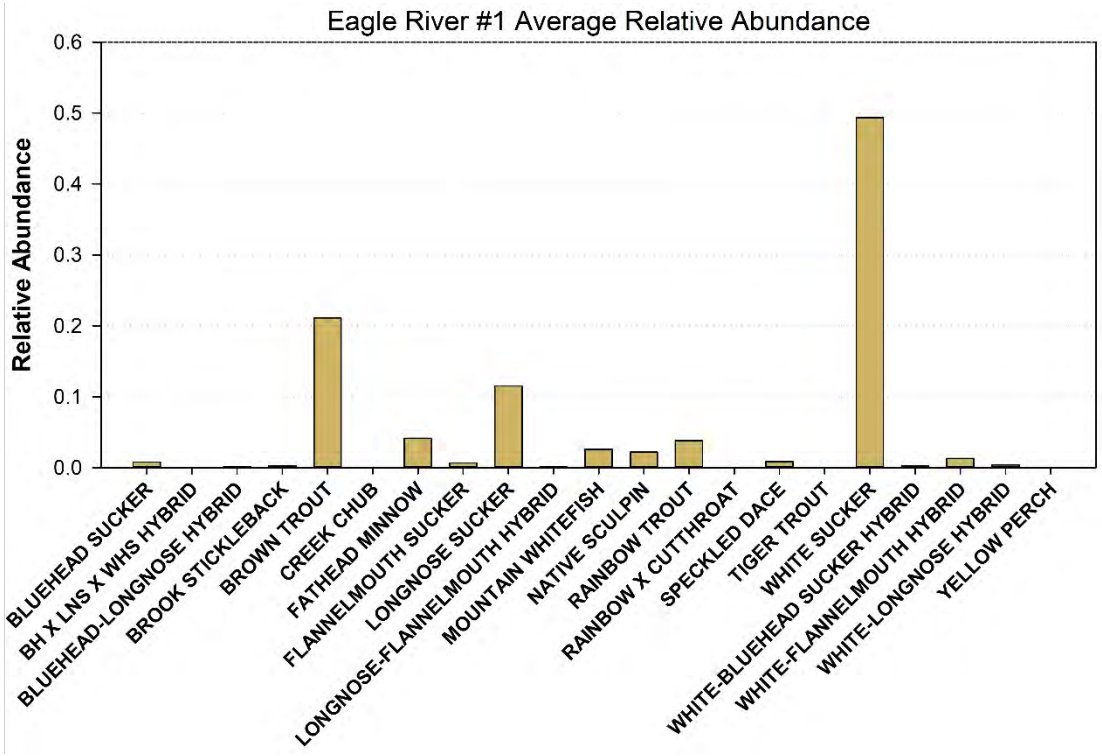


Figure 2-3.—Average relative abundance of fish species in the Eagle River #1 reach upstream of the confluence with the Colorado River. Sampling occurred in 2010, 2014, 2016, 2021, and 2023. Species without bars had relative abundances of less than 0.1%.

In the Colorado River downstream of the Study Reach just above Glenwood Springs, Colorado River #4A (at Grindstone Creek), was sampled in 2021, 2023, and 2024. Brown Trout were the dominant species and were collected in each survey (Figure 2-4). White Sucker, Mountain Whitefish, and Longnose Sucker were also commonly collected. Small numbers of Flannelmouth Sucker, native sculpin, Speckled Dace, and hybrid suckers were found during the three sampling events. The most recent sampling event occurred at this site in 2024; Brown Trout and Rainbow Trout were the dominant species. Lower numbers of Longnose Sucker, native sculpin, Mountain Whitefish, Speckled Dace, White Sucker, and hybrid suckers were also collected in 2024. Additionally, low numbers of two SGCN-1 species, Bluehead Sucker and Flannelmouth Sucker, were collected within this reach among all sampling events. Species diversity was lower at this site, with 12 species collected in 2021 and 2023; a total of 21 and 20 species were collected at Eagle River #1 and Colorado River #4B, respectively. However, the lower fish diversity at Colorado River #4A may be due to the lower number of surveys performed at this site. Despite the lower diversity, comparable numbers of Brown Trout and Rainbow Trout have been collected in most years among Colorado River #4A near Grindstone Creek, Colorado River #4B, and Eagle River #1.

The Study Reach, Colorado River #4A (Shoshone), was sampled once, in the fall of 2024, and the dominant species collected were Brown Trout and Rainbow Trout (Figure 2-5). Moderate numbers of Speckled Dace, Longnose Dace (*Rhinichthys cataractae*) and low numbers of native sculpin and Mountain Whitefish were also collected. One SGCN-1 species, Bluehead Sucker, was also collected at this site in low numbers. The total number of species/hybrids collected in this reach was lower than all other reaches analyzed but was mostly due to the absence of hybrid suckers. All species collected at Colorado River #4A Shoshone in 2024 were also present among all other reaches and years.

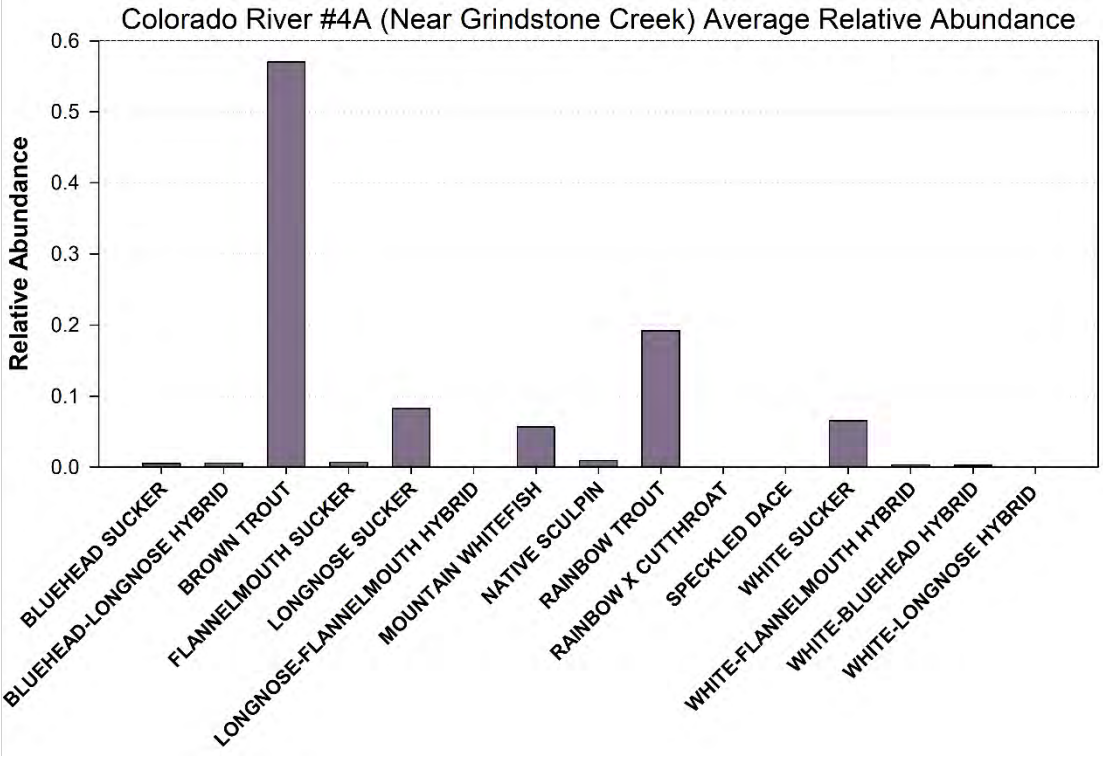


Figure 2-4.—Average relative abundance of fish species in the Colorado River #4A (at Grindstone Creek) downstream of the confluence of the Eagle River near Glenwood Springs, Colorado. Sampling occurred in 2021, 2023, and 2024. Species without bars had relative abundances of less than 0.1%.

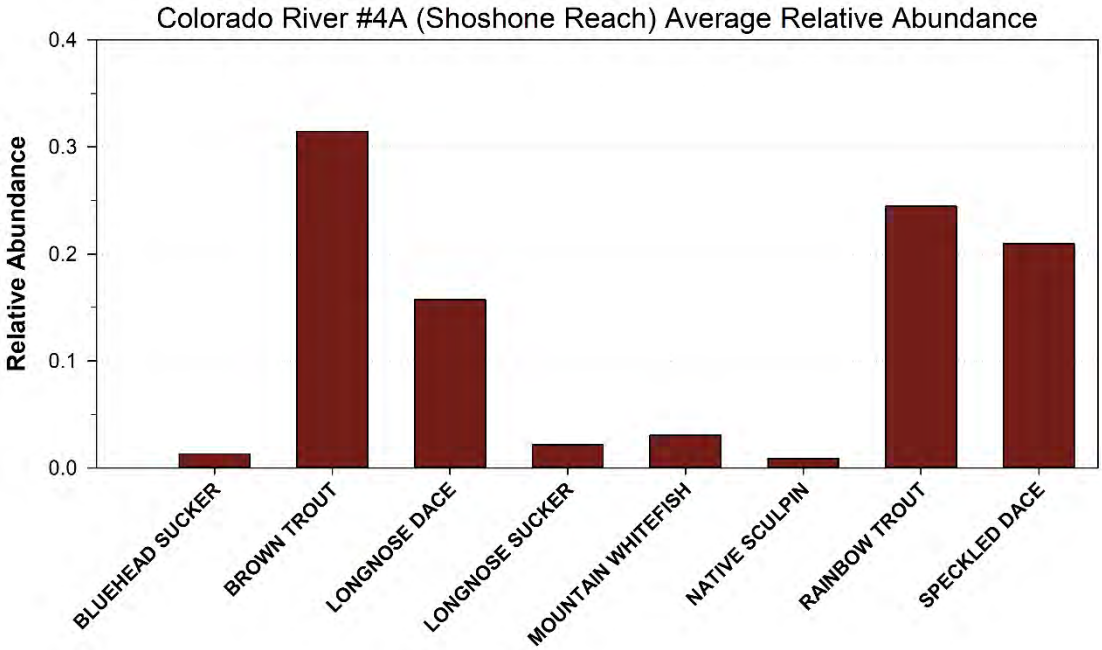


Figure 2-5.—Average relative abundance of fish species in the Colorado River #4A (Shoshone) downstream of the Shoshone Dam and upstream of the Shoshone Hydroelectric Station (referred to as the Study Reach in this report). Sampling occurred in 2024.

The fish density and fish biomass values in the Eagle River #1 site were generally higher than the Colorado River sites from 2010 through 2023 (Figure 2-6). At the Colorado River #4B site, these same metrics remained relatively stable from 2010 through 2022. Limited surveys were completed at the Colorado River #4A site; however, density and biomass values appear similar to Colorado River #4B site. Overall, fish densities have fluctuated considerably at the Eagle River #1 site from 2010 to 2023. The highest fish densities occurred in 2014 and 2021, with 6,285 and 1,818 fish per hectare, respectively. The density value was the highest at Colorado River #4B in 2010, with 732 fish per hectare. The extraordinarily high density values in the Eagle River were attributable to a large number of White Suckers.

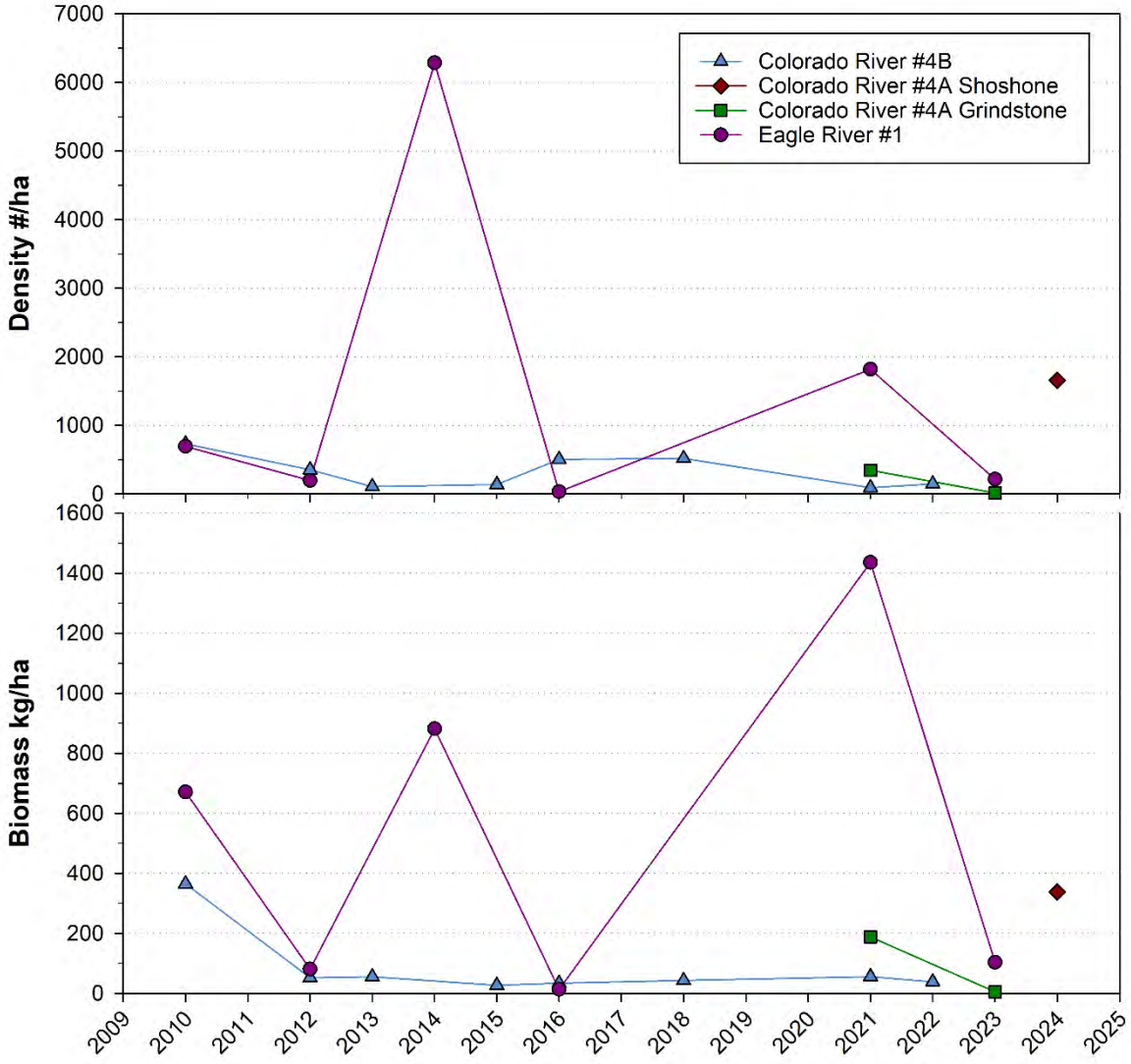


Figure 2-6.—Density and biomass of fish populations in the three Colorado River sites and the Eagle River site from 2010 to 2024.

Patterns in fish biomass explain further differences between the fish communities at the four sites (Figure 2-6). The highest biomass value of all sites was in 2021 at Eagle River #1; this

is the only site of the three sites sampled among multiple years that consistently supported a large number of larger-bodied fish such as White Suckers. Biomass was also relatively high at Site Colorado River #4A (Shoshone), which has only been sampled one time. The lowest biomass values occurred at Colorado River #4A (at Grindstone) in 2023 when low numbers were present. At Colorado River #4A (at Grindstone) in 2023, a relatively small number of large Brown Trout and Rainbow Trout comprised 71 percent of the total biomass. Biomass at Site Colorado River #4B has been relatively stable from 2012 through 2022.

Surveys recorded in CPW's database continued to indicate that White Sucker, Brown Trout and Mountain Whitefish were the most abundant species in almost all surveys. Rainbow Trout, Longnose Sucker, Bluehead Sucker, and Flannelmouth Sucker were also commonly collected and abundant. In addition, a small number of native sculpin, Speckled Dace, Cutthroat Trout species, Roundtail Chub, Tiger Trout, and hybrid suckers were present in several surveys. Despite variations in surveys due to survey goals and sampling methods, fish assemblages were similar between all sites and reflect the fact that nonnative fishes pose a significant threat to native fish persistence. Of note, Mountain Whitefish and Roundtail Chub were collected more frequently and often in high abundances from Colorado River #4B, above the Eagle River confluence, and Bluehead Sucker were common, and sucker hybrids were absent at Colorado River #4A (Shoshone).

2.3 Instream Flow Benefits to Fish

The fish assemblage described above is typical in perennial coldwater or transitional (i.e., between coldwater and warmwater) stream reaches in medium to large rivers on Colorado's Western Slope. Under the current flow regime, the fish assemblage in the Study Reach is subject to significant environmental challenges that are absent in perennial reaches.

Some of the species in the Study Reach can survive in intermittent streams. Most fish that live in intermittent streams do not have specialized adaptations to survive periods of zero flow, such as the ability to breathe air or aestivate. Instead, fishes such as suckers and salmonids survive in intermittent systems because they can tolerate the environmental conditions presented to them during intermittency (Kerezsy et al. 2017), or they emigrate from drying reaches into perennial ones. Suckers and salmonids are known to successfully use intermittent streams for spawning, refuge, and seasonal habitat (Levick et al. 2008; Kelly and Bruckerhoff 2024).

Despite their ability to tolerate intermittent systems, the resident fish assemblage in the Study Reach would benefit from consistent base flows for two reasons. First, even if abiotic conditions in an intermittent stream are conducive to survival, these systems are often food limited. For example, Brook Trout in intermittent Appalachian streams relied heavily on terrestrial insect prey during periods of low flow and did not switch to consuming more aquatic prey as available food was depleted (Courtwright et al. 2013). The authors noted that in 17 days of intermittency, the probability of individual fish having empty stomachs

increased from 4% to 37%. The Study Reach does not support extensive riparian vegetation, so food shortages downstream of the Shoshone Dam may be more severe during periods of zero flow because of a limited terrestrial prey subsidy. Second, intermittent systems contain shorter, simpler food webs than perennial streams. Based on a study of 36 North American streams of varying sizes, flow variability and intermittency significantly reduced aquatic food chain length and complexity, regardless of stream size (Sabo et al. 2010). For example, none of the intermittent streams in the study supported a piscivorous fish, and many of the intermittent streams supported small-bodied fishes or did not support fishes at all. This study implies that conditions in intermittent systems are not necessarily supportive of desirable species such as salmonids. However, if the Study Reach does receive intermittent flow, it is likely that resident fishes will use it on a seasonal basis, as recolonization of rewetted streams tends to be rapid. For example, rewetting of a stream in British Columbia resulted in the return of macroinvertebrates and spawning salmonids within a month (Decker et al. 2008). Rapid recolonization of the Study Reach could be expected after rewetting, particularly because it is close to a perennially flowing reach (e.g., Kerezsy et al. 2017; Kelly and Bruckerhoff 2024).

The expectation would be that an intermittent flow regime in the Study Reach would allow some resident fishes to seasonally inhabit the Study Reach. For example, the presence of native fish larvae (Bluehead Sucker, Flannelmouth Sucker, Roundtail Chub, and Speckled Dace) in the Colorado River in years of negligible runoff (Robinson et al. 1998), indicates that they are adapted to large interannual variations in flow. However, perennial flows would result in markedly improved conditions for fishes. Further, a perennial flow regime that exhibited some increase in flow during spring and early summer (i.e., during the natural spring runoff period) would greatly benefit the resident fishes in the Study Reach for the reasons discussed in the remainder of this report.

3. Macroinvertebrates

3.1 Macroinvertebrate Assemblages in the Study Reach

To provide information on the existing condition of macroinvertebrate assemblages in the reach of the Colorado River between the Shoshone Dam and the return at the Shoshone Power Plant (the "Study Reach"), a general internet search, a search of the Colorado Data Sharing Network (CDSN), and a search of the Water Quality Portal (WQP) of the National Water Quality Monitoring Council (NWQMC) Information System were all completed. No data from within or in the vicinity of the Study Reach were found in the CDSN database, but relevant data were available in the WQP. The internet search also produced multiple reports of macroinvertebrate surveys by Timberline Aquatics (Timberline) that were completed for the Upper Colorado River Wild & Scenic Stakeholder Group (Rees and Musto 2019, Rees and Grap 2019 Rees and Fenske 2022, Rees 2024a). In addition, CPW provided macroinvertebrate data for a single location sampled in November 2024.

Of the existing data, the site sampled by CPW was the only location that was surveyed within the Study Reach (Figure 3-1). The downstream extent of our searches for data in CDSN and WQP was the confluence of the Roaring Fork and the Colorado River, approximately 6.5 miles downstream of the Study Reach. No data were available between the Study Reach downstream to the mouth of the Roaring Fork. The data available from the WQP and Timberline were from samples collected upstream of the Study Reach and upstream of the confluence of the Colorado and Eagle rivers (Figure 3-1). Conditions are not strictly the same upstream of the confluence of the Colorado and Eagle rivers as downstream of it. However, the macroinvertebrate communities upstream of the confluence would likely share many of the attributes of the downstream communities in the absence of dewatering in the Study Reach.

CPW sampled a single site within the Study Reach in November 2024, described as being below Devil's Hole. While full operations of the Shoshone Hydroelectric Plant resumed in August 2024, likely leaving much of the Study Reach dewatered, the CPW located an area to sample that appeared to have perennial flow, most likely due to dam seepage and to input from springs on adjacent hillslopes. Based on this, data from this site does not represent the intermittent flow conditions present in much of the Study Reach when the plant is operating but instead provides information on what the macroinvertebrate assemblages could be expected to resemble throughout the Study Reach if consistent flows were present.

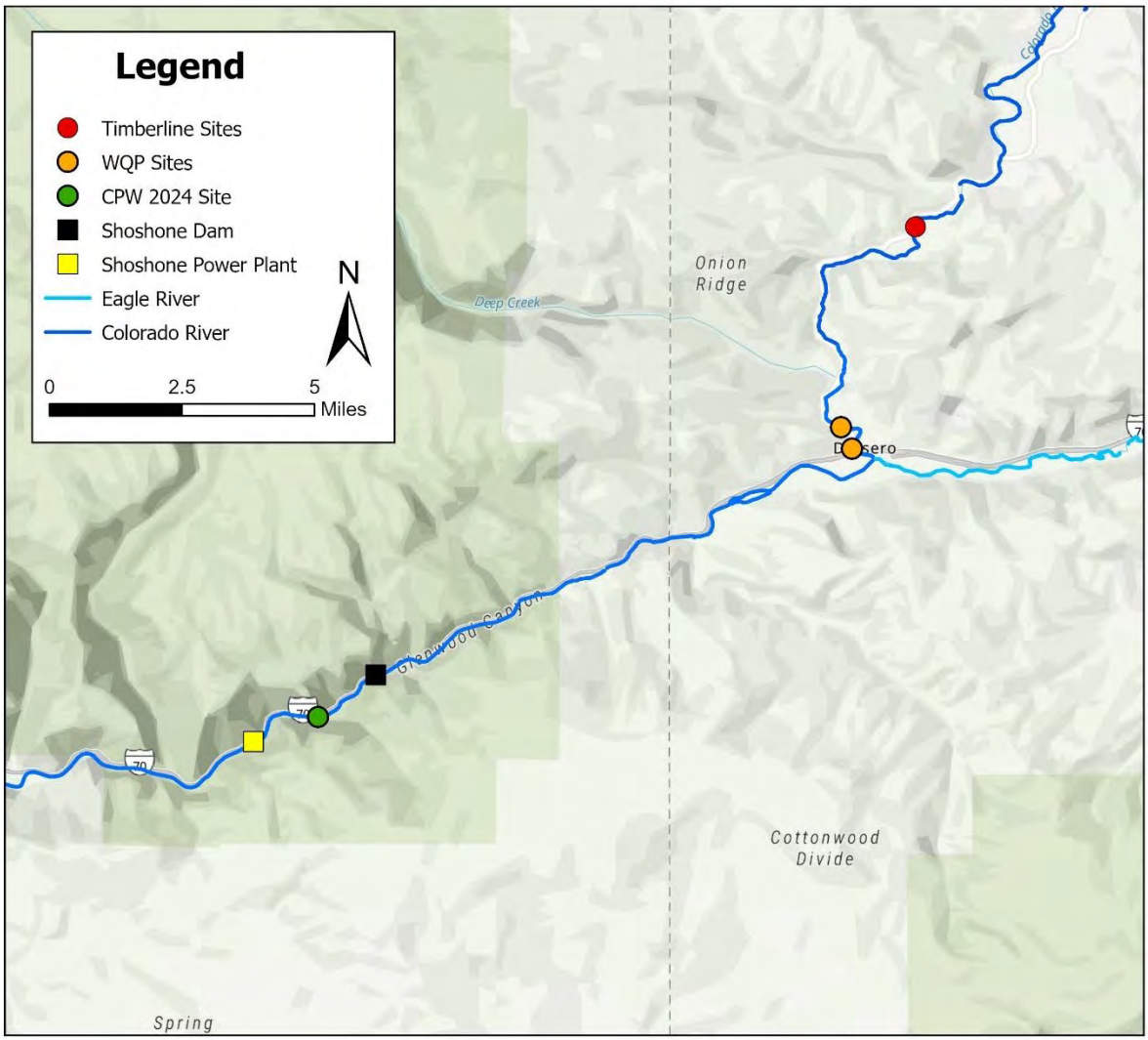


Figure 3-1.—Map of macroinvertebrate sampling sites on the Colorado River, within and upstream of the Study Reach.

Within the sample collected by the CPW in 2024, the generally sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa comprised 55 percent of the total number of taxa present, suggesting favorable conditions exist for these species (Table 3-1). The diversity value indicated that the community was slightly unbalanced; this resulted from a common and moderately tolerant mayfly taxon, *Baetis tricaudatus*, dominating the community, making up 64 percent of the total abundance. Multiple other mayfly taxa were also present at lower abundances, and these taxa included three mayflies from the Heptageniidae family, a family that is considered especially sensitive to metals as well as other disturbance (Kiffney and Clements1994; Clements et al. 2002, Clements et al. 2021) and generally prefers moderate to high current velocities. Sensitive stonefly and caddisfly taxa were also present, including a single salmonfly individual, *Pternonarcella badia*.

Table 3-1.—Summary of macroinvertebrate metrics for the samples collected from the Colorado River within and upstream of the Study Reach. Data are presented from upstream to downstream. NC = not calculated.

Year Sampled	Number of EPT Taxa	Number of Total Taxa	Diversity Value	MMI Score	HBI Score	TIVSED
Timberline Site						
2018	23	41	3.46	74.7	3.88	4.60
2019	21	41	3.20	71.6	2.64	4.66
2021	25	43	2.56	70.3	4.64	4.45
2023	22	44	3.43	73.4	3.42	4.58
WQP Sites						
2000	19	31	3.34	NC	NC	NC
2013	66	25	4.21	NC	NC	NC
CPW Site (Study Reach)						
2024	18	33	2.40	64.3	4.46	5.63

Multiple indices were calculated from the data provided by the CPW (Table 3-1). The Colorado Multimetric Index (MMI), a measure of macroinvertebrate community health (CDPHE 2020), was calculated to be 64.3, well over the threshold (45) indicating attainment of the aquatic life use. Being in attainment of the aquatic life indicates that the location sampled supports a wide variety of macroinvertebrate species, including sensitive species, and that there are no indications that the abundance or diversity of the community is impaired. This score is also over the threshold designating it as a high-scoring water (56). Such waters are considered exceptional and worth additional protections to prevent any declines in condition.

Two other indices were calculated to describe the macroinvertebrate community, including the Hilsenhoff Biotic Index (HBI) that evaluates the macroinvertebrate assemblages' tolerance to poor water quality and disturbance (Hilsenhoff 1987) and the Tolerance Indicator Value specific to sediment (TIV_{SED}) that evaluates the macroinvertebrate assemblages' tolerance to excessive fine sediment (CDPHE 2024). Values for both were favorable, with the HBI value suggesting conditions were "very good" based on the categorization scale and the TIV_{SED} suggesting that excessive fine sediment is not impacting the macroinvertebrate community. Of note, while metric values suggest a healthy community exists within this location with perennial flow in the Study Reach, scores associated with these metrics were generally lower for this site than for the sites further upstream (see following paragraphs). This may reflect the limited areas with perennial flow that are present within the Study Reach or could indicate that this location has experienced some drying periods in the past. Alternatively, differences in substrate composition or other aspects of the stream habitat may differ, accounting for the slightly lower values.

Macroinvertebrate data were collected on the Colorado River approximately 6 miles upstream of the confluence with the Eagle River over several years, with sampling conducted

in 2018, 2019, 2021, and 2023 (Rees and Musto 2019, Rees and Grap 2019, Rees and Fenske 2022, Rees 2024). In addition to the raw data, multiple metrics were provided in these reports for the samples collected (Table 3-1). Of note, additional sites on the Colorado River were sampled further upstream; the data presented here is from the site location that was in the closest vicinity to the Study Reach. As with the site sampled within the Study Reach, the generally sensitive EPT taxa comprised half or more of the total taxa present. The MMI values ranged from 70 to 75. These values indicated healthy communities were supported in this reach, and these scores were also above the high-scoring water threshold that indicates sensitive communities that are worth additional protection. Diversity values also suggested that balanced assemblages were present. Mayflies were the dominant group in all years, although, as in the CPW sample, typically the common and moderately tolerant mayfly taxon, *Baetis tricaudatus*, was the most abundant taxon. The HBI values were also favorable, categorizing the communities as excellent, very good, or good. The TIV_{SED} values were all less than the threshold for this region, indicating excessive fine sediment is not impacting the macroinvertebrate communities in this stream reach.

Two other sites were sampled upstream of the Study Reach and between 0.3 and 1.0 miles upstream of the confluence with the Eagle and Colorado rivers. Only raw data were available for these sites; the MMI, HBI, and TIV_{SED} values were not provided (Table 3-1). Also of note, data for these sites was included in the WQP database; little background information is provided in this database as to the purpose of the sampling or more specific details about sampling methods. The metrics calculated from these data are not necessarily comparable to the CPW and Timberline data because of this. The site 1.0 mile upstream of the confluence with the Eagle River was sampled in September 2013 and likely consisted of multiple composited replicates or a large area were sampled based on the data. Thirty-eight percent of the taxa were EPT taxa, and the diversity value again suggested a well-balanced community was present. In contrast to the samples collected farther upstream, the common and moderately pollution tolerant caddisfly, *Hydropsyche* sp., was the dominant species, comprising 24 percent of the relative abundance. In April 2000, a site was sampled 0.3 miles upstream of the confluence with the Eagle River. While the total number of taxa collected at this site was lower than observed at the Timberline or other WQP site, EPT taxa comprised 61 percent of the total taxa. Diversity was within the range observed at the other sites, and *B. tricaudatus* was again the dominant species, comprising over 30 percent of the relative abundance.

For the sites sampled by CPW and Timberline (Rees and Musto 2019, Rees and Grap 2019, Rees and Fenske 2022, Rees 2024a, 2024b) on both the Colorado and Eagle rivers, a functional feeding group analysis of the macroinvertebrate assemblage was completed. As is often typical, collector-gatherers or collector-filterers were the dominant groups. These groups feed on fine particulate organic matter in the substrate or water column, respectively. Scrapers which graze on algae by scraping it off of hard substrates or surfaces and are often considered sensitive to pollution and disturbance were also often abundant, although this

group was not well represented in the sample collected within the Study Reach. Shredders, which feed on coarse organic particulate matter such as leaves, and predators, which feed on other macroinvertebrates or organisms, were less abundant but were consistently present. The presence of at least a few long-lived taxa in these samples indicates conditions are favorable and stable over time in and upstream of the Study Reach in the Colorado River, although these taxa were more limited in the sample collected from the Study Reach itself.

3.2 Instream Flow Benefits to Macroinvertebrates

The macroinvertebrate communities described above are only found in perennial systems, but an intermittent flow regime could support a subset of the taxa found in perennial reaches. Intermittent streams can support a diverse macroinvertebrate community. Macroinvertebrates can tolerate periods of little to no flow through physiological adaptations such as tolerance of low dissolved oxygen and behavioral mechanisms such as refuging in the hyporheic zone during periods of no flow (Magland et al. 2020). However, densities and species richness tend to be lower than those found in perennial systems (Levick et al. 2008). The presence of a healthy community in the location within the Study Reach that appeared likely to have more consistent flows present suggests that if continuous flow were present throughout more of this reach, such a community could serve as a source population to provide individuals that could colonize newly wetted areas.

Intermittent streams present challenges ranging from water quality changes to increased predation risk by vertebrates (Stubbington et al. 2017). Environmental changes associated with cessation of flow create unsuitable conditions for taxa that prefer riffle habitat, rheophilic (i.e., flow-loving) taxa, and specialist feeders (Rolls et al. 2012). For example, riffles are more prone to drying than other stream habitat features, and filter feeders rely on flows for food delivery. Scrapers and shredders are also considered specialist feeders, and predators tend to be long-lived, taking one to three years to complete their life cycles. Many of these taxa cannot tolerate flow regimes that include zero-flow days. A 1994 study of an intermittent system in Australia tracked community richness as a function of flow; detritivores were most common during periods of no flow and predator taxa were the last to recolonize after flows resumed (Closs and Lake 1994).

Many of the taxa that do not tolerate intermittency (EPT taxa, select functional feeding groups, and long-lived taxa, Stubbington et al. 2017) provide high-quality forage for trout. Suttle et al. (2004) categorized specific macroinvertebrate families as being vulnerable to predation by juvenile trout, indicating these families are preferred forage for these fish. Several of these families, including mayflies in the family Baetidae, were well represented in the sample data for the Colorado River within and upstream of the Study Reach. Other groups present in lower abundances that were categorized as vulnerable included mayflies in the families Heptageniidae, Leptophlebidae, and Leptohyphidae, stoneflies in the Perlodidae family, caddisflies in the family Brachycentridae, and true flies in the Chironomidae family,

as well as occasional representatives in most of the remaining groups. Several of these EPT families are rheophilic and may presently be uncommon or absent in the Study Reach under current flow conditions other than within the limited locations that support more perennial flow such as the site sampled by CPW. If flows are persistent, these groups would likely become established, providing a forage base for trout and other fish species.

The macroinvertebrate community throughout most of the Study Reach is likely impacted by inconsistent and sometimes absent flows. Other than the locations where perennial flow is present due to dam seepage, groundwater upwellings, or tributary inflows, the current macroinvertebrate community in the Study Reach may be dominated by short-lived taxa such as many chironomid midges that can complete their life cycle quickly during the time that flow is present (Stubbington et al. 2017; Colorado Water Quality Control Division 2020). Other taxa that have adaptions that allow them to disperse aerially, have desiccation tolerant adaptions, or have the ability for certain life stages to persist in the hyporheic zone may also be present in the Study Reach. The expectation would be that if flows in the Study Reach were intermittent, the macroinvertebrate community would contain a subset of the taxa that were found in the samples from the Colorado River by CPW and Timberline and that these taxa would provide some forage for resident fishes. If flows were perennial, the macroinvertebrate communities in the Study Reach would be similar to the ones described from upstream of the Study Reach and within the Study Reach at the location exhibiting perennial flow. In other words, the robust communities found at these locations would presumably expand to all areas with perennial flow. The communities would be comprised of a high proportion of EPT taxa, diverse functional feeding groups, and long-lived taxa, many of which are preferred by trout. These communities would provide ample high-quality forage for fish.

4. Flow and Food Webs

Nutrient dynamics are strongly influenced by flow regime (Poff et al. 1997; Palmer and Ruhi 2019). Although flow regimes vary across river types and climates (Poff et al. 1997), human activities such as water withdrawal and reservoir operations are major influences on hydrological regimes and, therefore, nutrient dynamics (Jiang et al. 2021).

Nutrients are transported downstream in a cyclical fashion. They are taken up by organisms, transformed, and then released back into the water column, where they can be transported further downstream. This process, referred to as nutrient spiraling, requires physical transport of nutrients and biological uptake and transformation (Allen et al. 2021). Therefore, nutrient cycling is affected by flow changes because of their effects on transport rates and on the biological communities that process nutrients.

4.1 Consistent Base Flows Benefit Stream Food Webs

Reduction or cessation of flow can reduce or prevent nutrient and organic matter inputs from upstream, riparian, and hyporheic sources (von Schiller et al. 2017). Dam operations such as flow reduction can reduce the availability of already-limited nutrients such as phosphorus (Maavara et al. 2020) or impact nitrogen concentrations by altering microbial activity in streambed sediments (Merbt et al. 2016). Low flows can also alter nutrient dynamics by stranding of materials during flow recession or drying (von Schiller et al. 2017).

In addition, low flow or lack of flow can inhibit incorporation of raw materials into the food web in a number of ways. First, terrestrial plant litter is a crucial component of the aquatic food web in headwaters and mid-order river systems (Vannote er al. 1980, Rosi and Vallis 2016). This organic material is an integral component of the food web because it provides a primary food source for numerous bacterial and macroinvertebrate taxa. Bacteria living on organic matter can also provide significant nutrition to macroinvertebrates; Hall and Meyer (1998) determined that benthic macroinvertebrates obtained 10 to 100 percent of their carbon from this source. Low flows or lack of flow can inhibit or prevent transport of terrestrial plant litter within or downstream of a stream reach. Low flow or absence of flow can also strand terrestrial plant litter and make it unavailable to the aquatic food web.

Low flow or lack of flow also alters the microbial community in a stream system, which affects the food web. Microbes are essential for breakdown of leaf litter (Rolls et al. 2012) and for maintaining algal communities in aquatic habitat. Algal production can support invertebrate and fish production in a river and be of greater importance than allochthonous inputs (terrestrial inputs) in some systems. This may have particular applicability to the Study Reach, as it is characterized by a limited riparian community (and therefore potentially lower allochthonous inputs). Specific biochemicals that are synthesized by algal communities can

have an inordinate influence on productivity of multiple trophic levels (Brett et al. 2017). The algal community may synthesize long carbon chain polyunsaturated fatty acids, which provide high-quality nutrition to macroinvertebrates and therefore higher trophic levels (Guo et al. 2016). Microbial assemblages recover after drying periods, once aquatic habitat is restored with increased water levels, but an increase in the frequency and magnitude of drying periods greatly inhibits these assemblages from rebounding (Hall and Meyer 1998). When aquatic habitat is exposed to fully dry periods, as opposed to wetted periods, autotrophs (e.g., algae, cyanobacteria, and aquatic plants) are also slow to recolonize (Hall and Meyer 1998). Therefore, consistent base flow facilitates development of a more robust community of primary producers. Finally, low flow or lack of flow selects against certain macroinvertebrate taxa, such as shredders (See Section 3) which also break down organic matter such as leaves for incorporation into the aquatic food web.

4.2 Periodic High Flows Benefit Stream Food Webs

In rivers with variable hydrology, seasonal or occasional high-flow events play a crucial role in nutrient dynamics. These floods can redistribute materials across the floodplain, enhancing nutrient availability and influencing the productivity and diversity of aquatic and terrestrial ecosystems associated with the river (Bunn and Arthington 2002). A lack of periodic high flows in a river restricts connectivity to the floodplain and alters the exchange of energy between aquatic and terrestrial systems. For example, leaf litter availability to and terrestrial invertebrate input into aquatic habitats decline with a reduction in wetted area (Courtwright et al. 2013). Linkages between the terrestrial and aquatic environments are critical to stream health, as they promote reciprocal subsidies (i.e., beneficial exchanges of materials) between the two environments. The subsidies range from bacteria and organic matter to terrestrial invertebrates, and they are essential to the function of aquatic environments (Hall and Meyer 1998; Baxter et al. 2005). For example, multiple studies have shown that inundated floodplains subsidize food webs and increase growth and survival of juvenile salmonids (Sommer et al. 2001; Bellmore et al. 2013; Sturrock et al. 2022). The importance of reciprocal subsidies was demonstrated by Rolls et al. (2012); reduced connection to the floodplain can change the dominant energy source in a stream reach from allochthonous (i.e., external/terrestrial) to autochthonous (i.e., internal/aquatic, Rolls et al. 2012).

Regular exchange of materials between the limited aquatic floodplains and the aquatic environment would still support the aquatic food web in the Study Reach. However, macroinvertebrate prey transport may be more critical in the Study Reach than in lower-gradient reaches, simply because a limited riparian plant community may result in reduced input of terrestrial insect prey. Gresswell et al. (2005) found that shrub cover on stream bank habitat was highly associated with terrestrial prey availability for Coastal Cutthroat Trout and that terrestrial prey comprised seasonally varying but significant portions of trout diets. Saunders and Fausch (2012) determined that in forest and grassland stream ecosystems in the Colorado Rocky Mountains with two or more species of trout, terrestrial invertebrates falling

into streams from riparian vegetation provided 30 to 45 percent of trout annual energy consumption. Because trout benefit from terrestrial invertebrate prey, and because terrestrial insect inputs may be less common in canyon reaches, a healthy food web in the Study Reach will rely on sufficient base flow to maintain aquatic macroinvertebrate drift and to maintain robust, diverse macroinvertebrate populations (See sections 3.2 and 6.4 for more details).

4.3 Intermittent Flow Causes High Unpredictability in Aquatic Food Webs

The spatial and temporal variability of nutrient and prey availability is far higher in intermittent streams than in perennial ones. While the effects of drying were discussed earlier in this section, the variability in nutrient and organic matter availability during and after intermittency is discussed here.

During periods of intermittency, concentrations of nutrients and dissolved organic carbon exhibit high spatiotemporal variability (Stubbington et al. 2020). For example, high temperatures and solar radiation in isolated pools can stimulate high rates of photosynthesis and an uptake in nutrients that decreases water column concentrations. Conversely, in isolated pools with low algae and plant densities, evaporation can increase water column nutrient concentrations. Changing water temperatures also alter microbial activity, which has a large influence on rates of organic matter decomposition and resultant concentrations of dissolved organic carbon (Stubbington et al. 2020). Therefore, the conditions in an isolated pool are dependent on local conditions and the duration of drying and are not typically as stable as would be expected in a perennial system.

The return of consistent flows after intermittency can have significant effects on nutrient and organic matter availability, both within and downstream of the intermittent reach. During dry periods, breakdown of organic matter still occurs in the terrestrial environment (von Schiller et al. 2017), and rewetting causes significant and sudden inputs of allochthonous material. Recovery of bacterial metabolism is rapid and facilitates a pulse of nutrient availability, and flows deliver these materials and nutrients into and downstream of the reach (von Schiller et al. 2017). These “first-flush events” often have high nutrient concentrations and can create water quality issues downstream of the rewetted reach (Stubbington et al. 2020).

The food web in the Study Reach would benefit from a stable base flow that facilitated transport and cycling of organic material and nutrients. Higher flows that allowed periodic floodplain connection would confer benefits such as reciprocal prey subsidies and enhanced exchange of terrestrial and aquatic materials. Intermittent flows in the Study Reach would likely support a limited food web, particularly because of low rates of terrestrial leaf litter input. Finally, because streams are longitudinally constrained, changes in nutrient dynamics at upstream sites, particularly those near dams, can cause cascading effects downstream (Nixon 2003). Therefore, cycles of drying and rewetting in the Study Reach may lead to

periodic downstream disturbances in water quality, but this would depend on myriad factors such as nutrient dynamics during intermittency and flow rates upon rewetting.

5. Flow, Sediment, and Temperature

5.1 Flow Effects on Sediment Regimes in Rivers

Sediment transport in rivers is tightly coupled with water discharge and depends on sediment sources, valley geometry, and in-channel topography. Canyon reaches are typically considered transport reaches, where sediment is predominantly transported rather than sourced or stored (Schumm 1977). Sediment supply and transport capacity determine channel geometry and habitat availability, including bedforms such as riffles, pools, and bars. When averaged temporally at a point in space, the channel-maintaining discharge, or dominant discharge, can be defined as the single most effective discharge that shapes a channel's cross section. This discharge maximizes the flow frequency with the magnitude of geomorphic work, or amount of sediment transported by the channel. Classical geomorphology literature defines this discharge to typically occur every 1-2 years (Wolman and Miller 1960), though the actual recurrence can vary depending on characteristics of the environment (i.e., climate, flashiness, history of disturbance). Though actual channel geometry formation is much more complex and depends on the entire range of flows including baseflows and large floods, these intermediately occurring channel maintenance flows are a useful concept when assessing reaches for instream flows. Channel maintenance flows flush interstitial spaces, scour encroaching vegetation and create germination surfaces, maintain channel conveyance capacity, help maintain bedforms, and recruit and transport wood (Knighton 2014, Wohl 2014).

As sediment transport zones, canyon reaches typically do not contain the same magnitude of physical diversity and biogeochemical cycling as unconfined reaches (Wohl et al. 2018). Within canyon reaches that already lack prolific habitat diversity compared to unconfined reaches, small pockets of habitat are highly valuable as they provide refugia and seasonal habitat for resident species. Aside from the need for biotic inputs, physical maintenance of these pockets of habitat requires balance between flow and sediment regimes (Poff et al. 1997; Wohl et al. 2015).

Flow regulation from dams, reservoirs, hydropower, water diversion, and other water uses impacts channel morphology by disrupting the natural flow regime and the sediment balance (Poff et al. 1997; Wohl et al. 2015; Grant 2012; Church 1995). Typical changes in channel morphology in response to flow regulation include armoring, narrowing, and degradation, though aggradation can occur from the lack of transport capacity to remove sediment inputs from tributaries or suspended sediment (Schmidt and Wilcock 2008). Flow regulation decreases topographic diversity, including pool amplitude and frequency (Duffin et al. 2023), through the accumulation of fine sediments in pools and lack of scouring flows to maintain the pools. To combat this and other potentially negative impacts of flow regulation, several

approaches have been produced for regulated reaches to achieve ecological function with environmental flows that are designed to meet human and ecosystem needs (Poff et al. 2010). Functional flows can target specific ecological functions in regulated reaches (Yarnell et al. 2015) and can even be designed to favor native aquatic species over nonnatives (Chen and Olden 2017). Larger flows, such as seasonal transition flows and peak runoff, serve ecological functions that allow channels to maintain nutrient cycling and population dynamics, and to adjust to rapid sediment inputs such as landslides and debris flows (Yarnell et al., 2015, Figure 5-1).

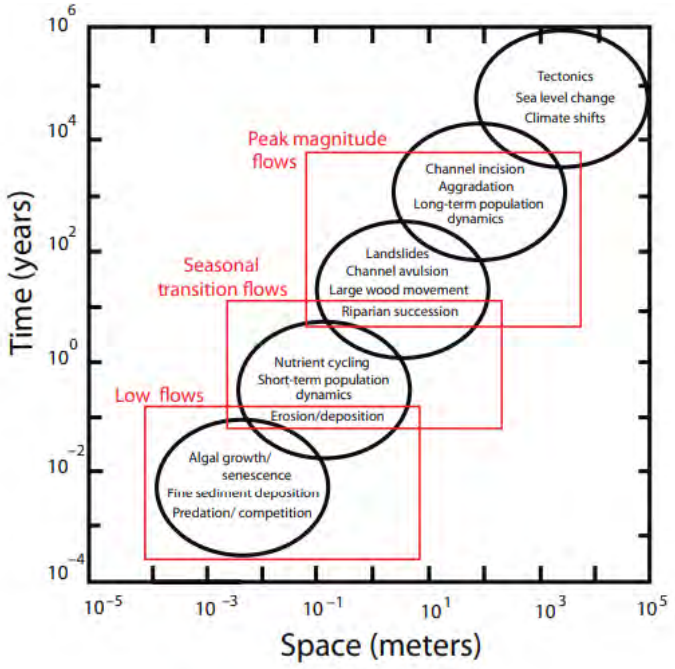


Figure 1. Examples of interrelated physical and ecological riverine processes at varying spatial and temporal scales. Key functional flows supporting specific processes are shown in boxes.

Figure 5-1.-- *Figure 1 of Yarnell et al. (2015) exemplifies the ecological and geomorphic significance of a range of flows.*

The designation of medium to high flows, or flushing flows, that regularly maintain ecosystem function on an annual to bi-annual time span, allows for the evacuation of fine material from the interstitial spaces between larger particles (Kondolf and Wilcock 1996). Flushing flows are often defined by the threshold of incipient motion for particles within the reach. Lower flows, such as consistent base flows, maintain the connection between surface water and groundwater, regulate the thermal regime, and provide consistent access to habitats along channel boundaries (Miller et al. 2016; Wohl et al., 2015). Rumsey et al. (2015) estimate that baseflows comprise up to 48% of total streamflow in the Upper Colorado River Basin. Though not as efficient at transporting sediment as flushing flows, baseflows can help prevent over-siltation of the streambed which could cause loss of habitat (Wohl et al. 2015).

The Study Reach lies within the burn scar of the 2020 Grizzly Creek Fire. Colluvial and tributary sediment sources, especially from debris flows following wildfire, add significant fine material to the Colorado River that may require flushing flows to allow the river to morphologically adjust. Extreme sediment sources such as debris flows also increase overbank flood hazards by filling in the riverbed and leading to lasting turbidity concerns (Rengers et al. 2024; Erku 2021). In 2021, a debris flow from Devil's Hole Creek, a perennial tributary entering the Colorado River from river left approximately one river mile downstream of the dam, temporarily dammed the Colorado River. Large sediment inputs and resulting flow disruptions have also occurred in Blue Gulch and the gulch near local landmark Flag Buttress at Interstate 70-mile marker 124 (Bakich, pers. comm. 2025). In addition to damaging infrastructure, debris flows create biological disturbances where recovery typically takes one to several years (Foster et al. 2020; Graber et al. 2023) but may take longer under regulated flow conditions. Biological consequences from extreme sediment inputs can include large fish kills, such as the July 2012 fish kill upstream of Dotsero caused by large sediment inputs following summer thunderstorms (Willoughby 2012). Flushing flows are necessary to redistribute fine sediment that is input to the channel from debris flows and flash floods.

In addition to extreme, infrequent events, annual high-yield sediment events also add significant sediment load to the channel within the reach. Seasonal high turbidity consistently occurs annually as upstream sources and tributaries input fine sediments to the water column. Annual anthropogenic influences also impact sediment loading, including excess sediment releases from opening of the dam gate during lower flows that do not have capacity to transport the sediment released (Bakich, pers. comm 2025). Whether increased sediment loading events are annual or episodic in nature, flushing flows are required to maintain sediment continuity within the reach.

Just as tributary junctions are biological hotspots more broadly within river networks (Benda et al. 2004), confluences with sediment sources within steep canyon reaches also serve as valuable habitat for biota. Debris fans from tributaries, debris flows, or avalanche chutes not only provide regular sources of sediment but also create adjacent channel morphology that provide velocity refugia to fish and macroinvertebrates. The velocity refugia occur in eddy pools and recirculation currents upstream and downstream of debris fans. These areas are small depositional environments in otherwise transport-dominated canyon reaches (Cinderelli and Cluer 1998, Figure 5-2). With consistent sediment input but absence of flushing flows, the velocity refugia provided in the slower recirculation currents may completely fill with sediment and eliminate disproportionately important habitat. Channel flushing flows are also known to be important in regulated canyon reaches because they allow for removal of sediment from the bed and redistribution of sediment into bars that macroinvertebrates rely on (Mueller et al. 2014; Mueller et al. 2018).

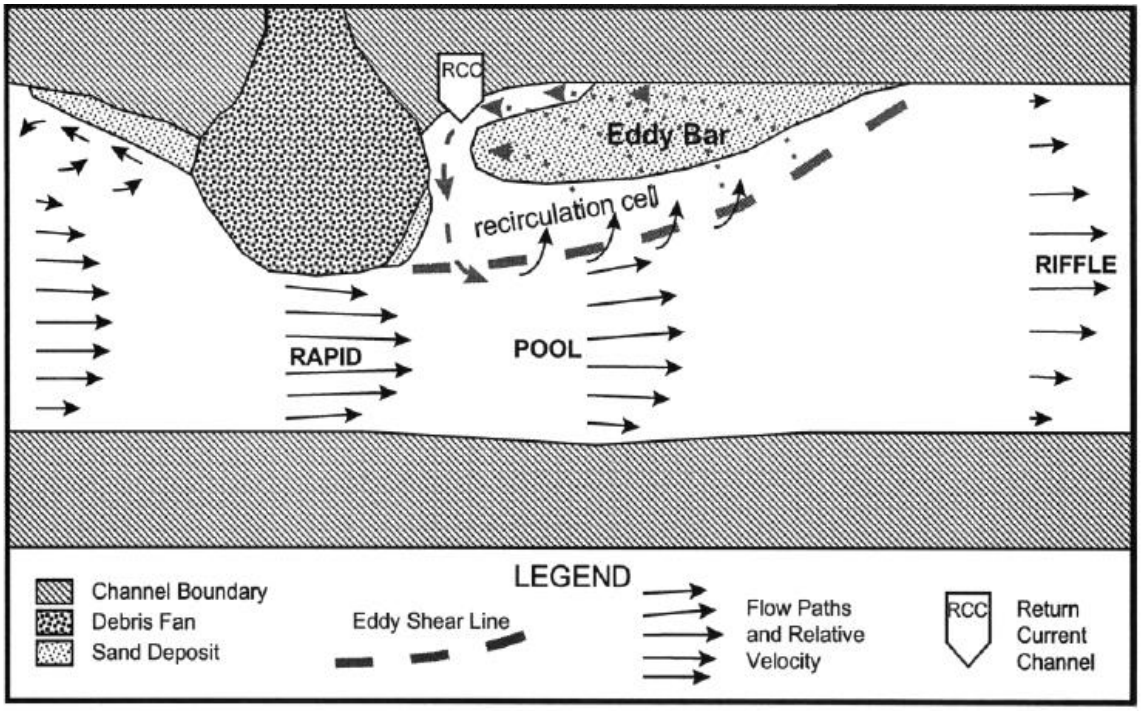


Figure 12. Schematic map showing typical channel margin sand deposits and features of lateral flow separation zones.

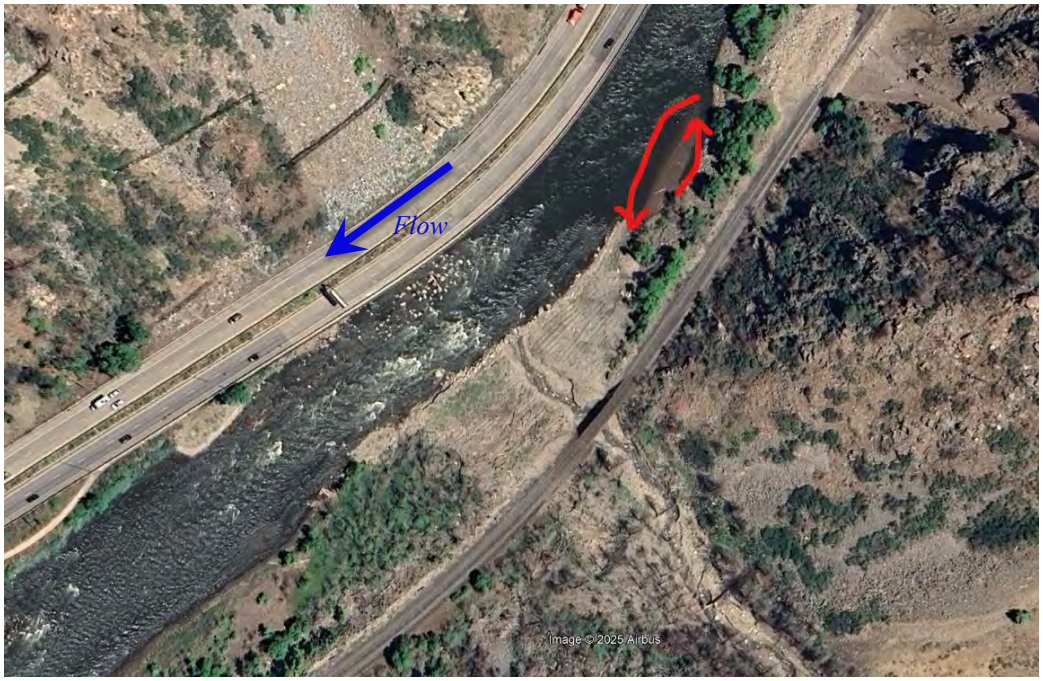


Figure 5-2.—*Cinderelli and Cluer (1998)'s Figure 12 provides a schematic of recirculation currents and eddy bars associated with sediment inputs at tributary junctions in canyon reaches (top). In Glenwood Canyon, these habitats are located upstream and downstream of steep tributary inputs (bottom).*

5.2 Flows Can Stabilize Temperatures in the Study Reach

The thermal regime of rivers controls biological function and timing, contributes to rates of biogeochemical cycling, and buffers ecological response to disturbances such as high temperature events (Olden and Naiman 2010). Major components of a stream's temperature regime include the annual range, the diel range, thermal periodicity, and the winter minimum and summer maximum temperatures (Giller and Malmqvist 1998). The range and distribution of temperatures in a stream system determine what species it can support. Aquatic species ranging from bacteria to fishes cannot regulate their body temperatures and have different thresholds of stream temperatures that they can tolerate, with decreased survival at and beyond the limits of their tolerance ranges. Accumulated thermal patterns, such as the number of days at or above a threshold temperature, determine species' maturation times and development times within their life cycles (Ward and Stanford 1982). Therefore, changes to thermal regimes can impact the survival of native coldwater and important sportfish species such as trout (Ficke et al. 2007; Bear et al. 2007; Elliot and Elliot 2010).

Stream temperature varies seasonally, daily, and spatially depending on solar radiation, atmospheric conditions, in-channel and surrounding topography, riparian vegetation, hyporheic exchange, interaction with groundwater, among other factors (Leach et al. 2023). Spatial thermal heterogeneity within streams is largely dependent on channel topography such as riffles, pools, and marginal backwater habitats. Various species selectively take advantage of thermal heterogeneity to optimize metabolic activity both under normal conditions and to maximize survival during times of stress (Armstrong et al. 2013). For example, over the course of a day, there may be more food availability in cold sections of a channel bed, but the rate of metabolism of the food obtained from colder sections can be optimized by moving to a warmer location. Increases in floodplain connectivity and habitat heterogeneity from river restoration, for example, can help enhance thermal heterogeneity that supports diverse species assemblages (Noone et al. 2024).

The thermal regime of a river is impacted by anthropogenic activity. Water temperatures below water infrastructure such as dams, and thus the ability for a stream to maintain thermal viability for species, is directly dependent on the volume of water in the stream and the temperature of the water released downstream (Mihalevich et al. 2020; Olden & Naiman 2010, Poole and Berman 2001). Inadequate flows do not provide volumes of water sufficient to buffer the impacts of radiation from extreme air temperatures (Sinokrot and Gulliver 2000), and flow diversions typically result in warm summer temperatures and cool winter temperatures outside of the river's typical range (Meier et al. 2003). Thermal regimes altered by flow regulation can also lead to asynchrony between natural seasonal patterns that cue growth, development and other components of the life cycles of species present in the reach (Vannote and Sweeney 1980; Olden and Naiman, 2010). The geomorphic homogenization of channel topography due to flow regulation (Duffin et al. 2023; Rahel 2002; Poff et al. 2007) reduces thermal heterogeneity and the opportunities for species to optimize metabolic

processes and survival through behavioral thermoregulation (Armstrong et al. 2013). Altered temperature regimes can alter the maturation time or development time of species native to the area and make them more sensitive to disturbance or more susceptible to predation.

The Study Reach is categorized as a Cold Tier I stream temperature segment by the Colorado Department of Public Health and Environment (CDPHE), with some variations from typical Cold Tier I standards depending on the time of year (5 CCR 1002-33). As shown in Table 1, temperature standards for this reach include daily maximum temperature (DM, acute) of 21.2° C and maximum weekly average temperature (MWAT, chronic) of 16.9°C between April 1st and May 31st. Between June 1st and September 30th, the segment follows Cold Stream Tier II standards of 18.3° C MWAT and 24.3° C DM. From October 1st-October 31st, the standard for DM temperature is 21.2° C and the MWAT is 16.9° C. Between November 1st and March 31st, the segment is classified under Tier II with standards of 9° C and 13° C for MWAT and DM respectively (Table 5-1).

Table 5-1.—*Temperature standards for the Study Reach.*

	Temperature Standard (°C)	
Date Range	**Daily Maximum**	**Maximum Weekly Average Temperature**
April 1st–May 31st	21.2	16.9
June 1st–September 30th	24.3	18.3
October 1st–October 31st	21.2	16.9
November 1st–March 31st	13	9

Between 2021 and 2025, the daily temperature did not exceed the DM temperature standards at the USGS gages located upstream of the Study Reach at Dotsero or downstream of the Study Reach above Glenwood Springs (Figure 5-3). Weekly average temperatures exceed the defined standards both upstream and downstream of the Study Reach (Figure 5-4).

Though daily maximum temperatures fall within the regulatory standards for reaches upstream and downstream of the Study Reach, the reach does not meet the weekly average temperature standards that were developed in part to be compatible with the biology of resident fishes. Months of July and August did not meet MWAT standards consistently between 2021 and 2024 at the upstream and downstream gages. Flow intermittency or absence of flow within the Study Reach would likely exacerbate unfavorable temperature conditions within the Study Reach, because of a lack of appropriate-magnitude continuous (i.e., baseflow) and episodic (i.e., flushing flow) cold water inputs. Maintenance of spring runoff flows and baseflows could provide thermal benefits through channel maintaining flows that physically scour pools to offer thermal refugia during summer months, and via more consistent supply of cooler flowing water during baseflow.

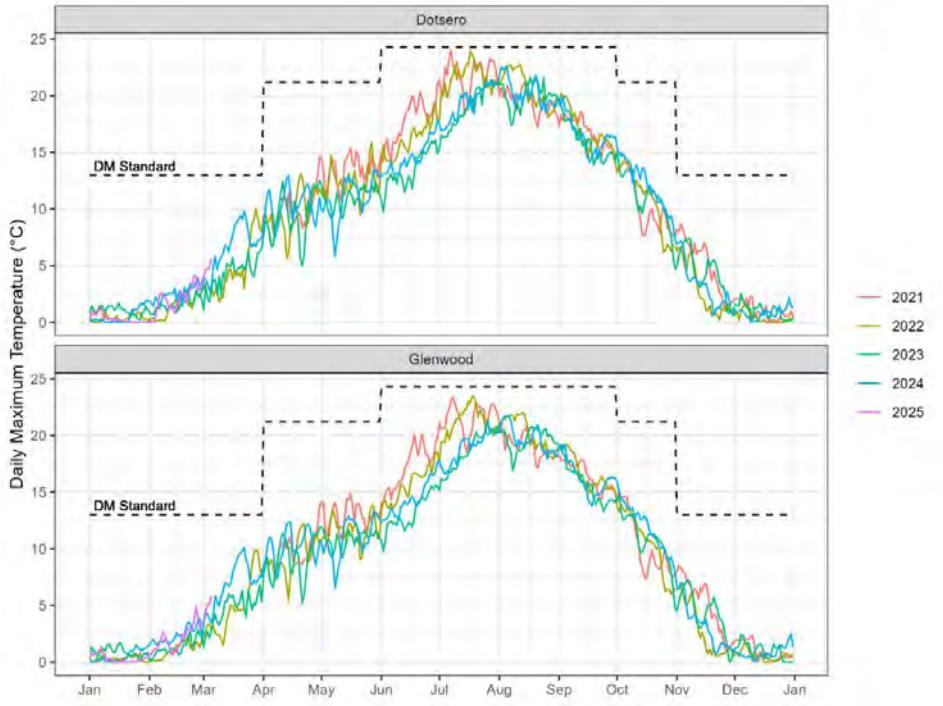


Figure 5-3.—*Daily maximum temperatures from Dotsero and Glenwood USFS stream gages on the Colorado River.*

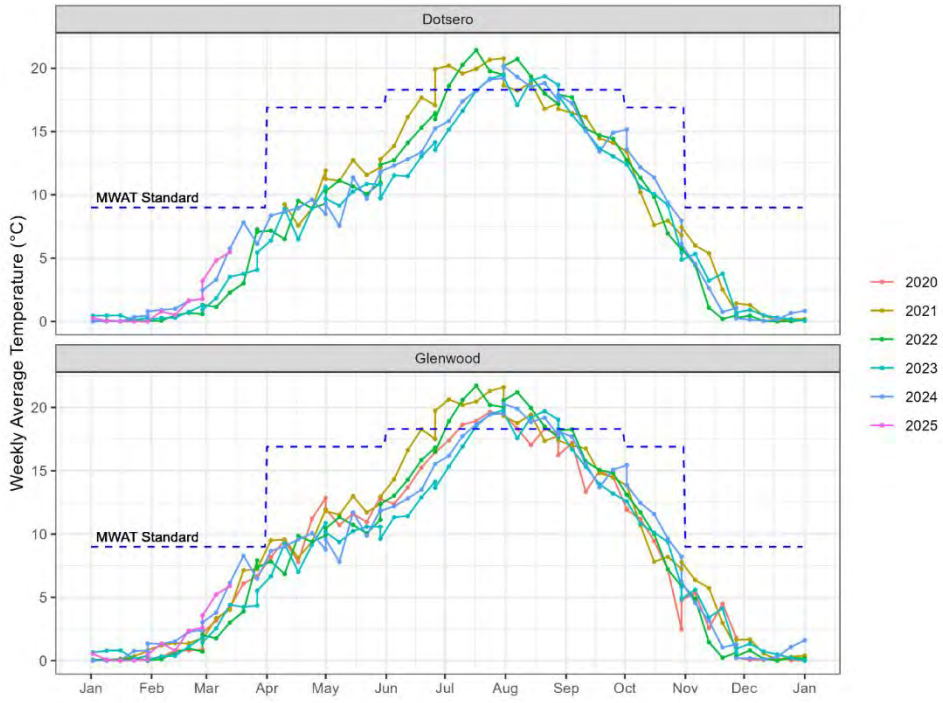


Figure 5-4.—Weekly *average temperature with MWAT standard temperature thresholds for Dotsero and Upstream of Glenwood USGS gages (Gages 09070500 and 09071750). The average weekly temperatures are calculated with continuous 15-minute temperature data.*

6. Flow and Aquatic Habitat

Stream flow and aquatic habitat availability are inextricably linked. To provide context for the ecological importance of the Study Reach, its value to native fishes is discussed in Section 6.1. Subsequent sections review the effects of flow regime in the Study Reach on habitat availability, habitat connectivity, flow-dependent biological processes that maintain connectivity, and habitat maintenance.

6.1 Native Fish Utilize Canyon Habitat

Canyon reaches are characterized by variability in flow velocity, water depth, and water temperature, because flow regimes vary in response to spring runoff from snowmelt, precipitation events, and drought. The interaction of this flow regime with the bed and bank features in canyon reaches create unique and seasonally dynamic fish habitat (Bustard and Narver 1975; Valdez et al. 2001). The Colorado River basin is largely a snowmelt driven system that experiences high water conditions in the spring and lower flow conditions in the summer that can be punctuated by high magnitude floods resulting from convective thunderstorms. This variable flow regime facilitates the survival and growth of native species as they are presumably adapted to find and utilize novel temporary habitat created by high flows.

Though field data is limited, use of canyon habitat has been documented for native fishes in the Colorado River, and these species benefit from habitats that are created by seasonal high flows. Further, connectivity between the main channel and its tributaries is also critical for native species. Connected and diverse rocky habitat found in many canyons is necessary for migration, spawning, feeding, and shelter for Bluehead Sucker and Roundtail Chub (USFWS 2018). The presence of Bluehead Sucker and the absence of White Sucker or hybrid suckers in the Study Reach supports this finding and also suggests that this area may be particularly valuable for native species. Backwaters can form when flows connect with the limited floodplain to provide nursery habitat that promotes fish growth and recruitment (Dodrill et al. 2016). Backwatering of tributaries by seasonally high flows in the Colorado River may have once provided critical rearing habitat for native juvenile fishes in the vicinity of Glen Canyon Dam (Robinson et al. 1998). Tributaries and connected floodplain are beneficial to Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub as they provide refuge (Bower et al. 2008), increase channel complexity (Fraser et al. 2017), and create spawning/nursery areas with increased nutrient availability (Magoulick and Kobza. 2003; Gido and Probst 1999). While these habitats are critical for early life stages of fish, they are utilized by all life stages. Connectivity between tributaries and the main stem provide an opportunity for native fishes to spawn in areas that are not typically utilized by undesirable nonnative species such as White Sucker or predatory species like Brown Trout (Hooley-Underwood et al. 2018;

Thompson and Hooley-Underwood 2019). Native species can be resident or migratory, but both will typically move into tributaries in spring when cued by a combination of increasing flows and increasing water temperatures; because they are often less regulated, tributaries tend to have a more natural flow pattern, thermal regime, and sediment load than mainstem systems (Fraser et al. 2017). Small ephemeral tributaries that are completely dry for most of the year also provide critical habitats for native fish. As snowmelt fills these tributaries, species such as Bluehead Sucker and Flannelmouth Sucker migrate from larger rivers to spawn in these reaches, and then quickly return to the river (Hooley-Underwood et al. 2018). Canyon habitat availability and the connectivity between the main stem of a river and its tributaries rely on sufficient flow in the main stem. Consistent base flows help maintain habitat availability in the main stem, and higher flows in spring help maintain connectivity to critical tributary habitat and to seasonally available habitats used by multiple life stages. For more details on the role of flow in maintaining sediment dynamics and physical habitat, please see Section 5.

While habitat preferences vary by fish species, Colorado's native fishes often utilize similar habitat. Bluehead Sucker and Roundtail Chub occurrence is associated with deep, rocky pools in the Colorado River. Both species feed on periphyton and macroinvertebrates that inhabit rocky substrate in canyon reaches (Holden and Stalnaker 1975; Baxter and Simon 1970). However, while species such as Roundtail Chub are associated with deep, rocky pool habitat, Speckled Dace prefer the swifter sections of pools and are not typically found in slackwater habitats (Vlach et al. 2005). Adult Flannelmouth Sucker, Bluehead Sucker, Rainbow Trout, and Brown Trout typically prefer deep water as they provide stable temperatures, larger substrates, and resting areas (Bustard and Narver 1975). Thus, inundation of the large substrate in the Study Reach should increase habitat availability, even if average velocities increase.

Further, because increased flows can increase habitat availability and variability, and because fish have species-specific habitat preferences, consistent base flows and high flows in spring may facilitate ecological partitioning in the Study Reach. Ecological partitioning occurs when aquatic habitat varies enough to allow species to occupy different physical locations based on their preferences. An extensive literature review of ecological partitioning in aquatic systems demonstrated that fish exhibit partitioning with respect to diet/food availability, physical habitat, and/or timing of usage, and that partitioning appears to allow coexistence of fish species (Ross 1986). This is significant for the Study Reach for two reasons. First, consistent base flow and increased flows in spring would increase habitat variability. Second, many of Colorado's native fishes lack behavioral mechanisms to deal with nonnative predators or competitors, and introduced game fishes such as Rainbow Trout are adapted to environments with limited fish species richness. Therefore, stable base flows sufficient to permit ecological partitioning could reduce negative interspecific (i.e., between-species) interactions, to the benefit of the resident fishes in the reach; this benefit could be increased with a flow regime that included higher flows during spring runoff. On the other

hand, habitat partitioning is less evident in streams with unstable flow regimes and/or large, sudden fluctuations in environmental variables like flow and water chemistry (e.g., Matthews and Hill 1980). Thus, it is possible that an intermittent flow regime or one where flows changed rapidly due to water management would limit or prevent ecological partitioning, consistent base flow would facilitate ecological partitioning, and high flows in spring would further increase opportunities for ecological partitioning in the Study Reach.

6.2 Instream Flows Maintain Interstitial Habitat

Interstitial spaces, or clear spaces between gravel and cobble substrate, are a major component of both physical and biological processes, and the absence of this habitat negatively impacts fish and macroinvertebrate assemblages (e.g., Kondolf et al. 1993; Gayraud and Philippe 2001). The biological implications of the available interstitial space among gravel and cobble stream substrate are discussed here. Specific flow dynamics required to maintain clean sediment are discussed in Section 5.1.

Interstitial spaces are a critical component of fish habitat. Fish such as sculpin and dace live some or all of their lives in the interstitial spaces in riffles (See Section 2.1). Further, interstitial spaces are critical for reproductive success of salmonids. Interstitial habitats are sensitive to low or intermittent flows for two reasons. First, because they do not store water like pools, riffles are particularly prone to drying during low flows (Rolls et al. 2012), which leads to loss of habitat for multiple fish species. Second, low flows and/or lack of flushing flows can facilitate infilling of interstitial spaces with fine sediment. Excess sediment can adversely affect salmonid spawning habitat by eliminating or reducing its capability to support fish eggs, alevins, and juvenile fish (Wood and Armitage 1997, Chapman 1988, and Moring 1982). The time between egg deposition and emergence of young from the gravel is typically several months for salmonids. During this time, fine sediment can have deleterious effects on embryonic development and emergence (Wood and Armitage 1997, Olsson and Petersen 1986). For example, infilling of interstitial spaces can prevent flow from delivering oxygen or removing metabolic wastes from salmonid redds and can prevent fry from emerging from the substrate (Kondolf et al. 1993, Moring 1982).

Excess sediment alters substrate composition (and therefore macroinvertebrate habitat) on the surface of a riverbed and within the hyporheic zone. Reduced substrate porosity and infilling of interstitial spaces eliminates habitat that is utilized and/or preferred by many macroinvertebrate taxa (Wood and Armitage 1997). For example, riffle-dwelling species such as caddisflies require benthic substrate with heterogenous substrate, interstitial spaces, and connectivity to the hyporheos for refuge and foraging habitat (e.g., Natsumeda and Iguchi 2019). Therefore, sedimentation of interstitial spaces at the streambed and in the hyporheic zone may significantly reduce macroinvertebrate habitat and limit secondary production (Richards et al. 1994). Excess sedimentation has been shown to affect macroinvertebrate assemblages by inducing emigration from the reach (Wood and Armitage

1997). Surface dwelling macroinvertebrates, especially those sensitive or most exposed to sediment like stoneflies and mayflies, will emigrate immediately in response to increasing sediment levels (Rosenberg and Wiens 1978).

Therefore, base flows, which help maintain sediment dynamics through near-constant transport of small amounts of fine sediment (Wohl et al. 2015, See Section 5.1), are important for maintenance of fish and macroinvertebrate habitat. Further, because the Study Reach receives sediment from canyon walls, ephemeral and perennial tributaries, and dam releases, higher, flushing flows may be needed to disrupt the riverbed armor layer and resuspend fine sediment that has infiltrated the benthos and hyporheic zone (Gayraud and Philippe 2001).

6.3 Instream Flows Maintain Longitudinal Habitat Connectivity

Moderate to high flows would likely increase the longitudinal connectivity within the Study Reach. A limited number of studies have examined the effects of flow on fish passage over natural obstacles. Some studies have indicated that low flows increase successful movement over waterfalls (e.g., Lennox et al. 2018), and others have indicated that low flows can prevent migration of adult salmonids (e.g., Warren et al. 2015). However, these studies focused on streams with perennial flow regimes and did not address the effects of extremely low flows or intermittent flows on fish passage; fish passage in the Study Reach is highly restricted under the current flow regime. Consistent base flows and periodic higher flows could facilitate fish passage through the Study Reach in multiple ways. First, increased flow can decrease effective drop heights in cascades and at vertical drops. An increase in pool depth downstream of an obstacle has a positive effect on fish passage probability and drop height from the pool to the crest of the obstacle decreases passage probability (Kondratieff and Myrick 2006, Lauritzen et al. 2010). Under high flows, the increase in downstream pool depth and the decrease in drop height can facilitate migration over obstacles for multiple fish species, including salmonids (e.g., Schwalme et al. 1985). Second, increased flows cause an increase in cross-sectional complexity; even if water velocities and turbulence in the thalweg present conditions that are not conducive to fish passage, alternate pathways will likely become available as new areas are inundated near the margins of the stream. Multiple studies of fish passage in a whitewater park demonstrated that adult trout and suckers were unable to move across selected structures at base flows but were able to do so at higher flows, presumably because multiple pathways for upstream movement become available as flows increase (e.g., Fox et al. 2016; Stevens et al. 2015). Increased flows in a confined reach of the Cache la Poudre River also appear to inundate alternate pathways for upstream fish movement (discussed briefly in Stack et al. 2024). This is likely the case in the Study Reach as well (Figure 6-1); many flow pathways that present vertical obstacles under low-flow conditions could likely be navigated without jumping at higher flows. Maintaining connectivity within the Study Reach will benefit resident fishes (See Section 2.1 for information on the importance of movement to native fishes).

6.4 Instream Flows Control Fish and Macroinvertebrate Drift

Ecological connectivity within the Study Reach also depends on drift of larval fishes and of macroinvertebrates; drift rates are affected by flow regime. Drift of early life stages of riverine fish is an important part of their life histories and may help maintain population connectivity and increase or maintain geographic range (Lechner et al. 2016). Native Colorado River fishes (e.g., Bluehead Sucker, Flannelmouth Sucker, Roundtail Chub, native sculpin, and Speckled Dace) hatch from eggs deposited from gravel bars. Larval drift begins in mid-July, on the descending limb of the hydrograph (Carter et al. 1986).

Dispersal by drift is a critical component of the life history of many fishes, as it transports them from spawning to rearing areas. Larvae drift passively with the current until they can swim well enough to leave the current and select near-shore habitats (Robinson et al. 1998). Thus, flows must be sufficient to allow dispersal from spawning to rearing areas. Flow-mediated drift to allow dispersal of early fish life stages within the Study Reach is still important, even though long-distance dispersal from upstream reaches would be prevented by the Shoshone Dam.



Figure 6-1.—*Vertical drop in Upper Death Rapid that would likely be more passable at higher flows.*

While most fish larvae drift on the descending limb of the hydrograph, macroinvertebrate drift occurs at a wide range of flows, including during floods and spring runoff. Drift is a fundamental process in rivers that allows macroinvertebrates to disperse and colonize new habitat, escape from predation, and avoid unfavorable conditions (Kennedy et al. 2013, Caldwell et al. 2018). Drift in response to flow can have a profound effect on macroinvertebrate community composition and size distribution. Most organisms are behavioral (i.e., not accidental) drifters at low flow, and drift appears to be species- and life-stage specific (i.e., due to varying swimming ability). A study by Kennedy et al. (2013) on the Colorado River below Glen Canyon Dam determined that short-term increases in discharge below the dam induced drift in mobile collector-gatherer macroinvertebrates. They also determined that a twofold increase in daily flow discharge increased drift concentrations linearly for chironomids and exponentially for certain amphipod and snail taxa, indicating that river discharge alters drift behavior among macroinvertebrate assemblages on a short time scale. A study on a small coldwater stream below an active diversion determined that invertebrate drift increased with increases in streamflow, average body size of invertebrates decreased with decreases in streamflow, and that significant reductions in streamflow significantly reduced drifting behavior (Caldwell et al. 2018). Macroinvertebrates will also accidentally enter the drift after being dislodged from substrate during high flows. For example, during an experimental flood on the Colorado River, macroinvertebrate drift densities followed the same pattern as sediment transport, indicating that drift was passive and not behavioral at peak or runoff flows (Robinson et al. 2004). While drift in response to high flow events can lead to large local reductions in macroinvertebrate density, the process is still beneficial. For example, investigations of the food web in the Colorado River downstream of Glen Canyon Dam before and after an experimental flood showed a dramatic decrease in macroinvertebrate density but an increase in fish biomass due to higher drift rates and higher production of more desirable macroinvertebrate prey (Collins et al. 2011).

Macroinvertebrates drift to disperse and maintain population connectivity, but this process also delivers macroinvertebrate prey to drift-feeding fishes. Drifting organisms account for large portions of certain fish species diets and is a crucial element in sustaining a natural and healthy river food web. Further, drift density and taxonomic composition is a function of local processes and not attributable to distant sources such as tributaries or distant, upstream reaches (Danehy et al. 2011), indicating that the magnitude and the variability of the flows released from Shoshone Dam would have direct effects on the rate and composition of drift in the Study Reach.

These studies on the effects of flows on macroinvertebrate drift illustrate the importance of consistent base flows and spring runoff flows in maintaining natural invertebrate behavior. Drift is affected by anthropogenic alteration of a wide range of flows, and altered drift patterns can subsequently alter macroinvertebrate assemblages (Caldwell et al. 2018). When alteration of high or low flows changes macroinvertebrate drift patterns, macroinvertebrate assemblages and the aquatic food web can be impacted.

6.5 High Flows Maintain Canyon Habitat

Peak flows are a crucial component for maintenance of aquatic habitat in canyons (Bunn and Arthington 2002). Higher flows increase aquatic habitat by inundating undercut banks, large, low-velocity spaces between boulders, and low-velocity areas downstream of boulders (referred to hereafter as velocity refuges) (e.g., Bustard and Narver, 1975). Providing consistent base flows and allowing them to increase during spring runoff would increase the availability of shoreline habitat for resident fishes. While habitat analyses based on hydraulic modeling may indicate that habitat suitability decreases once flows increase past a certain, site-specific threshold, high flow events typically do not significantly affect distribution and abundance of native fish in canyon reaches. Instead, negative effects have typically been observed in small-bodied invasive species (Valdez et al. 2001).

In many cases, the relationship between flow and aquatic habitat availability/quality is analyzed with a combination of hydraulic models and known information about fish habitat preferences. Often, these models indicate deterioration of habitat with increased flows. The disconnect between modeling results that indicate deteriorating habitat quality/quantity at high flows and the presence of native fish in canyon reaches at all flow stages likely has to do with an incomplete understanding of canyon systems. The incredible complexity of flow in steep canyon reaches is difficult to model, the understanding of fish swimming behavior in these complex flow fields is limited, and habitat suitability information for fish is typically not derived from deep, turbulent systems such as canyons. There is little question that use of one-dimensional, two-dimensional or three-dimensional hydrodynamic models (1D, 2D, and 3D models, respectively) greatly increase our understanding of how hydraulic conditions change with flow in natural systems. However, all hydraulic models have limitations, particularly at small scales that are relevant to a fish. For example, 1D and 2D hydraulic models provide cross-section and depth-averaged hydraulics, respectively, which are useful for characterizing habitat in low-gradient reaches such as pool-riffle complexes. Within canyon reaches, boulder roughness may create slower velocities and refugia at higher flow rates, which cannot be fully captured by these models. The terrain in the project area was captured using comprehensive drone and ground survey and used to develop a modeled surface of Upper Death Rapid in the Study Reach (Figure 6-2). This effort resulted in a representation of the complex and rough stream bed. However, despite detailed surveying, the large interstitial velocity refuges between the boulders in the Study Reach are not well-characterized (Figure 6-1). Further, species-specific microhabitat preferences in canyon habitat are not well understood, due to difficulties associated with collecting fish location data in fast, deep stream reaches. However, multiple laboratory and fishway prototype studies have shown that fish detect flow through multiple sensory pathways, utilize behaviors such as flow refuging and exploitation of vortices to save energy, and are adept at locating hydraulic conditions that are advantageous to them (e.g., Sutterlin and Waddy 1975; Castro-Santos 2005; Liao 2007). This suggests that fish are utilizing small-scale habitat patches in canyon reaches that cannot be described with hydraulic models.

Many of Colorado's native fishes are adapted to and can be found in canyon habitats, including the Study Reach. Consistent base flow in the Study Reach would provide year-round habitat for these species, as well as game species such as Brown Trout and Rainbow Trout, because they can utilize habitat in large interstitial or behind-boulder velocity refuges. Periodic high flows (i.e., increased flows during the spring runoff period) would increase habitat availability in the Study Reach by creating more habitat between and behind large boulders.

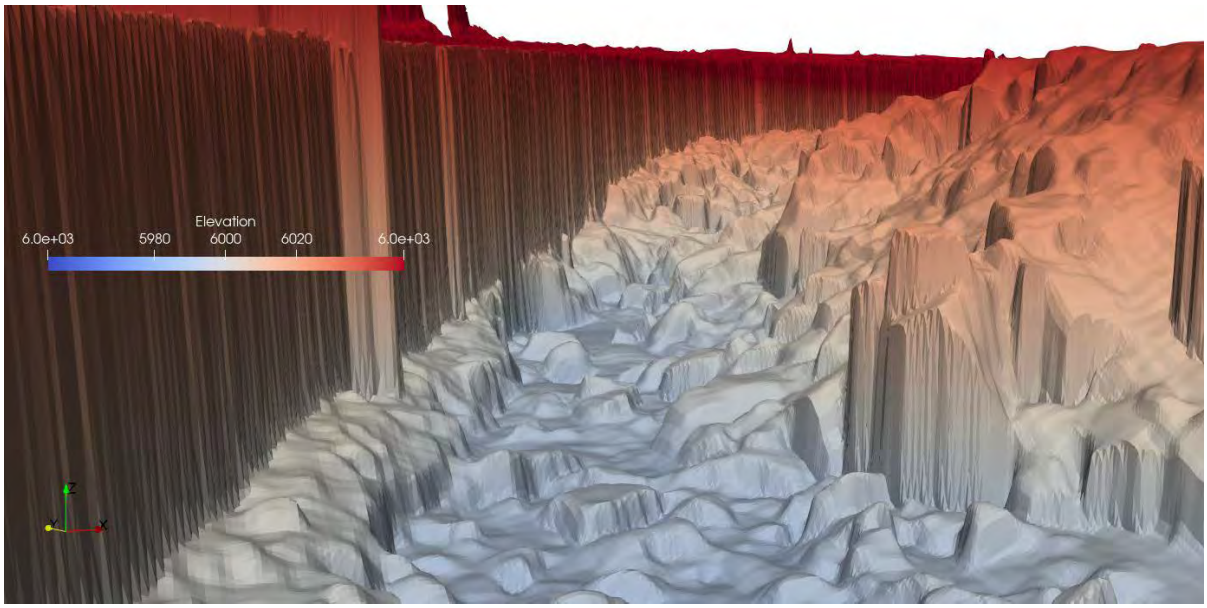


Figure 6-2.—*Modeled surface of Upper Death Rapid, below Shoshone Dam.*

7. Conclusion

The data, literature review, and syntheses contained in this report provide a biological basis for establishing consistent base flows and periodic high flows in the Study Reach. This synthesis incorporated information from studies focused on fish/macroinvertebrate biology, food webs, fluvial geomorphology, and lateral and longitudinal stream connectivity. Together, these studies show how a natural flow regime shapes and supports aquatic systems, and site-specific examples detail the potential benefits of instream flows for the Study Reach.

Fish data from the Study Reach and surrounding area on the Colorado River indicate that fish populations are relatively similar upstream of the Study Reach and within it. CPW data indicate that the Colorado River supports multiple SGCN-1 species (Colorado River Cutthroat Trout, Bluehead Sucker, Flannelmouth Sucker, and potentially Roundtail Chub), as well as Mountain Whitefish. The site sampled within the Study Reach displayed comparable sportfish densities and biomasses to the other sites, but it supported a lower number of nonnative species and hybrids than the other sites. These data suggest that the Study Reach may be particularly valuable to native fishes and that SGCN species and sportfish will inhabit the Study Reach in greater numbers given adequate flow conditions.

Macroinvertebrate data analyzed from a perennial section of the Study Reach and from upstream reaches on the Colorado River showed that sensitive taxa and long-lived taxa were present at all sites. Analysis of macroinvertebrate community metrics showed that the upstream Colorado River sites have greater diversity, slightly greater MMI scores, and more favorable HBI and TIV_{SED} scores than the Study Reach. The difference in scores suggests that existing flow conditions in the Study Reach are negatively affecting the macroinvertebrate assemblage by selecting for species more tolerant to disturbances such as sedimentation. The differences in scores upstream and within the Study Reach emphasizes the potential of the Study Reach to support a robust and ecologically valuable macroinvertebrate community, given a more natural flow regime.

Consistent base flows and periodic high flows would provide major benefits in the Study Reach that include maintenance of food webs and sediment dynamics, dampening of temperature extremes, and increased aquatic habitat. While intermittent flow regimes do support fish and macroinvertebrate communities, specific challenges exist in these systems. Food webs and nutrient dynamics are highly variable in space and time, sediment and temperature dynamics are altered compared to perennial systems, and aquatic habitat is not consistently connected or available. Thus, if an intermittent flow regime or a fully dewatered condition persists in the Study Reach, the fish and macroinvertebrate community will not be as robust as they are in adjacent reaches of the Colorado River.

Logistic difficulties associated with sampling limit our understanding of the geomorphic, biological, and ecological conditions in canyon habitats such as the Study Reach. However, based on the empirical data and the literature presented in this report, it is our opinion that the Study Reach will benefit significantly from consistent base flows, as well as periodic high flows, and that some or all of these benefits will propagate to downstream reaches of the Colorado River.

8. References

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Colorado Springs Utilities
It's how we're all connected

Enclosure H
Agenda Item 10.d
CWCB Board Meeting
May 21-22, 2025

May 8, 2025

Ms. Lauren Ris, Director
Colorado Water Conservation Board
1313 Sherman St., Room 718
Denver, Colorado 80203

Re: Colorado Springs Utilities' Comments on the River District's Request to the Colorado Water Conservation Board for Acceptance of Shoshone Water Rights for Instream Flow

Dear Ms. Ris,

We are writing in regard to the Colorado River Water Conservation District's ("River District") proposed offer of an interest in the senior and junior Shoshone water rights to the Colorado Water Conservation Board ("CWCB") for instream flow ("ISF") purposes. The purpose of this letter is to provide Colorado Springs Utilities' specific comments on the CWCB's proposed acquisition of an interest in and judicial change of the Shoshone water rights.

Colorado Springs Utilities, the River District, and several other West Slope entities entered into a Memorandum of Agreement in which Colorado Springs Utilities agreed not to oppose adding ISF purposes as a decreed use of the senior Shoshone right, and agreed to negotiate in good faith to add ISF uses to the junior Shoshone right. Colorado Springs Utilities does not oppose the acquisition and subsequent change of the senior Shoshone water right to provide for permanency of the historic Shoshone call and preservation of the historical Colorado River flow regime. However, Colorado Springs Utilities is concerned that the River District's proposed methodology for determining the historical use of the senior and junior Shoshone water rights will result in the expansion of the junior right that could materially injure Colorado Springs Utilities' and other decreed water rights owned by users across the State of Colorado.

The *Rules Concerning The Colorado Instream Flow and Natural Lake Levels Program* (2 CCR 408-2) (the "Rules") require the CWCB to consider: (a) the natural flow regime of the river; (b) any potential material injury to existing decreed water rights; and (c) the historical use of the water right proposed for acquisition that may be available for ISF when evaluating the appropriateness of any acquisition of water for ISF purposes. Therefore, it is critical for the change of use of the senior and junior Shoshone water rights for ISF purposes to be supported by a quantification of the historic beneficial use of the right that is based on diversions of native water available in priority and put to beneficial use. Colorado Springs Utilities is concerned that the River District's proposed methodology for quantifying the historic use of the Shoshone water rights does not meet this standard and could have significant and consequential effects on the administration of the mainstem of the Colorado River and its tributaries above the Shoshone power plant. Specifically, Colorado Springs Utilities has the following concerns with the River District's proposed methodology:

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1. The proposed methodology defines the study period as 1975-2003 which excludes the most recent 21 years of beneficial use of the Shoshone water rights for hydroelectric power generation.
2. We have concerns with proposed methodology for determining historic use of the Shoshone water rights. An appropriate methodology is to limit Shoshone water rights historic use to the lesser of available (a) natural Colorado River streamflow unenhanced by upstream reservoir releases, and (b) diversions that were demonstrated to have been put to beneficial use as recorded in Colorado's Decision Support System. This database stands as the official public record of diverted water put through the Shoshone power plant generating turbines and were provided annually to the Colorado Division of Water Resources by the owner of the Shoshone water rights.
3. The River District's proposed methodology does not appropriately factor outages of the Shoshone power plant. The diversion record period should include zeros by default when the power plant was not operating. In other applications the non-use of a water right is carried as a zero when historic use is determined. If non-maintenance outages occurred, then appropriate evidence must be provided to support using a non-zero record. This will prevent inflating the average annual volumetric.

An analysis performed on behalf of the FRWC members indicates that, due to these discrepancies, the River District's preliminary historic use analysis inflates the historical use of the Shoshone water rights by approximately 40%, resulting in an expansion of use of the Shoshone water rights, especially the junior right. Specifically, the River District's proposal showing the Bishop Brogden Associates annual volumetric (WY 1975-2003) is 844,644 acre-feet. On the contrary, using a more recent study period, appropriately factoring times of power plant outage, and appropriately utilizing water user supplied diversion records would result in an annual use volume of about 592,190 acre-feet – **a difference of over 250,000 acre-feet.** Such an expansion based on a flawed historic use analysis would negatively impact all water supplies above the Shoshone power plant, and potentially negatively impact timing of flows through the 15-Mile Reach that supports the Upper Colorado River Endangered Fish Recovery Program. Any reduction in water supplies from a growing community like Colorado Springs results in increased reliance on changing agricultural water rights in other basins to meet their customers' demands and limits our ability to fully develop our Colorado River basin supplies. This outcome would seem contrary to the goals of the Colorado State Water Plan.

The Rules also require the CWCB to consider the effect of the proposed acquisition on any relevant interstate compact issue, including whether the acquisition would assist in meeting compact obligations or result in the delivery of more water than is required. While the use of the Shoshone water rights for ISF purposes may help Colorado continue to meet its obligations under the Colorado River Compact and Upper Colorado River Compact of 1948, it is important that the ISF use not reduce the amount of Colorado River water available for existing users and future water supply development within the State under Colorado's Compact apportionments. If the changed Shoshone water right for ISF purposes results in an expansion of historical use under the Shoshone water rights, then more water may be delivered than required under Colorado's compact obligations.

Colorado Springs Utilities, along with other FRWC members, have shared these concerns with River District and other impacted parties, but the River District has not yet been willing to alter their

methodology to address our fundamental concerns. Colorado Springs Utilities encourages the CWCB to work with the River District and other interested parties to develop an agreed upon methodology for determining the historic use of the Shoshone water rights in advance of any decision to accept the Shoshone water rights in an ISF program. A consensus methodology would ensure that the CWCB's exercise of the Shoshone water rights for ISF purposes does not injure other water users. If an appropriate methodology cannot be agreed upon by the parties, then Colorado Springs Utilities requests that the CWCB not endorse a particular methodology or volumetric quantification but rather should affirmatively state in any approved acquisition agreement that it will rely on the Water Court's determination of the proper methodology and resulting volumetrics.

Colorado Springs Utilities also believes that the following terms and conditions are necessary components of an agreement for the CWCB's acceptance of an interest in the Shoshone water rights for ISF purposes to ensure consistency with law and to protect its decreed water rights from injury:

1. The Upper Colorado River Endangered Fish Program shall not be impaired by the use of the changed Shoshone water rights for ISF purposes.
2. Use of the changed Shoshone water rights for ISF purposes shall not impair use or development of Colorado River water under the Colorado River Compact, including currently decreed and operating water rights.
3. Use of the changed Shoshone water rights for ISF purposes must be subject to appropriate seasonal volumetric limitations reflective of the quantified historical use as determined by an adjudicated change decree.

Thank you in advance for consideration of Colorado Springs Utilities' comments. We look forward to working with the CWCB, River District, and other stakeholders to develop an agreed upon methodology for determining the historic use of the Shoshone water rights as well as terms and conditions necessary to protect water rights from injury in advance of any CWCB decision to accept the Shoshone water rights in an ISF program. Please do not hesitate to contact me if you have questions.

Sincerely,

Lisa Barbato

Lisa Barbato
Chief System Planning & Projects Officer

Cc: Colorado River District; Andy Mueller, Peter Flemming, Jason Turner

Aurora Water
City of Aurora
26791 E Quincy Ave.
Aurora CO 80016
phone 303.739.7370
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May 9, 2025

Colorado Water Conservation Board
ATTN: Director Lauren Ris
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Concerns Regarding Proposed Changing to the Shoshone Water Rights to Include Instream Flow as an Authorized Use

Dear Director Ris:

The City of Aurora appreciates the Colorado Water Conservation Board's leadership in advancing streamflow protection through the instream flow (ISF) program. Aurora has long supported collaborative and balanced approaches that preserve river flows while protecting existing water rights. In that spirit, Aurora respectfully submits this letter to express specific concerns with the current proposal to add ISF use to the senior and junior Shoshone water rights.

As a statewide agency, the CWCB plays a critical role in ensuring that instream flow acquisitions are implemented in a manner that protects all Colorado water users and upholds the integrity of the prior appropriation system. In doing so, the CWCB must take a balanced, statewide view that accounts not only for environmental objectives but also for the legal and operational impacts to existing water rights. It is essential that the outcome of this process is an ISF right that reflects the historical flow regime of the river, not one that is improperly expanded to the detriment of other water users.

As a party to the 2018 Intergovernmental Agreement (IGA) on Shoshone Permanency, Aurora agreed not to oppose a change to the senior Shoshone water right to include ISF as a decreed use and committed to negotiating in good faith regarding the junior Shoshone right. Aurora continues to support efforts to preserve the streamflow regime historically maintained by the Shoshone Power Plant. Consistent with the 2018 IGA, Aurora does not oppose the loan and subsequent change of the senior Shoshone right if it serves to maintain the historic Shoshone call and the historical flow regime of the Colorado River.

However, Aurora has significant concerns that the River District's proposed methodology for determining the historical use of both the senior and junior Shoshone rights may result in an unlawful expansion of those rights. Such expansion poses a substantial risk of material injury to Aurora's water rights and to other decreed water rights held by users across Colorado.

Specifically, Aurora is concerned that the current historical use (HU) analysis underpinning the proposed change suffers from the following flaws:

1. It includes pre-1998 data that reflects releases from Green Mountain Reservoir, rather than isolating natural flow available to the Shoshone diversion;

2. It ends the study period in 2003, omitting more recent years with significant outage periods and over 30% of the driest years;

3. It excludes outage periods from volumetric averages which artificially inflates the calculated historical use; and

4. It relies on the Dotsero gage, which overstates diversions, rather than on CDSS diversion records that more accurately reflect hydropower deliveries at Shoshone.

Aurora's analysis indicates that these deficiencies could result in inflated historical use estimates—by hundreds of thousands of acre-feet—and lead to a material expansion of the Shoshone rights, to the detriment of existing water rights, including Aurora's.

These concerns are consistent with positions Aurora has previously communicated directly to the Colorado River Water Conservation District. Aurora maintains that any change to the Shoshone rights to include ISF use must be based on a credible and accurate historical use analysis and must avoid injury to other water rights.

If the parties are unable to agree on an appropriate methodology, Aurora respectfully requests that the CWCB refrain from endorsing any specific methodology or volumetric quantification. Ideally, the CWCB would support and help facilitate a collaborative process in which all stakeholders work together to identify a methodology that protects the stream while avoiding injury to the water rights of utilities serving the majority of Colorado's citizens. If such a facilitative role is not feasible, the CWCB should remain neutral in the Water Court proceedings and defer to the Court's determination of the appropriate methodology and volumetric quantification.

Aurora remains committed to continued good-faith engagement with the River District, the CWCB, and other stakeholders to reach a durable and legally sound outcome—one that protects instream flows while safeguarding Colorado's existing water rights system.

Thank you for your time and consideration. We welcome the opportunity to further discuss our concerns and to contribute to the development of a fair and sustainable path forward.

Sincerely,



Marshall Brown,
General Manager
Aurora Water

CC:
Colorado River Water Conservation District

Aurora Water
City of Aurora
26791 E Quincy Ave.
Aurora CO 80016
phone 303.739.7370
AuroraGov.org

May 9, 2025

Colorado Water Conservation Board
ATTN: Director Lauren Ris
1313 Sherman Street, Room 718
Denver, CO 80203

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As a statewide agency, the CWCB plays a critical role in ensuring that instream flow acquisitions are implemented in a manner that protects all Colorado water users and upholds the integrity of the prior appropriation system. In doing so, the CWCB must take a balanced, statewide view that accounts not only for environmental objectives but also for the legal and operational impacts to existing water rights. It is essential that the outcome of this process is an ISF right that reflects the historical flow regime of the river, not one that is improperly expanded to the detriment of other water users.

As a party to the 2018 Intergovernmental Agreement (IGA) on Shoshone Permanency, Aurora agreed not to oppose a change to the senior Shoshone water right to include ISF as a decreed use and committed to negotiating in good faith regarding the junior Shoshone right. Aurora continues to support efforts to preserve the streamflow regime historically maintained by the Shoshone Power Plant. Consistent with the 2018 IGA, Aurora does not oppose the loan and subsequent change of the senior Shoshone right if it serves to maintain the historic Shoshone call and the historical flow regime of the Colorado River.

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Aurora remains committed to continued good-faith engagement with the River District, the CWCB, and other stakeholders to reach a durable and legally sound outcome—one that protects instream flows while safeguarding Colorado's existing water rights system.

Thank you for your time and consideration. We welcome the opportunity to further discuss our concerns and to contribute to the development of a fair and sustainable path forward.

Sincerely,



Marshall Brown,
General Manager
Aurora Water

CC:
Colorado River Water Conservation District

PAGOSA AREA WATER AND SANITATION DISTRICT and San Juan Water Conservancy District, Applicants–Appellees

v.

TROUT UNLIMITED, Opposer–Appellant

and

Bruce Whitehead, Division Engineer, Water Division 7, Appellee Pursuant to C.A.R. 1(e).

No. 06SA338.

Supreme Court of Colorado, En Banc.

Oct. 22, 2007.

As Modified Nov. 13, 2007.

Background: Fisheries conservation organization opposed water district's application for conditional water rights. The District Court, Water Division 7, Gregory G. Lyman, J., issued a decree for a planning period extending 100 years. Conservation organization appealed.

Holding: The Supreme Court, Hobbs, J., held that water court failed to make findings of fact to enable Supreme Court's review of its decree granting water district conditional water rights for a 100 year planning period.

Reversed and remanded.

Coats, J., issued an opinion concurring in the judgment only.

Eid, J., issued an opinion specially concurring that was joined by Rice, J.

1. Waters and Water Courses ⇦133

A governmental water supply agency has the burden of demonstrating three elements in regard to its intent to make a non-speculative conditional appropriation of unappropriated water: (1) what is a reasonable water supply planning period; (2) what are the substantiated population projections based on a normal rate of growth for that period; and (3) what amount of available unappropriated water is reasonably necessary to serve the reasonably anticipated needs of the governmental agency for the planning period, above its current water supply.

2. Waters and Water Courses ⇦133

A governmental water supply agency must show under the "can and will test" that it can and will put the conditionally appropriated water to beneficial use within a reasonable period of time.

See publication Words and Phrases for other judicial constructions and definitions.

3. Waters and Water Courses ⇦152(12)

Whether an applicant has met the legal standards for a conditional appropriation of water presents mixed questions of fact and law that the Supreme Court reviews de novo.

4. Waters and Water Courses ⇦152(12)

The Supreme Court defers to the water court's findings of fact on an application for conditional appropriation if the evidence supports them.

5. Waters and Water Courses ⇦130

Maximum utilization does not mean that every ounce of Colorado's natural stream water ought to be appropriated; optimum use can be achieved only through proper regard for all significant factors, including environmental and economic concerns. West's C.R.S.A. § 37–92–501(2)(e).

6. Waters and Water Courses ⇦133, 139

Neither a private nor a governmental agency may obtain a right to use a portion of the public's water resource unless it establishes intent to make a non-speculative appropriation; once an appropriator makes an actual beneficial use, it holds a vested property right of use protected by constitutional guarantees.

7. Waters and Water Courses ⇦133, 135

To obtain a conditional water right, an applicant must demonstrate that: (1) it has taken a first step, which includes an intent to appropriate the water and an overt act manifesting such intent; (2) its intent is not based on a speculative sale or transfer of the water to be appropriated; and (3) there is a substantial probability that the applicant can and will complete the appropriation with diligence

and within a reasonable time. West's C.R.S.A. § 37–92–103(6).

8. Waters and Water Courses ⚿133

For an applicant to satisfy the first step in obtaining conditional water right, he or she must meet the burden of demonstrating intent to appropriate the water for beneficial use. West's C.R.S.A. § 37–92–103(6).

9. Waters and Water Courses ⚿133

For a private entity to meet its intent burden in obtaining a conditional water right, it must have contractual commitments for any appropriations that are not planned for its own use, or the application will fail as unduly speculative. West's C.R.S.A. § 37–92–103(6).

10. Waters and Water Courses ⚿133

A governmental agency need not be certain of its future water needs; it may conditionally appropriate water to satisfy a projected normal increase in population within a reasonable planning period. West's C.R.S.A. § 37–92–103.

11. Waters and Water Courses ⚿133

A governmental agency has the burden to demonstrate that its conditional appropriation of water is not speculative. West's C.R.S.A. § 37–92–103(3)(a)(II).

12. Waters and Water Courses ⚿133

A government agency's conditional appropriation of water must be consistent with the agency's reasonably anticipated water requirements based on substantiated projections of future growth within its service area; the conditional appropriation must not be based on a conjectural population projection that becomes a self-fulfilling prophecy of growth. West's C.R.S.A. § 37–92–103(3)(a).

13. Waters and Water Courses ⚿135

An applicant for a conditional decree of water cannot reasonably prove that its project can and will be completed with diligence and within a reasonable time if it lacks the requisite non-speculative intent. West's C.R.S.A. § 37–92–305(9)(b).

14. Waters and Water Courses ⚿135

The factors a court considers for a conditional water right under the "can and will" requirement in diligence proceedings include, but are not limited to: (1) economic feasibility; (2) status of requisite permit applications and other required governmental approvals; (3) expenditures made to develop the appropriation; (4) ongoing conduct of engineering and environmental studies; (5) design and construction of facilities; and (6) nature and extent of land holdings and contracts demonstrating the water demand and beneficial uses which the conditional right is to serve when perfected. West's C.R.S.A. § 37–92–305(9)(b).

15. Waters and Water Courses ⚿152(11)

In the design of water law, the essential function of the water court in a conditional decree proceeding is to determine the amount of available water for which the applicant has established both a need and a future intent and ability to actually use. West's C.R.S.A. § 37–92–305(9)(b).

16. Waters and Water Courses ⚿133

The limited governmental agency exception to the anti-speculation doctrine for conditional water rights should be construed narrowly, in order to meet the state's maximum utilization and optimum beneficial use goals. West's C.R.S.A. § 37–92–103.

17. Waters and Water Courses ⚿133

The water court should closely scrutinize a governmental agency's claim for a planning period that exceeds fifty years for purposes of obtaining conditional water rights. West's C.R.S.A. § 37–92–103.

18. Waters and Water Courses ⚿152(10, 12)

Water court failed to make findings of fact to enable Supreme Court's review of its decree granting water district conditional water rights for a 100 year planning period, and thus, remand was necessary; the water court failed to make findings of fact justifying the planning horizon for the conditional appropriation the water court decreed, which doubled the 50 year period for the conditional appropriation the court decreed in previous case, or justifying the amount of consumptive use water the court decreed, which greatly exceeded the amount water district engineer's

report supported. West's C.R.S.A. § 37–92–103.

19. Waters and Water Courses ⇨152(10)

In approving a conditional decree: a water court must make findings of fact concerning future land use mixes and per capita water usage requirements, taking into account implementation of water conservation measures, and the measure of consumptive use the districts reasonably need to serve their population in the future during a reasonable planning period.

Collins Cockrel & Cole, Evan D. Ela, Denver, Colorado, Attorneys for Applicants–Appellees.

Trout Unlimited, Andrew Peternell, Boulder, Colorado, Attorney for Opposer–Appellant.

Brownstein Hyatt Farber Schreck, P.C., Steven O. Sims Adam T. DeVoe, John A. Helfrich, Denver, Colorado, Attorneys for Amicus Curiae the City of Aurora.

Hill & Robbins, P.C., David W. Robbins, Dennis M. Montgomery, Jennifer H. Hunt, Denver, Colorado, Attorneys for Amicus Curiae the City of Colorado Springs and the Southwestern Water Conservation District.

City of Denver General Counsel, Patricia L. Wells, Michael L. Walker, Casey S. Funk, Daniel J. Arnold, Denver, Colorado, Attorneys for Amicus Curiae the City and County of Denver acting by and through its Board of Water Commissioners.

Western Resource Advocates, Bart Miller Boulder, Colorado, Attorneys for Amicus Curiae Western Resource Advocates.

Justice HOBBS delivered the Opinion of the Court.

Opposer–Appellant Trout Unlimited appeals a judgment and decree entered by the District Court for Water Division No. 7.[1] The decree confirms for the Pagosa Area Water and Sanitation District ("PAWSD") and San Juan Water Conservancy District ("SJWCD") a conditional water storage right for a planning period extending to the year 2100 for 29,000 acre-feet of water, along with the right to fill and refill the reservoir continuously to achieve a total annual amount of stored water of 64,000 acre-feet, with the right of reuse, utilizing a 100 cubic foot per second ("cfs") diversion. The decree also confirms for the districts a direct flow 80 cfs diversion right independent from the storage right.

Trout Unlimited asserts that the districts did not carry their burden of proving their intent to make a non-speculative conditional appropriation. It argues that the water court should not have adjudicated conditional water rights in amounts premised on demands projected nearly one hundred years into the future. It also argues that the districts intend to sell some of the water to customers outside their boundaries, and that the districts do not have a specific plan and intent for the recreation, fish and wildlife, and aesthetic uses listed in the decree.

In response, the districts contend that the conditional decree does not violate Colorado's anti-speculation doctrine and that their one hundred year planning period, their population projections, their per capita water use figures, and their water demand projections for the one hundred year period are all reasonable.

We hold that a governmental water supply agency has the burden of demonstrating three elements in regard to its intent to make a non-speculative conditional appropriation of unappropriated water: (1) what is a reasonable water supply planning period; (2) what are the substantiated population projec-

1. Trout Unlimited presents the following issues for review: (1) whether Applicants have the requisite reasonably anticipated requirement for the decreed amount of water; (2) whether, as a matter of law, Applicants may obtain water rights in amounts premised on growth 100 years into the future; (3) whether Applicants may obtain water rights in amounts premised on hypothetical water availability conditions; (4) whether the evidence established that Applicants have a reasonably anticipated requirement for the decreed amount of water; (5) whether Applicants substantiated their population projections; (6) whether Applicants substantiated their projections of per capita water usage; (7) whether Applicants possess the intent necessary to appropriate water rights in the amounts and for the uses decreed; (8) whether the court should have reduced the decree by the amount of water Applicants intend to sell for use outside their boundaries; and (9) whether the court should have denied claimed water uses for which Applicants did not demonstrate the requisite specific plan and intent.

tions based on a normal rate of growth for that period; and (3) what amount of available unappropriated water is reasonably necessary to serve the reasonably anticipated needs of the governmental agency for the planning period, above its current water supply. In addition, it must show under the "can and will" test that it can and will put the conditionally appropriated water to beneficial use within a reasonable period of time. In the case before us, we determine that the water court has not made sufficient findings of fact enabling our review of its judgment and decree. Accordingly, we set aside the decree, reverse the judgment, and remand this case to the water court for further proceedings. The water court, in its discretion, may take additional evidence and argument as it deems appropriate on remand.

I.

A water and sanitation district,[2] PAWSD operates a municipal water supply system that currently provides potable water to most of the existing Archuleta County population. It also supplies nearly all of the current commercial water demand of Archuleta County, and provides irrigation water for parks, athletic fields, and golf courses.

In 2005, PAWSD provided approximately 2,000 acre-feet of treated water to the 9,500 people in its service area, plus about 900 acre-feet of raw water for irrigation and related demand. PAWSD currently obtains water from four reservoirs with a total storage capacity of approximately 3,000 acre-feet, as well as two direct diversions from the San Juan River with a total rate of 6.9 cfs.

Local voter approval established the SJWCD [3] in 1987. SJWCD aims to conserve, maximize, and utilize the water resources of the San Juan River and its tributaries for the benefit of property and residents within its boundaries. The SJWCD includes much of Archuleta County, including the Town of Pagosa Springs, and most of the PAWSD service area.

The districts have much in common. There is significant geographic overlap between the districts, but there are also places of exclusive coverage, such as an area known as Aspen Springs that only the SJWCD encompasses. The districts also share leadership, including board members who serve both districts and the PAWSD manager who is on the board of the SJWCD.

The districts have joint meetings to discuss water resource issues several times a year, and they are generally united on their approach to issues. There is an administrative services agreement between the districts, according to which they work together and share services such as accounting, office space, and administrative support. Their overlap is complemented by the fact that they operate under different governmental grants of authority because PAWSD is a water and sanitation district and SJWCD is a water conservancy district. SJWCD defers to PAWSD in the arena of water and sewer service and does not plan to operate the facilities.

The SJWCD currently holds a conditional decree for water diversion from the San Juan River and storage of 6,300 acre-feet of water for the proposed Dry Gulch Reservoir, an off-stream reservoir to be constructed approximately one and one-half miles above the town of Pagosa Springs towards Wolf Creek Pass. In 2002, the water court issued to the SJWCD a diligence decree for 6,300 acre-feet of water, conditional, for domestic, municipal, industrial, recreation, and piscatorial purposes with an appropriation date of July 22, 1967. In 2004, the two districts passed a resolution to make an additional conditional appropriation for the Dry Gulch Reservoir. The districts' engineer, Steve Harris, had prepared and submitted a 2003 report to the board of directors of both districts that documented a water storage need of approximately 12,000 acre-feet in the Dry Gulch Reser-

2. Colorado water and sanitation districts exist under the provisions of the Special District Act, sections 32–1–101 to –547, C.R.S. (2007). They are quasi-municipal corporations and political subdivisions that supply water for domestic and other public and private purposes and have, among other powers, the authority to construct, operate, and maintain reservoirs, treatment works, and facilities, incident thereto. §§ 32–1–103(20), –103(24 & 25); 32–1–1006, C.R.S. (2007).

3. A water conservancy district exists under the Water Conservancy Act, sections 37–45–101–153,

voir to meet the 2040 annual demand of the districts' users.

Harris's testimony at trial in the water court includes the following statement about the year 2040 Dry Gulch storage need and diversion rate to meet the districts' projected demand.

> Okay. Also in this report [the 2003 Harris report] we looked at several different places to have direct diversions out of the river and several different options for reservoir storage. And out of that I concluded or recommended that the Dry Gulch pump station would be the best location for the 18 and a half additional cfs that's needed....
> * * *
> Yes, There are eight storage alternatives: two sizes of Dry Gulch Reservoir, a 4,000 acre-foot and a Dry Gulch Reservoir at 12,000 acre-foot, Stevens Enlargement, the West Fork Reservoir, Turkey Creek Reservoir—that was an old reservoir studied by the town back in the '80s by Western Engineers—and the Martinez Reservoir, which is up in the neighborhood of Hatcher, up in the Stollsteimer Basin, and the East Fork Reservoir, which at that time there were some water rights and that one's probably not an option any longer. And of those, either—Dry Gulch Reservoir was the least expensive at any size of those options.

As Harris and the districts' legal counsel turned to preparing the 2004 water court application in this case, Harris recommended that the districts apply for conditional water rights sufficient to fill the Dry Gulch Reservoir to the maximum possible size this off-channel location would provide. His rationale for applying for a year 2100 supply of water, rather than the 2040 supply set forth in his 2003 report to the districts, considers the possibility of other uses being made in the future of the San Juan River water.

> This recommending 35,000 acre-feet for the water rights application was, to me, a no-brainer, cause you go to the site capacity and you do your darndest to get that amount built....
> * * *
> [The] town of Pagosa Springs is looking at a recreation in-channel diversion, much like what Durango has already applied for. That would essentially tie up a good portion of the river and if you don't get in ahead of it, you're essentially not going to have hardly any water left to use.

Harris was also concerned that the Colorado Water Conservation Board's instream flow water right on the San Juan River of 30 cfs in the winter and 50 cfs in the summer might be increased sometime in the future through an additional appropriation, or that the United States Forest Service might impose a right-of-way permit condition requiring a large amount of bypass flow.

The application was initially opposed by three parties [4] that eventually stipulated to the districts' proposed decree. The application was also opposed by Trout Unlimited, a non-profit fisheries conservation organization. Trout Unlimited filed a statement of opposition and participated in the trial.

In its trial brief, Trout Unlimited explained that while it "appreciate[d] the Districts' need to secure water rights to serve future municipal growth," it believed that the application was flawed because the proposed appropriation would give the districts more water than they could reasonably anticipate using over a reasonable period of time, in contradiction to Colorado's anti-speculation doctrine.

In contesting the districts' population projections, Trout Unlimited introduced into evidence a study from the National Research Council's Committee on Population that cautions against making population projections for long time periods. "[P]opulation forecasts should not be made over longer horizons than thirty years or so, due to the rapid increase in uncertainty of forecasts beyond

C.R.S. (2007). Its authority includes appropriation and acquisition of water and water rights. § 37–45–118(1)(j), C.R.S. (2007).

4. The three opposing parties that eventually stipulated include the Park Ditch Company, which was concerned over how the Dry Gulch project would impact Park Ditch's traditional flow and usage; Koinonia, LLC, another appropriator of San Juan River water; and the Weber Entities, a group representing the owners of land where the Dry Creek Gulch would be located.

this point." *Beyond Six Billion: Forecasting the World's Population* 189–90 (John Bongaarts & Rodolfo A. Bulato eds., 2000).

Trout Unlimited's engineer, John Gerstle, used the same spreadsheet model that Harris used for calculating future water demand, in order to demonstrate how excessive the districts' projections were. He substituted what he thought were more realistic model inputs, such as existing direct diversions available to the districts, revised growth projections based on Colorado State Demography Office estimates, per capita water requirements taking conservation measures into account, and storage and diversion needs for different time periods, including 2050 projections. His conclusion was that the districts' claim exceeds their actual need.

After taking evidence, the water court decreed additional conditional rights (above the 6,300 acre-feet previously decreed for the Dry Gulch Reservoir) that gave the districts essentially all they had asked for in their application. It entered a conditional decree for a wide variety of municipal, commercial, irrigation, and recreational uses, accompanied by reuse of the water, in the following amounts:

> 18. The Districts are hereby decreed a conditional water storage right for Dry Gulch Reservoir confirming the right to storage in the amount of 29,000 acre-feet, along with the right to fill and refill continuously to achieve a total annual storage volume of 64,000 acre-feet by capture of inflow tributary to the reservoir and by diversion from the San Juan River via the Dry Gulch Pumping Station and Park Ditch points of diversion, together at a combined rate not to exceed 100 cfs ... with a priority established by the appropriation date of December 20, 2004.
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> 19. The Districts are hereby decreed an additional conditional water right for the Dry Gulch Pumping Station confirming the right to divert water from the San Juan River for direct flow purposes and/or for storage in reservoirs owned or controlled by the Districts, including trans-basin use and storage in District 78 (Piedra River watershed), at a rate of up to 80.0 cfs ... with a priority established by the appropriation date of December 20, 2004.
>
> * * *
>
> 24. Return flows from water derived from the Subject Water Rights and returned to the San Juan River shall be reusable by the Districts using any available means that can be properly accounted for. In addition, the Districts, or either of them, may devise and employ an augmentation and/or exchange plan that relies on the reuse of the water appropriated herein. Prior to reusing any portion of the water appropriated herein, the Districts, or either of them, shall obtain water court approval of an augmentation plan and/or appropriative rights of exchange that incorporate the reuse of such water and that provides a specific plan for the quantification, accounting, control and administration of the reuse of such water.

The decree provides that the "[d]istricts may exercise the storage or direct flow rights independently or in any combination," with the limitation that the diversion rate "shall never exceed 180 cfs at any given time."

In regard to Colorado's anti-speculation and "can and will" standards for issuance of a conditional decree, the court entered the following conclusions of law:

> 15. The Districts have properly initiated the appropriation of the Subject Water Rights as of December 20, 2004, have proceeded with reasonable diligence in the development of the Subject Water Rights from the date of initiation, have demonstrated that water can and will be diverted and beneficially used, and that completion of the appropriations can be accomplished with diligence and within a reasonable time, and therefore the Districts are entitled to a decree confirming and approving the Subject Water Rights within the meaning of §§ 37–92–103(3)(a) and 37–92–305, C.R.S. The Districts' intent to beneficially use the Subject Water Rights is nonspeculative and based upon its reasonable needs for a growing population.

On a number of grounds, appellant Trout Unlimited asserts on appeal that the judgment and decree in this case allows the districts to speculate in the public's water resource in violation of the applicable Colorado legal standards.

In light of the absence of water court findings of fact on the elements concerning a governmental agency's non-speculative intent to appropriate and the "can and will" test, we reverse the water court's judgment.

II.

[1, 2] We hold that a governmental water supply agency has the burden of demonstrating three elements in regard to its intent to make a non-speculative conditional appropriation of unappropriated water: (1) what is a reasonable water supply planning period; (2) what are the substantiated population projections based on a normal rate of growth for that period; and (3) what amount of available unappropriated water is reasonably necessary to serve the reasonably anticipated needs of the governmental agency for the planning period, above its current water supply. In addition, it must show under the "can and will" test that it can and will put the conditionally appropriated water to beneficial use within a reasonable period of time. In the case before us, we determine that the water court has not made sufficient findings of fact enabling our review of its judgment and decree. Accordingly, we set aside the decree, reverse the judgment, and remand this case to the water court for further proceedings. The water court, in its discretion, may take additional evidence and argument as it deems appropriate on remand.

A.

Standard of Review

[3, 4] Whether an applicant has met the legal standards for a conditional appropriation presents mixed questions of fact and law that we review de novo. *City of Thornton v. Bijou Irrigation Co.*, 926 P.2d 1, 40 (Colo. 1996); *Bd. of County Comm'rs. v. Upper Gunnison River Water Conservancy Dist.*, 838 P.2d 840, 847 (Colo.1992). We defer to the water court's findings of fact if the evidence supports them. *Bijou*, 926 P.2d at 40.

B.

Anti–Speculation and Beneficial Use

Water is a public resource. The water of every natural stream, including tributary groundwater, is the property of the public, subject to appropriation.[5] Colo. Const. art. XVI, § 5. Thus, surface and tributary groundwater is dedicated by Colorado's constitution and statutes to appropriation for beneficial use by public agencies and private persons in order of their adjudicated priorities. *High Plains A & M, LLC v. Se. Colo. Water Conservancy Dist.*, 120 P.3d 710, 718 (Colo.2005).

Colorado's system of public ownership of water, combined with the creation of public and private use rights therein by appropriation, circumscribes monopolist pitfalls. When the beneficial use requirement was put into practice in the nineteenth century, its fundamental purpose was to establish the means for making the public's water resource available to those who had the actual need for water, in order to curb speculative hoarding. David B. Schorr, *Appropriation as Agrarianism: Distributive Justice in the Creation of Property Rights*, 33 Ecol. L.Q. 3, 9, 22 (2005).

Colorado water law continues to fill this role today, through its requirements for optimum beneficial use, efficient water management, and priority administration. *Empire Lodge Homeowners' Ass'n v. Moyer*, 39 P.3d 1139, 1146–47 (Colo.2001).

The public's water resource is subject to maximum utilization, a doctrine intended to make water available for as many decreed uses as there is available supply. § 37–92–102(1)(a), C.R.S. (2007); *Farmers Reservoir & Irrigation Co. v. City of Golden*, 44 P.3d 241, 245 (Colo.2002); *see also* § 37–92–501(2)(e), C.R.S.(2007). Within the priority system, maximum utilization spreads the benefit of the public's water resources to as many uses as possible, within the limits of the physically available water supply, the constraints of interstate water compacts, and

5. Author David B. Schorr discusses the anti-speculation basis for public ownership of water and the creation of public and private use rights therein recognized by the Colorado Constitution.

> With ownership of the state's water vested in the people, private actors could acquire only the right to use that water, and then only under conditions stipulated by the owner through its agent, the state. This notion of public ownership provided the theoretical basis for much of the law developed to counter water companies and speculators in Colorado.

David B. Schorr, *The First Water–Privatization Debate: Colorado Water Corporations in the Gilded Age*, 33 Ecol. L.Q. 313, 319–20 (2006).

the requirements of United States Supreme Court equitable apportionment decrees.

[5] In turn, the objective of maximum use administration, under the prior appropriation system, is to achieve "optimum use" in every appropriator's utilization of the water. § 37–92–501(2)(e) ("[A]ll rules and regulations shall have as their objective the optimum use of water consistent with preservation of the priority system of water rights."). Maximum utilization does not mean that every ounce of Colorado's natural stream water ought to be appropriated; optimum use can be achieved only through proper regard for all significant factors, including environmental and economic concerns. *See Alamosa–La Jara Water Users Prot. Ass'n v. Gould,* 674 P.2d 914, 935 (Colo.1983).

[6] Neither a private nor a governmental agency may obtain a right to use a portion of the public's water resource unless it establishes intent to make a non-speculative appropriation. *See Vought v. Stucker Mesa Domestic Pipeline Co.,* 76 P.3d 906, 912 (Colo.2003). Once an appropriator makes an actual beneficial use, it holds a vested property right of use protected by constitutional guarantees. *Empire Lodge,* 39 P.3d at 1147; *Strickler v. City of Colo. Springs,* 16 Colo. 61, 70, 26 P. 313, 316 (1891).

Colorado's system for decreeing conditional appropriations encourages beneficial use by antedating the priority of a water right, but only to the extent of the actual beneficial use that subsequently occurs. *Dallas Creek Water Co. v. Huey,* 933 P.2d 27, 35 (Colo. 1997). This makes public and private projects possible by giving appropriators the time and certainty necessary to obtain and complete engineering, financing, and construction of the necessary works for capturing, possessing, and controlling water for beneficial use in the completion of an appropriation. *Public Serv. Co. of Colo. v. Blue River Irrigation Co.,* 753 P.2d 737, 739 (Colo. 1988).

[7] A conditional water right is "a right to perfect a water right with a certain priority upon the completion with reasonable diligence of the appropriation upon which such water right is to be based." § 37–92–103(6). To obtain a conditional water right, an applicant must demonstrate that: (1) it has taken a "first step," which includes an intent to appropriate the water and an overt act manifesting such intent; (2) its intent is not based on a speculative sale or transfer of the water to be appropriated; and (3) there is a substantial probability that the applicant can and will complete the appropriation with diligence and within a reasonable time. *Bijou,* 926 P.2d at 31.

[8] For an applicant to satisfy the first step, he or she must meet the burden of demonstrating intent to appropriate the water for beneficial use. *Id.* at 36; *City of Aspen v. Colo. River Water Conservation Dist.,* 696 P.2d 758, 761 (Colo.1985). This requirement is the basis of the anti-speculation doctrine. *See Bijou,* 926 P.2d at 37.[6]

[9] For a private entity to meet its intent burden, it must have contractual commitments for any appropriations that are not planned for its own use, or the application will fail as unduly speculative. *Colo. River Water Conservation Dist. v. Vidler Tunnel Water Co.,* 197 Colo. 413, 415–16, 594 P.2d 566, 568–69 (1979). On the other hand, a governmental water supply agency has a unique need for planning flexibility because it must plan for the reasonably anticipated water needs of its populace, taking into account a normal increase in population. *City & County of Denver v. N. Colo. Water Conservancy Dist.,* 130 Colo. 375, 384, 276 P.2d 992,

6. Our opinion in *Bijou* provides an overview of the common law and legislative development of the anti-speculation doctrine. 926 P.2d at 36–40. In 1979, the General Assembly modified the definition of appropriation found in the Water Right Determination and Administration Act of 1969. This legislation endorsed the *Vidler* intent requirement for private entities that we announced in *Colorado River Water Conservation District v. Vidler Tunnel Water Co.,* 197 Colo. 413, 594 P.2d 566 (1979). The legislation also recognized the need for a more flexible anti-speculation requirement that would allow government agencies planning flexibility, the "great and growing cities" concept that we had earlier recognized in *City & County of Denver v. Sheriff,* 105 Colo. 193, 96 P.2d 836 (1939), and *City & County of Denver v. Northern Colorado Water Conservancy District,* 130 Colo. 375, 276 P.2d 992 (1954).

997 (1954); *City & County of Denver v. Sheriff,* 105 Colo. 193, 202, 96 P.2d 836, 841 (1939).

Thus, Colorado's 1969 Act defines "appropriation" in a manner that differentiates private appropriators from governmental agency appropriators. Section 37–92–103 states:

> (3)(a) "Appropriation" means the application of a specified portion of the waters of the state to a beneficial use pursuant to the procedures prescribed by law; *but no appropriation of water, either absolute or conditional, shall be held to occur when the proposed appropriation is based upon the speculative sale or transfer of the appropriative rights to persons not parties to the proposed appropriation, as evidenced by either of the following:*
>
> (I) The purported appropriator of record does not have either a legally vested interest or a reasonable expectation of procuring such interest in the lands or facilities to be served by such appropriation, *unless such appropriator is a governmental agency or an agent in fact for the persons proposed to be benefited by such appropriation.*
>
> (II) *The purported appropriator of record does not have a specific plan and intent to divert, store, or otherwise capture, possess, and control a specific quantity of water for specific beneficial uses.*

(emphasis added).

[10] As we explained in *Bijou,* the statute excuses governmental agencies from the requirement to have a legally vested interest in the lands or facilities served, but the exception "does not completely immunize municipal applicants from speculation challenges." 926 P.2d at 38. A governmental agency need not be certain of its future water needs; it may conditionally appropriate water to satisfy a projected normal increase in population within a reasonable planning period.

[11] The governmental agency does not have carte blanche to appropriate water for speculative purposes; in effect, the statute provides for a limited exception from certain requirements otherwise applicable to private appropriators. Public agencies must still substantiate a non-speculative intent to appropriate unappropriated water, and they must "have a specific plan and intent to divert, store, or otherwise capture, possess, and control a specific quantity of water for specific beneficial uses." § 37–92–103(3)(a)(II). Accordingly, the governmental agency has the burden to demonstrate that its conditional appropriation is not speculative. *Bijou,* 926 P.2d at 39.

[12] The conditional appropriation must be consistent with the governmental agency's reasonably anticipated water requirements based on substantiated projections of future growth within its service area.

> Thus, under section 37–92–103(3)(a), a municipality may be decreed conditional water rights based solely on its projected future needs, and without firm contractual commitments or agency relationships, *but a municipality's entitlement to such a decree is subject to the water court's determination that the amount conditionally appropriated is consistent with the municipality's reasonably anticipated requirements based on substantiated projections of future growth.*

Id. (emphasis added). The conditional appropriation must not be based on a conjectural population projection that becomes a self-fulfilling prophecy of growth.

> Most front range municipalities in Colorado could conjecture growth in the next few decades at exponential rates. To some extent, that growth is directly related to the ability of the municipality to supply water. Hence, the projection becomes a self-fulfilling prophecy if the municipality secures a right to the water necessary to sustain the growth. We do not view such conjecture as sufficient substantiation to support a conditional decree for water. Municipalities must do more than represent to the water court that if they had water, they would be able to grow.

Id. at 39 n. 25.

Only a reasonable planning period for the conditional appropriation is allowed. In *Bijou,* the water court's findings of fact addressed what constitutes a reasonable water supply planning period, fifty years in that

case, and found the existence of substantiated population and water use projections. *Id.* at 42. The judgment and decree we upheld also included sufficient "reality checks" for the purpose of ensuring in subsequent diligence proceedings that the appropriator will utilize the "newly appropriated rights for its own purposes and does not become a permanent lessor or wholesaler of water yielded by these rights." Id. at 50 n. 40.

We also determined in *Bijou* that use of a volumetric limitation in a conditional decree, rather than a flow rate standard, curbs the otherwise speculative tendency of a lengthy conditional appropriation period. *Id.*

Requiring adjusted, realistic estimates of future need in subsequent diligence proceedings is consistent with the purpose underlying both the anti-speculation doctrine and the diligence requirement, i.e., preserving unappropriated water for future users having legitimate, documented needs. *Id.* at 51.[7]

In addition to demonstrating non-speculative intent, a governmental agency must satisfy the "can and will" requirement in order to obtain a conditional decree. Section 37–92–305(9)(b) provides:

> No claim for a conditional water right may be recognized or a decree therefor granted except to the extent that it is established that the waters can and will be diverted, stored, or otherwise captured, possessed, and controlled and will be beneficially used and that the project can and will be completed with diligence and within a reasonable time.

[13] The anti-speculation and the "can and will" requirements are closely related. A conditional decree applicant cannot reasonably prove that its project can and will be completed with diligence and within a reasonable time if it lacks the requisite non-speculative intent. *City of Black Hawk v. City of Central*, 97 P.3d 951, 956–57 (Colo. 2004).

[14] The factors a court considers under the "can and will" requirement in diligence proceedings include, but are not limited to: 1) economic feasibility; 2) status of requisite permit applications and other required governmental approvals; 3) expenditures made to develop the appropriation; 4) ongoing conduct of engineering and environmental studies; 5) design and construction of facilities; and 6) nature and extent of land holdings and contracts demonstrating the water demand and beneficial uses which the conditional right is to serve when perfected. *See Dallas Creek*, 933 P.2d at 36. The purpose of the diligence proceeding is to gauge whether the conditional appropriator is making steady progress in putting the water to beneficial use with diligence and within a reasonable period of time. *Id.*

The reason for continued scrutiny of the conditional appropriation through diligence proceedings is to prevent the hoarding of priorities to the detriment of those seeking to use the water beneficially. *Id.* The effect of a long-term conditional right is to preclude other appropriators from securing an antedated priority that will justify their investment. *See generally Natural Energy Res. Co. v. Upper Gunnison River Water Conservancy Dist.*, 142 P.3d 1265, 1277 (Colo.2006).

Those in line behind a conditional appropriation for a long planning period risk losing any investment they may make in the hope that the prior conditional appropriation will fail. They also may not be able to raise the necessary funds in the first instance that will enable them to proceed, in light of their subordinated status. Those who obtain a priority date junior to the antedated priority and proceed to put the water to beneficial use must involve themselves in a continued expensive struggle throughout numerous six

7. Among governmental agencies, a water conservancy district has no authority to sell water outside of its boundaries. § 37–45–118(IV)(j), C.R.S. (2007) ("[T]he sale, leasing, and delivery of water ... whether the water is developed by the principal district or a subdistrict thereof, shall only be made for use within the boundaries."). Other municipal and quasi-municipal agencies may be able to sell to customers outside of their boundaries. *City & County of Denver v. Colo. River Water Conservation Dist.*, 696 P.2d 730, 742 (Colo.1985) (holding that Denver could appropriate water for the purpose of extraterritorial leasing); *but see Bijou*, 926 P.2d at 40 (stating that in such an instance the governmental agency is acting on the open market and is

year diligence periods to knock out all or part of the antedated conditional appropriation, in order to protect their appropriations. The General Assembly's intent is to prevent decreed conditional appropriations from accumulating to the detriment of those whose priority will be advanced by cancellation of the senior conditional priority in whole or part, or those who might proceed to initiate a new or enlarged appropriation. *Dallas Creek,* 933 P.2d at 37–38, 42.

[15] Thus, in the design of water law, the essential function of the water court in a conditional decree proceeding is to determine the amount of available water for which the applicant has established both a need and a future intent and ability to actually use. *Bijou,* 926 P.2d at 47. As a prerequisite, the applicant has the burden of demonstrating a nonspeculative intent to put the water to beneficial use and, under the "can and will" test, a substantial probability that its intended appropriation will reach fruition. *Id.* at 42.

C.

Lack of Sufficient Trial Court Findings

The case before us involving a one hundred year planning horizon requires us to determine whether the governmental agency exception to the otherwise applicable anti-speculation requirements should be broadly or narrowly construed. We determine that our decision in *Bijou* stands for a narrow construction.

As *Bijou* demonstrates, Colorado's anti-speculation doctrine includes constraints on conditional appropriations by governmental agencies.[8] The length of the governmental agency's water supply planning period, its anticipated future needs for a normal rate of population growth based on substantiated population projections for that period, the amount of conditionally-decreed water to be allocated for its use, and its ability under the "can and will" test to put the conditionally appropriated water to beneficial use within a reasonable planning period were the focus of our factual and legal inquiry into the water court's judgment and decree in *Bijou. Id.* at 37–45.

In upholding the water court's approval of a fifty year water supply planning horizon for the conditional appropriation, we observed that the applicant had "presented extensive evidence to support both its projections of future water demand and its ultimate intent." *Id.* at 40. That evidence included witnesses, planning experts, planning documents, and studies prepared by water consultants. *Id.* In addition, the water court imposed "reality checks" in the conditional decree to verify in subsequent six year diligence proceedings that the population and water usage forecasts continued to be reasonable. *Id.* Also, we approved the inclusion of a decree provision for a volumetric limit on the conditional appropriation. *Id.*

[16, 17] Based on Colorado's statutory requirements and *Bijou,* the limited governmental agency exception to the anti-speculation doctrine should be construed narrowly, in order to meet the state's maximum utilization and optimum beneficial use goals. Although the fifty year planning period we approved in *Bijou* is not a fixed upper limit, and each case depends on its own facts, the water court should closely scrutinize a governmental agency's claim for a planning period that exceeds fifty years.

The ultimate factual and legal issue in a governmental agency conditional appropriation case involves how much water should be conditionally decreed to the applicant. The experts who testified at the water court trial in this case were called upon to address such pertinent factors as: (1) implementation of reasonable water conservation measures for the planning period;[9] (2) reasonably expect-

bound by the anti-speculation standards applicable to private appropriators).

8. The limited governmental entity water supply exception to the anti-speculation law, often called "the great and growing cities" doctrine, has been criticized for allowing public agencies to do just what private entities cannot do, i.e., speculate in the public's water resource. *See* Dan Tarlock & Sarah Bates Van de Wetering, *Water and Western Growth,* Water Report, Sept. 15, 2007, at 1, 1–13.

9. "Water conservation" is defined as "water use efficiency, wise water use, water transmission and distribution system efficiency, and supply substitution. The objective of water conservation is a long-term increase in the productive use of

ed land use mixes during that period; (3) reasonably attainable per capita usage projections for indoor and outdoor use based on the land use mixes for that period; and (4) the amount of consumptive use reasonably necessary for use through the conditional appropriation to serve the increased population.[10]

[18, 19] But in this case, the water court did not make sufficient findings of fact enabling our review of its judgment and decree. For the water court's guidance and consistent with the statutes and *Bijou*, we identify areas of unresolved factual findings bearing on whether the districts have met their burden to demonstrate a nonspeculative intent to appropriate the amount of water they claim and whether the districts' have satisfied the "can and will" test. In doing so, we do not limit the water court's authority to: (1) consider additional factors based on the issues raised by the parties; (2) make findings based on the evidence already contained in the record and that which it takes on remand; and (3) enter a judgment and decree for the districts' conditional appropriation.

In decreeing to the districts a total diversion into storage of 64,000 acre-feet of water annually, with a right of reuse, and decreeing a separate 80 cfs direct flow diversion, the water court did not make findings of fact with regard to the disputed threshold issue of what planning period is reasonable, whether 2040, 2050, or 2100.

When the districts were forming their intent to appropriate water, they started with a planning horizon that was well within the fifty year planning horizon approved in *Bijou*. They had before them the 2003 Harris report that supported a conditional appropriation to meet their 2040 demands. Because SJWCD already holds a 6,300 acre-foot conditional water right, the Harris report supported a year 2040 need for the appropriation of an additional 5,700 acre-feet of water for a total of 12,000 acre-feet of water at a diversion rate of 18.5 cfs through the Dry Gulch Pump Station into the reservoir.

In contrast, the conditional decree approved by the water court contains a planning horizon, diversion rates, and a total volumetric annual consumption amount for stored water far in excess of what the districts initially considered to be reasonable for water supply planning purposes. The decree also contains an unexplained direct flow diversion rate of 80 cfs. The decree implements the districts' goal of appropriating water for the entire 35,000 acre-foot storage capacity of the Dry Gulch site, with a right to refill and make a fully consumptive reuse, based on population and water demand protections for the year 2100 put forth by their engineer.[11]

In approving the districts' conditional decree application, unlike the water court in *Bijou*, the water court did not resolve a factual dispute concerning substantiated projections of future growth. Trout Unlimited advanced population projections for Archule-

water supply in order to satisfy water supply needs without compromising desired water services.'' § 37–60–126(g), C.R.S. (2007).

10. Typically, a governmental agency utilizes the services of a water resources engineer to help assess the future water supply needs for its service area, above that which is available through use of its present supply. *See* Daniel S. Young & Duane D. Helton, *Developing A Water Supply In Colorado: The Role Of An Engineer,* 3 U. Denv. Water L.Rev., 373–390 (2000). The amount of water required to meet a public water supply agency's reasonably anticipated needs is based on a substantiated rate of normal population growth, and depends on estimating the amount of water that will be physically consumed by the agency's water users within a pre-determined planning horizon. *Id.* at 377.

11. The districts' concern in pursuing such a long water supply planning horizon was that the Colorado Water Conservation Board might make an additional instream flow appropriation under its statutory authority, section 37–92–102(3), C.R.S. (2007), or that a recreational in-channel diversion water right might be decreed to the Town of Pagosa Springs under its statutory authority, section 37–92–103(10.3), downstream of the districts' diversion point on the San Juan River, or both. The districts also conjectured that the U.S. Forest Service might require a significant bypass flow as a condition for federal permitting for the Dry Gulch Reservoir project. Such considerations do not fit into the applicable requirement to address water availability based on the conditions of the stream as they exist by reason of the exercise of prior-appropriated rights. *See Matter of Bd. of County Comm'rs of County of Arapahoe,* 891 P.2d at 971.

ta County based on figures from the State Demographer's Office and the districts' engineer made his own long-term projections based on recent growth rates in the county. Nor did the water court make findings concerning the future land use mixes for the Town of Pagosa Springs and Archuleta County and per capita water usage requirements, taking into account implementation of water conservation measures.[12] Further, the water court did not take into account the measure of consumptive use the districts reasonably need to serve their population in the future during a reasonable planning period.

The effect of decreeing reuse rights is to greatly increase an entity's usable water supply. As we pointed out in *Bijou,* an appropriation of native water is typically subject to only one use, with the return flows going back to the groundwater or surface water. 926 P.2d at 27–28. Return flows help fill other appropriations, whereas a right of reuse to extinction does not. We said in *Bijou* that one can appropriate reuse rights of unappropriated native flow water, but the need to do so must be substantiated. *Id.* Here, the water court did not make findings of fact relating to the amount of water that can be generated through reuse, in relationship to the total amount of available unappropriated water necessary to meet the districts' reasonably anticipated needs over a reasonable water supply planning period. *Id.* at 39–40.

Finally, the water court did not make findings of fact under the "can and will" test regarding the districts' ability to construct the 35,000 acre-foot reservoir and perfect the use and reuse of 64,000 acre-feet of stored water together with construction and use of a separate 80 cfs direct flow water right.

In sum, the planning horizon for the conditional appropriation the water court decreed doubles the fifty year period for the conditional appropriation the water court decreed in *Bijou,* and the amount of consumptive use water the water court decreed greatly exceeds the amount the 2003 Harris report supports as adequate to meet a 2040 planning horizon. The justification for the much longer planning horizon and the vastly greater amount of water conditionally decreed for the districts' consumption does not appear in the water court's findings of fact, judgment, and decree.

D.

Recreation, Fish, and Wildlife Uses

Trout Unlimited also contends that the districts failed to demonstrate the requisite specific plan and intent for a number of the uses listed in the decree, specifically recreation, fish and wildlife, and aesthetic purposes. The decree provides that water appropriated by the districts could be used for "recreation (including releases to benefit decreed recreational in-channel rights), piscatorial and wildlife preservation ... and aesthetic purposes." Recreational use of stored water in and on a reservoir is a recognized and frequent beneficial use in this state. § 37–92–103(4), (C.R.S.2007).

The districts satisfied the intent requirement for these uses to be confirmed in the conditional decree for recreation in and on Dry Gulch Reservoir. During the water court proceedings, PAWSD board member Karen Wessels testified that the reservoir would be useful for recreation and the districts were actively seeking to make recreational, wildlife and fish, and aesthetic uses of the stored waters. The districts' pursuit of facilities and agreements for such purposes in association with the Dry Gulch Reservoir can be evaluated in future diligence proceedings.[13]

12. Assessing a reasonable projection of the mixture of uses and their consumptive measures will yield monthly and annual consumptive use figures for the water applied to beneficial use. *Upper Eagle Reg'l Water Auth. v. Simpson,* 167 P.3d 729, 734–736 (Colo.2007). The conservation measures in the PAWSD plan include water efficient fixtures, low water landscapes, water rate structures, education, and regulatory measures such as plumbing codes. Pagosa Area Water & Sanitation Dist., *Water Conservation and Drought Management Plan* 9 (2004), *available at* http://www.pd–go.com/files/upload–3649.pdf.

13. The record does not identify a stream segment or the amount of water to be released downstream for augmentation of fish and recreational uses or recreational in-channel diversion use in compliance with the applicable requirements. Thus, the districts have not demonstrated their

E.

Conclusion

In accordance with the applicable statutory and case law requirements identified in this opinion, the water court should examine the evidence utilizing the elements applicable to determining whether the districts have met their burden for a non-speculative conditional appropriation, accompany its judgment with sufficient findings of fact based on the evidence, and fashion appropriate decree provisions, which may include "reality checks" and volumetric limitation provisions for the districts' conditional appropriation. The water court must also make factual findings concerning whether the districts can and will place the claimed amount of unappropriated water to beneficial use within a reasonable time.

III.

Accordingly, we reverse the water court's judgment, set aside the conditional decree, and remand this case for further proceedings consistent with this opinion. The water court, in its discretion, may take additional evidence and argument as it deems appropriate on remand.

Justice COATS concurs in the judgment only.

Justice EID specially concurs, and Justice RICE joins in the special concurrence.

Justice COATS, concurring in the judgment only.

While I agree that the judgment of the water court must be reversed and its conditional decree vacated, I do not agree with the majority's rationale for doing so or its remand order. In my view, the water court's error lies less in the inadequacy of its findings than in its failure to distinguish the reasonable time requirement of the "can and will" test from the reasonableness of a municipality's growth projections for purposes of the anti-speculation doctrine. Although the majority acknowledges, at least in principle, the independence of the "can and will" standard, I fear that its explanation for reversing the judgment in this case can only perpetuate a fundamental misreading of *Bijou* and encourage governmental agencies and water courts alike to tie up the state's water resources with conditional decrees long beyond the time reasonably required to complete a particular project and actually put the resulting water to a beneficial use.

In *City of Thornton v. Bijou Irrigation Co.*, 926 P.2d 1, 38–39 (Colo.1996), we clarified the scope of the governmental agency exception to the anti-speculation doctrine, holding that a municipality may be decreed conditional water rights without firm contractual commitments or agency relationships, but only to the extent of its reasonably anticipated requirements, based on substantiated projections of future growth. We also acknowledged the anti-speculation objective of the "can and will" statute and held that where speculation is not a real concern, the "can and will" test should not be applied to prevent on technical grounds an appropriation that would serve the goal of maximum utilization. *Id.* at 43 n. 31; *see also Bd. of County Comm'rs of Arapahoe County v. United States, et al.*, 891 P.2d 952, 962 (Colo. 1995). We nevertheless drew a clear distinction between the "can and will" standard and the anti-speculation doctrine and validated, even for governments, the separate "can and will" requirement that an applicant for a conditional water right establish a substantial probability that *within a reasonable time* the facilities necessary to effect the appropriation can and will be completed with diligence and the resulting waters applied to a beneficial use. *Bijou*, 926 P.2d at 42–43.

Perhaps because the applicant's satisfaction of the "can and will" test was challenged only as to various legal contingencies and the capacity of its proposed facilities, we did not more specifically address the "can and will" test's reasonable time requirement. By the same token, however, we clearly did not excuse municipalities from complying with it or equate it with a municipality's reasonable

intent to appropriate a specified amount of water to effectuate such uses. *See Bd. of County Comm'rs of the County of Arapahoe v. Upper Gunnison River Water Conservancy Dist.*, 838 P.2d 840, 849 (Colo.1992); §§ 37–92–103(10.3), 37–92–305(13)(a),(C.R.S.2007).

population projections. In context, we implicitly found it satisfied in *Bijou* only because of the complex circumstances surrounding the decree in that case.

In particular, we took pains to note that Thornton already served a population of 78,000 and that in addition to expected steady and substantial growth, the city's location downstream from other municipal and industrial users was resulting in a gradual deterioration of its water quality. *Id.* at 19. Its "Northern Project," which was the subject of the conditional decree, involved a complex interrelationship of water acquisition and distribution methods, including diversion, exchange, storage, augmentation, and physical transportation. *Id.* at 20. From an engineering perspective it required the utilization of a wide variety of structures and facilities, to be constructed incrementally, in carefully integrated phases, requiring some thirty to forty years for full implementation. *Id.* at 20–21. Legally, it involved four separate water right applications with statements of opposition by forty-nine parties, which had already involved some ten years of litigation by the time of our judgment. *Id.* at 21–22. We described the project as one of the largest municipal water projects to come before this court in recent memory. *Id.* at 19.

By contrast, virtually none of these complexities was present in the instant decree. By comparison with Thornton's Northern Project in *Bijou*, the population, engineering, and legal challenges faced by the applicants in this case seem almost trivial. As the testimony of its expert made clear, the application for a conditional decree of water rights that would not be needed, even by the applicant's projections, for nearly a century was not dictated in any way by the complexities of developing the water and making it available for use, but rather as a bid to preempt intervening appropriations for more immediate needs. On its face, such a practice is antithetical to the principle of maximum utilization in general, and the "can and will" statute in particular.

Once all connection between the time needed to diligently develop a project for the beneficial utilization of water and a conditional decree for the right to use it has been severed, the fundamental justification for relating priorities back to a time predating actual appropriation is no longer applicable. The right of municipalities to lay claim to available waters for future needs (before their neighbors can do so) becomes limited only by their ability to reasonably predict population growth. Recognizing the open-endedness of such a rule, the majority, virtually without any serious attempt at justification, purports to presumptively limit conditional decrees to the time frame approved in *Bijou.* While the danger foreseen by the majority is real enough, I believe the solution rests in the continued vitality of the reasonable time requirement of the "can and will" test, even for governmental agencies.

Rather than imposing an arbitrary presumption about what is not (and apparently what is) a reasonable period for municipal conditional decrees, this court need only make clear that the "can and will" statute requires completion within a reasonable time, in light of the legal, engineering, and economic circumstances of the project. Nothing in the anti-speculation exception for governmental agencies relieves municipalities of this additional requirement, excepting only that the anticipation of reasonable growth by municipalities is not considered speculation by the statute at all, and therefore municipal projects that would serve the goal of maximum utilization should not be thwarted by the "can and will" standard on technical grounds.

Because I believe the record in this case adequately demonstrates that the applicant failed to meet its burden under the "can and will" standard, and that remanding for further findings as the majority does will prove misleading about the actual requirements of that standard to both lower courts and concerned parties, I would simply reverse the judgment of the water court.

Justice EID, specially concurring.

The water court concluded that the conditional decree in this case was non-speculative and met the "can and will" requirement, but did not make findings to support its conclusions. Maj. op. at 310. In my view, we should simply remand the case to the water

court to make such findings. Because the majority goes beyond a simple remand—instead giving a "narrow construction" to our governing precedent of *City of Thornton v. Bijou Irrigation Co.,* 926 P.2d 1 (Colo.1996), and imposing a de facto fifty year cap on water planning efforts in Colorado—I respectfully concur in the result it reaches.

Under the anti-speculation doctrine, the "applicant must establish an intent to appropriate water for application to beneficial use," *id.* at 36, and "no appropriation of water ... shall be held to occur when the proposed appropriation is based upon the *speculative sale or transfer of the appropriative rights to persons not parties to the proposed appropriation* ...." § 37–92–103(3)(a), C.R.S. (2007) (emphasis added). Such speculation may be evidenced by the fact that "[t]he purported appropriator of record does not have either a legally vested interest or a reasonable expectation of procuring such interest in the lands or facilities to be served by such appropriation, *unless such appropriator is a governmental agency* ...." § 37–92–103(3)(a)(I) (emphasis added). In *Bijou,* we held that while the statutory language does not entirely immunize governmental entities from speculation challenges, it does reflect the fact that "municipalities require sufficient flexibility within the anti-speculation doctrine to allow them to plan for future water needs." 926 P.2d at 38–39.

We recognized a similar flexibility with regard to the "can and will" requirement, section 37–92–305(9)(b), C.R.S. (2007), which is closely related to the anti-speculation doctrine. In *Bijou,* we concluded that in order to satisfy the "can and will" requirement, an applicant for a conditional decree must "establish that there is a substantial probability that within a reasonable time the facilities necessary to effect the appropriation can and will be completed with diligence, and that as a result waters will be applied to a beneficial use." 926 P.2d at 42–43. Thus, under the anti-speculation doctrine, the governmental entity must show that it intends to use the water to serve a growing population. Under the "can and will" requirement, the governmental entity must show that there is a substantial probability that it will actually be able to build the water projects necessary to serve that growing population. *Id.* We concluded in *Bijou* that "the 'can and will' requirement should not be applied rigidly to prevent beneficial uses where an applicant otherwise satisfies the legal standard of establishing a nonspeculative intent to appropriate for a beneficial use." *Id.* at 43.

We have long recognized this need for flexibility in water planning by governmental entities. In *City & County of Denver v. Sheriff,* 105 Colo. 193, 202, 96 P.2d 836, 841 (1939), for example, we upheld a water plan by the City and County of Denver against a speculation challenge, noting that "it is not speculation but the highest prudence on the part of the city to obtain appropriations of water that will satisfy the needs resulting from a normal increase in population within a reasonable period of time." *See also* Amicus Curiae Brief of the City & County of Denver acting by and through its Board of Water Commissioners at 2 (urging us to preserve such flexibility because "it allows decisions about the most fundamental needs of citizens to be determined in a participatory process"); Amici Curiae Brief of the City of Colorado Springs and the Southwestern Water Conservation District at 7 (same).

The need for flexibility, of course, does not relieve a governmental entity from demonstrating that the conditional decree it seeks is non-speculative and meets the "can and will" requirement. *Bijou,* 926 P.2d at 38–43. In this case, the water court concluded that the conditional appropriation was non-speculative and met the "can and will" requirement, but made no findings to supports its conclusions. In my view, the solution to this lack of findings is a simple remand for entry of findings in accordance with the framework we set out in *Bijou.*

Instead, the majority instructs the water court on remand that our decision in *Bijou* "stands for a narrow construction." Maj. op. at 317. As part of that "narrow construction," the majority concludes that "[a]lthough the fifty year planning period we approved in *Bijou* is not a fixed upper limit, and each case depends on its own facts, the water court *should closely scrutinize a governmental agency's claim for a planning period that*

exceeds fifty years." *Id.* at 317 (emphasis added). This standard of "close scrutiny" imposes, in my view, a de facto fifty year cap on water planning in the state.

The majority's fifty year de facto cap is supported neither by the evidence adduced before the water court nor by *Bijou.* What a reasonable planning period would be in this case was not an issue fully developed in the water court, as the majority recognizes. Maj. op. at 318. And while we approved the plan in *Bijou* that used a fifty year planning horizon, we did not suggest that governmental entities could not adopt planning horizons in excess of fifty years. 926 P.2d at 40–42 (discussing the water court's ruling on the anti-speculation doctrine). The majority's transformation of *Bijou's* fifty year planning horizon into a de facto cap on water planning in Colorado is contrary to our longstanding recognition of the need for flexibility in this area.

At some point, it may be necessary for us to modify our decision in *Bijou.* But no one has urged us to do so here today. In my view, the better course of action would be to allow the water court, in the first instance, to consider this case in light of *Bijou,* and for us to later consider—or reconsider—the *Bijou* framework. Whether *Bijou* should be given a "narrow construction," maj. op. at 317, is an issue better left for another day. For this reason, I respectfully concur in the majority's judgment.

I am authorized to say that Justice RICE joins in this concurrence.



Osmundson, D.B. 2000. Importance of the 15-Mile Reach to Colorado River Populations of Endangered Colorado Pikeminnow and Razorback Sucker. Final Report to the Upper Colorado River Endangered Fish Recovery Program

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U.S. Fish & Wildlife Service

IMPORTANCE OF THE '15-MILE REACH' TO COLORADO RIVER POPULATIONS OF ENDANGERED COLORADO PIKEMINNOW AND RAZORBACK SUCKER





IMPORTANCE OF THE '15-MILE REACH' TO COLORADO RIVER POPULATIONS OF ENDANGERED COLORADO PIKEMINNOW AND RAZORBACK SUCKER

FINAL REPORT

A U. S. Fish and Wildlife Service Position Paper
Based on a Synthesis of Current Biological Information

March, 2000

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U. S. FISH AND WILDLIFE SERVICE

EXECUTIVE SUMMARY

The U. S. Fish and Wildlife Service (USFWS) takes the position that the quality and quantity of habitat in a 15-mile reach of the upper Colorado River must be protected and enhanced if Colorado River populations of two endangered species are to be maintained and recovered. The reach extends upstream from the Gunnison River confluence in Grand Junction, Colorado to the Grand Valley Diversion dam at Palisade, Colorado. The flow regime of the reach has been altered in two primary ways: (1) upstream diversion dams have significantly reduced summer flows since the turn of the century; and (2) headwater dams have reduced spring runoff flows since the middle of the century. Despite these and other impacts, the 15-mile reach and the 18-mile reach immediately downstream continue to be concentration areas for a remnant Colorado River population of the endangered Colorado pikeminnow, and until recent years, for the endangered razorback sucker, now almost extirpated. This report attempts to summarize the biological basis for why the 15-mile reach, and the Grand Valley in general, are so critically important to the maintenance and recovery of these populations.

Floodplains contain habitats critical to the reproductive strategy of razorback suckers. Alluvial valleys containing such habitats appear to have been centers of distribution for this species in the upper Colorado River. These areas include the Grand Valley as well as the more upstream De Beque-to-Rifle reach. Both areas should therefore be the focus of recovery efforts for this species in the upper Colorado River.

For Colorado pikeminnow, movements are an integral part of the life history strategy: adults migrate to spawn, larvae drift long distances down river, and sub- and young adults disperse from nursery areas to reaches containing more suitable adult habitat. As a consequence, an individual fish is likely to use many sections of river during the course of its life. Each part of the river is therefore important; however, based on the distribution of these life stages, some areas are clearly more important than others. For young, the reach downstream of Moab, Utah evidently contains the most important rearing habitat in the river. Conversely, the reach upstream of Westwater, Utah evidently contains the most important adult habitat.

Upstream of Westwater, the 33-mile long Grand Valley consistently supports the greatest concentrations of adult Colorado pikeminnow. The relatively high gradient, clear water, broad floodplain and a diversity of habitat types make these upstream sections of river more productive than more downstream sections. Higher standing stocks of periphyton and invertebrates support relatively high numbers of forage fish, in turn providing greater food availability for the river's top piscivore, the Colorado pikeminnow. However, main-channel temperatures decline with distance upstream and upstream movements therefore take these warmwater fish away from a more preferred thermal regime. The Grand Valley, including the 15-mile reach, may represent the best balance between food supply and preferred temperatures. It is not known how much farther upstream of the Grand Valley these fish would establish home ranges were it not for the diversion dams that currently block their movement. However, results of an analysis of pikeminnow distribution in the Yampa River (where adults have unlimited upstream access), and a comparison between the thermal regime there and that in the Colorado River, suggests that suitable temperatures in the Colorado River may extend approximately 14 miles into canyon habitat upstream of the Grand Valley.

Alluvial valleys with floodplain habitats, high productivity and relatively warm main-channel temperatures are in short supply in the upper Colorado River. The Grand Valley, including the 15-mile reach, is the center of distribution for adult Colorado pikeminnow in the upper Colorado River and may have historically been so for the razorback sucker. It is therefore clear that this area will be critical in recovering populations of these endangered fish.

INTRODUCTION

The '15-mile reach' is that portion of the Colorado River between the Grand Valley Diversion Dam at Palisade, Colorado and the confluence with the Gunnison River near downtown Grand Junction (Fig. 1). This reach is occupied by two endangered fish species, the Colorado pikeminnow *Ptychocheilus lucius* and the razorback sucker *Xyrauchen texanus*. Because the 15-mile reach is designated critical habitat and is sometimes acutely affected by local irrigation withdrawals of water, management of the reach has received considerable attention. Consequently, a need exists for a document that describes the biological importance of this reach and provides managers a common understanding from which issues can most effectively be addressed. This report attempts to meet that need by providing a synthesis of current information pertaining to the role that the 15-mile reach plays in providing habitat critical to the viability and recovery of Colorado River populations of endangered Colorado pikeminnow and razorback sucker.

BACKGROUND

Water Use

Water withdrawals, beginning at the turn of the century, have resulted in major changes in the flow regime of the 15-mile reach. Flows in both this reach and reaches downstream have diminished because of diversions of water used to meet local irrigation needs as well as transbasin diversions of water from west slope headwaters to metropolitan areas of Colorado's east slope. The likelihood of additional water depletions upstream of this reach is certain because the State of Colorado has expressed its intent to pursue full utilization of its apportioned share of Colorado River water, as set forth in the 1922 Colorado River Compact and the 1948 Upper Colorado River Compact. These multi-state agreements were formulated prior to societal concerns for environmental quality or the enactment of the Endangered Species Act. Consequently, the conflicting demands of water development and protection of endemic Colorado River fishes has resulted in an institutional tug-of-war over water flowing through the 15-mile reach. The Fish and Wildlife Service, recognizing the importance of the 15-mile reach, recently issued a programmatic biological opinion that stipulates the implementation of various recovery actions designed to offset the negative effects of past and future water depletions. Thus, additional depletions will be in compliance with the Endangered Species Act, provided that the recovery actions are implemented in a timely manner and a positive fish population response is detected.

Endangered Fish Use

As the name implies, this section of river is roughly 15 miles (24 km) long and runs through the upper half of the Grand Valley. The Grand Valley, extending approximately 35 miles (56 km) from Loma to Palisade, Colorado, is an alluvial valley containing the largest urban area and one of the largest farming areas in western Colorado. Razorback suckers, though rare, were captured throughout the Grand Valley in the late 1970s and early 1980s, primarily in

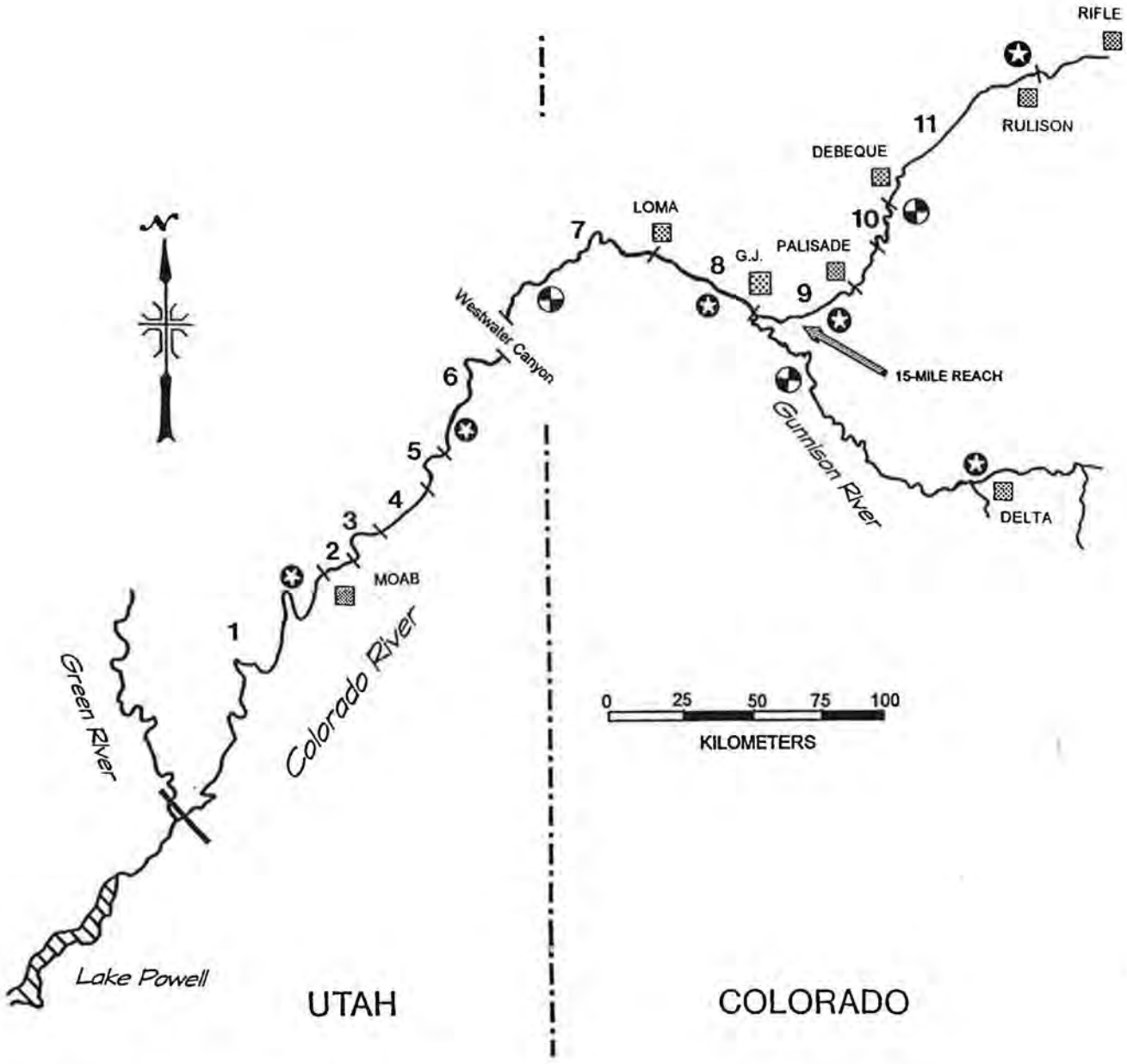


Figure 1. Warm-water reaches of the Colorado River upstream of the confluence with the Green River (lower black line). The river was stratified (see Osmundson 1999a) by landform type and gradient into 11 major strata (numbered). Strata 8 and 9 comprise the Grand Valley with 9 being the 15-mile reach. Diversion dams at Palisade block upstream movements of fish. Starred circles are locations of U. S. Fish and Wildlife Service thermographs; crossed circles are locations of U. S. Geological Survey gauging stations with thermographs.

flooded off-channel habitats where they concentrated during spring (Kidd 1977, Valdez et al. 1982). As recently as the late 1980s, razorback sucker were still occasionally captured in the 15-mile reach, primarily during their spring spawning season (Osmundson and Kaeding 1991). In the 1990s, only four razorback sucker were captured in the Colorado River and these were found in the reach immediately downstream of the 15-mile reach. Adult Colorado pikeminnow, though rare, are routinely captured in the 15-mile reach throughout the year (Osmundson and Kaeding 1989, Osmundson et al. 1998), and spawning there has been verified by the collection of larvae in 1982 and 1995 (McAda and Kaeding 1991; Anderson 1999).

SYNTHESIS

Distribution of Endangered Fish in the Upper Colorado River

Though more is known about the life history of Colorado pikeminnow than of razorback sucker, both species evidently require large stretches of river to fulfill their respective life history needs. As individuals progress through various life stages, their habitat requirements change. For instance, young Colorado pikeminnow rear in reaches where nursery habitat is most suitable, whereas larger and older individuals move to more upstream habitats where food for adults is more abundant (Osmundson et al. 1998). This distribution pattern appears to be consistent in both Colorado and Green river systems. Colorado pikeminnow are the top predator in the riverine food chain. They subsist almost exclusively on a diet of fishes and prefer areas where prey fish are abundant. In the Colorado River, the greatest fish production and consequently the greatest number of adult Colorado pikeminnow occur upstream of Westwater Canyon. During recent studies (Osmundson 1999a), electrofishing catch rates of forage-size fish (mostly native suckers) were 3-4 times higher in reaches upstream of Westwater Canyon than in reaches downstream (see Fig. 2). In the Green River, the majority of adult Colorado pikeminnow are also found in upper reaches as well as in two major tributaries, the Yampa and White rivers (McAda et al. 1994).

Upstream reaches generally have greater numbers of forage fish because food for these fishes (algae and aquatic insects) is more abundant than in downstream reaches (Lamarra 1999). Higher water clarity, and therefore deeper light penetration, allow greater production of phytoplankton (free-floating algae) and periphyton (algae that grows on rock surfaces). These algae are food for various species of aquatic invertebrates. Also, upper river reaches generally have steeper gradients than the more downstream reaches, causing water to flow more swiftly over the substrate. This serves to clean silt and sand from the upper layer of gravel and cobble. Silt-free crevices around rocks provide important attachment sites and living spaces for aquatic invertebrates (Osmundson and Scheer 1998). Algae and aquatic invertebrates living in these clean substrates are food for native fishes such as bluehead sucker *Catostomus discobolus*, flannelmouth sucker *Catostomus latipinnis* and roundtail chub *Gila robusta* which are potential prey for Colorado pikeminnow

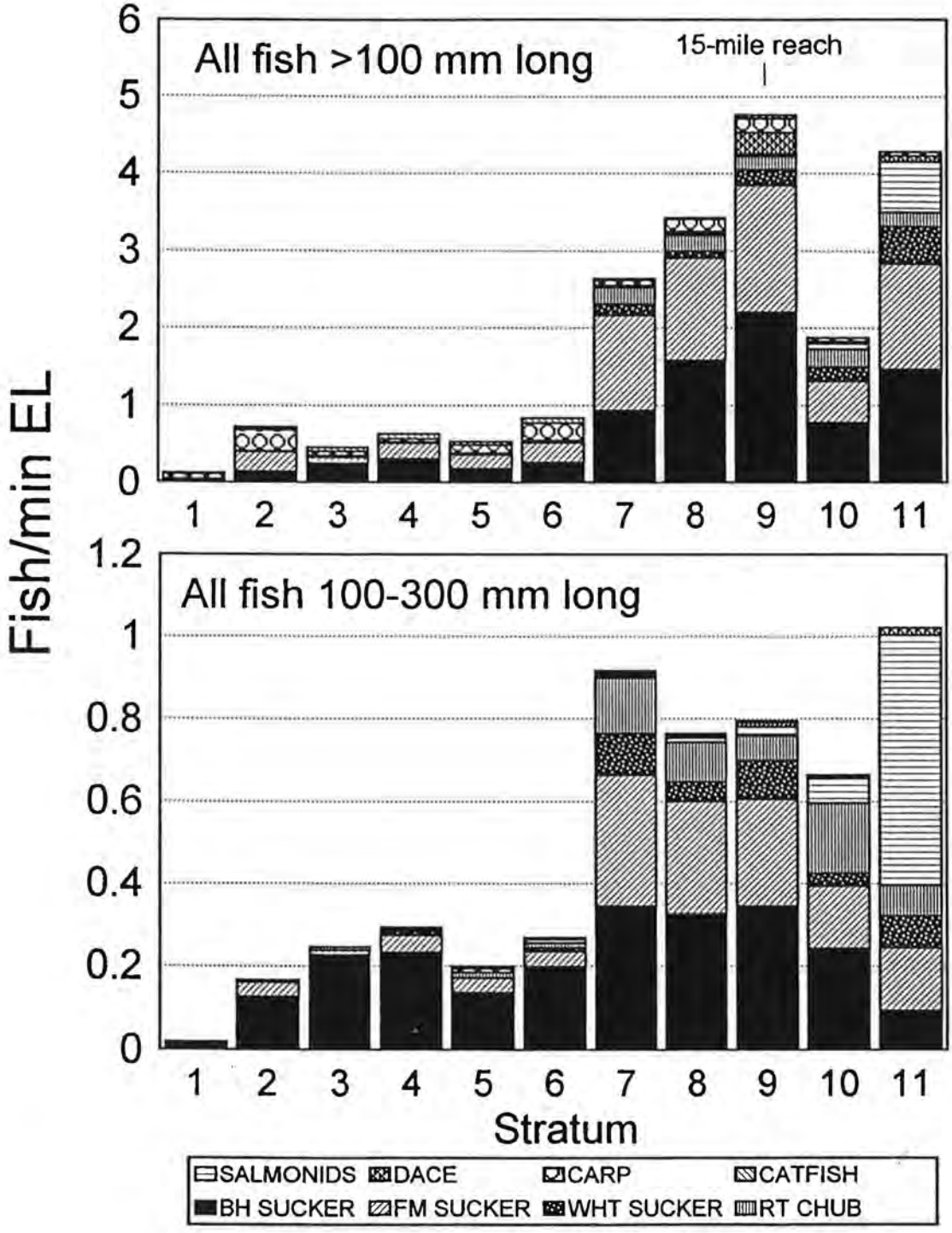


Figure 2. Electrofishing catch rates of fish in the Colorado River, 1994-1995. Upper graph depicts catch rates of all fish 100 mm long or larger; bottom graph depicts only those fish small enough to serve as forage for adult Colorado pikeminnow (<300 mm long). Graphs are from Osmundson (1999a). See Fig. 1 for locations of strata. Stratum 9 is the 15-mile reach.

(Osmundson 1999a).

Clean cobble and gravel substrates of upper reaches also provide suitable spawning sites for Colorado pikeminnow. As eggs deposited in these areas hatch, emerging larvae drift downstream with the current. In the Colorado River, most pikeminnow larvae end up downstream of Moab, Utah where the gradient flattens and the river slows (Trammell and Chart 1999). There, silt and sand is deposited creating bars and associated backwaters. Backwaters are warm, productive, still-water habitats well suited for rearing of young Colorado pikeminnow. During their first year of life, Colorado pikeminnow concentrate in backwaters and feed on zooplankton and chironomid larvae (Muth and Snyder 1995). Later, as Colorado pikeminnow become piscivorous, an abundance of small prey fish continues to provide ample forage (Osmundson et al. 1998).

As Colorado pikeminnow reach adulthood, larger forage fish are presumably required to maintain body condition and growth rates. However, such forage fish are scarce in downstream reaches. As young adults, Colorado pikeminnow begin to disperse up and down the river (Fig. 3), either in search of spawning areas or better feeding grounds. Eventually, the more abundant supplies of native fish in the upper river are discovered and adult pikeminnow remain there and establish home ranges (Osmundson et al. 1998). This dispersal pattern results in somewhat segregated life stages with adult densities clumped near the upstream margins of their range. Currently, the Grand Valley contains the greatest densities of adult Colorado pikeminnow in the Colorado River (Fig. 4). Also, this distribution pattern results in the average size of Colorado pikeminnow to progressively increase in an upstream direction, with the greatest average size occurring in the 15-mile reach (Fig. 5). Thus, the importance of this reach is in providing habitat for adults.

Compared to Colorado pikeminnow, specific attributes of the life cycle of the razorback sucker, in terms of its use of the entire river, is largely unknown. However, there are some similarities between the two species: like Colorado pikeminnow, razorback adults are generally concentrated in upstream regions of the Green and Colorado rivers, they exhibit long-range spawning migrations (Modde and Irving 1998), and larvae drift downstream from spawning sites in the middle and upper Green River (Chart et al. 1999). Other evidence suggests that flooded bottomlands along the Green and Colorado rivers historically served as nursery areas for larvae. Historically, bottomlands were inundated more frequently and for a greater duration each spring than occurs under current river regulation practices (Osmundson and Kaeding 1991; Modde 1996; Modde et al. 1996).

The 15-mile Reach in Perspective

Contemporary river ecology emphasizes the propensity for biodiversity and bioproduction to be largely controlled by habitat maintenance processes such as cut and fill alluviation mediated by river discharge. Along a river's length, environmental heterogeneity maximizes in alluvial reaches, and floodplains appear to function as centers of biophysical organization (Stanford et al. 1996). In addition, core populations (rela-

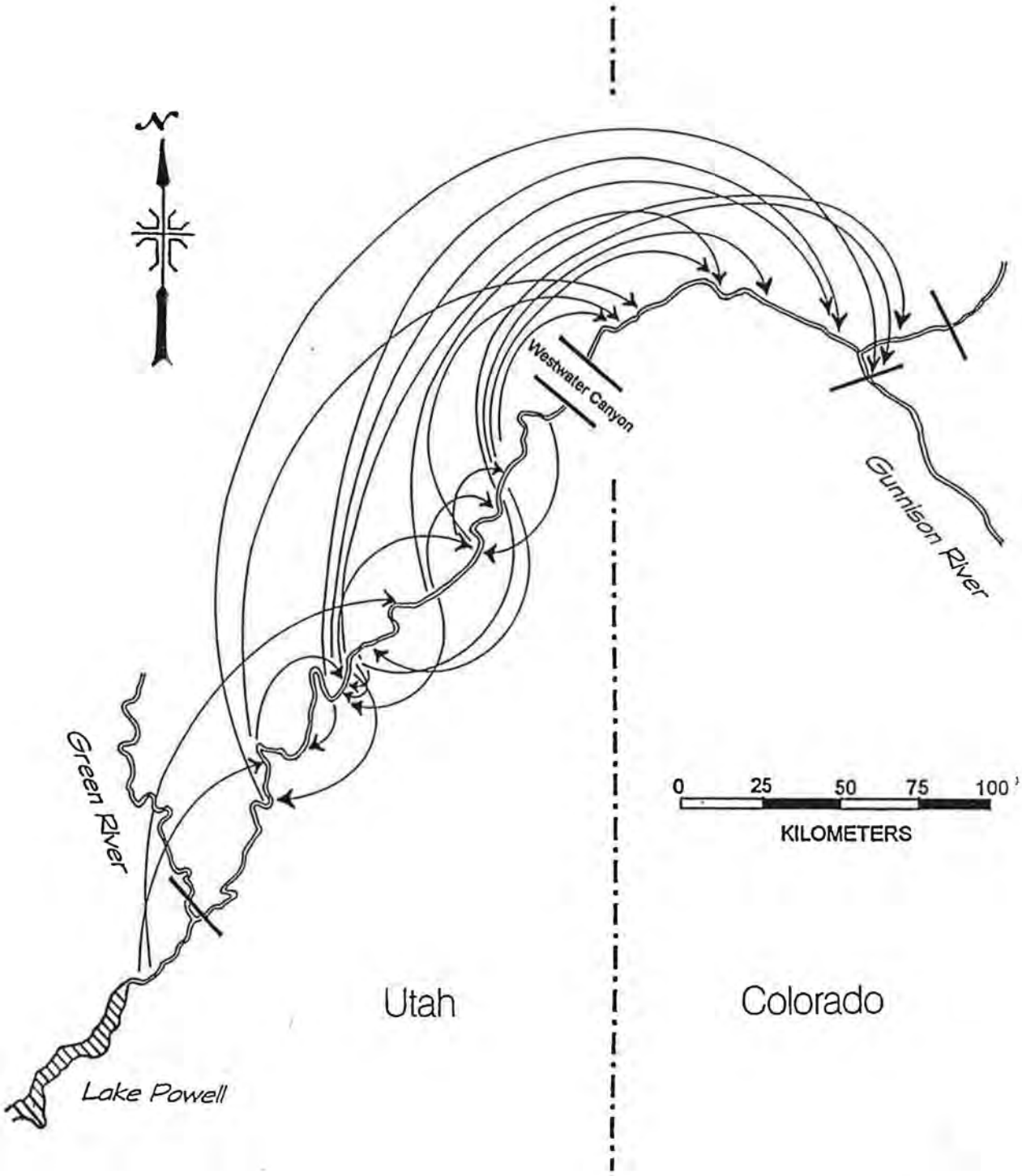


Figure 3. Movement of Colorado pikeminnow PIT-tagged in the lower reach of the Colorado River, 1991-1994. Arrow origins represent capture location; arrow points represent location of next capture. Consecutive captures were at least 1 year apart; only movements greater than 10 km are shown. Figure is from Osmundson et al. (1998).

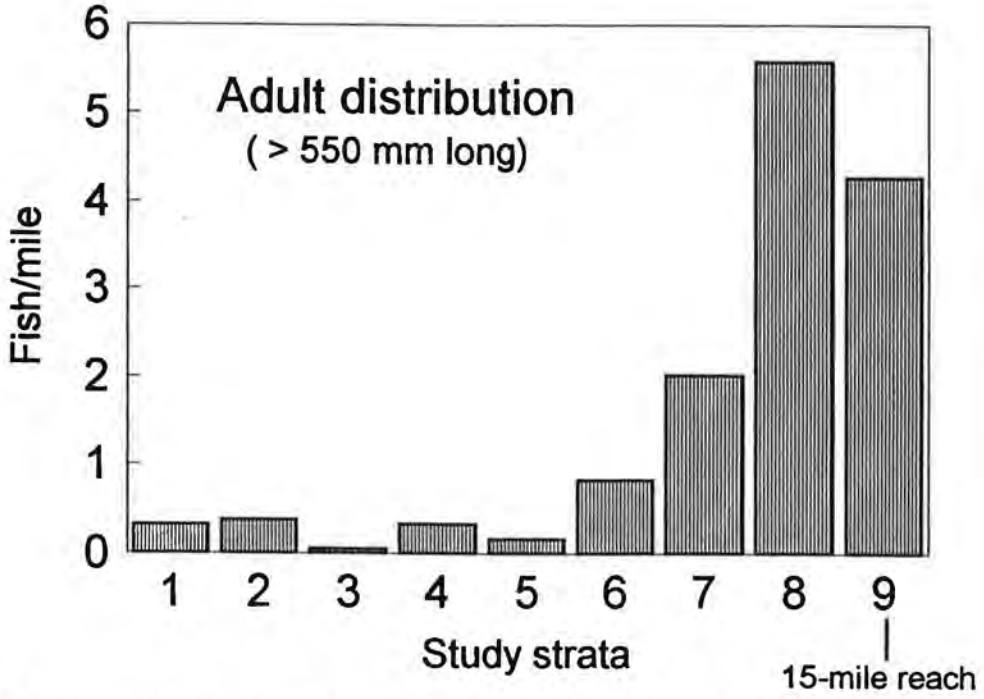


Figure 4. Longitudinal variation in densities of adult Colorado pikeminnow in the Colorado River. Fish per mile was calculated using annual population estimates (1991-1994 and 1998-1999) for the lower (strata 1-6) and upper (strata 7-9) reaches, proportion of fish captured each year greater than 550 mm, and correction factors that account for effort per stratum and miles per stratum. See Fig. 1 for strata locations and Osmundson and Burnham (1998) for sampling methodology.

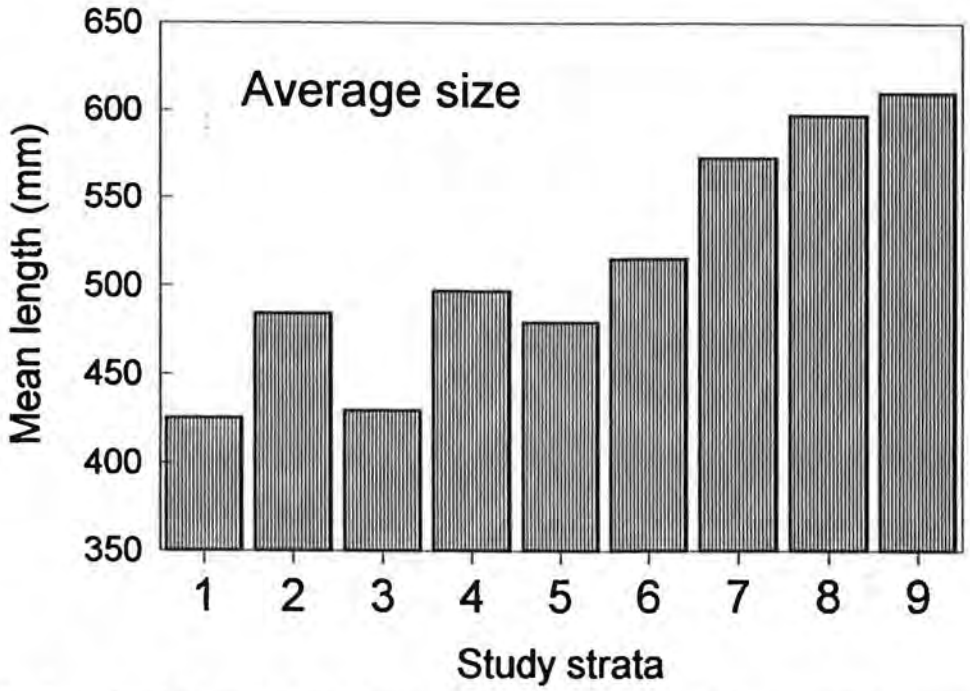


Figure 5. Longitudinal variation in mean length of Colorado pikeminnow captured with trammel netting and electrofishing in the Colorado River. Values are means of annual means (1991-1994 and 1998-1999). See Fig. 1 for strata locations and Osmundson and Burnham (1998) for sampling methodology.

tively large populations occupying quality habitat) are believed critical for persistence of metapopulations (Schoener 1991, Harrison 1991, 1994, Stanford et al. 1996). In rivers, large alluvial reaches often support core populations of fishes (Lichatowich and Mobrand 1995). The current distribution of Colorado pikeminnow and the historic distribution of razorback sucker in the upper Colorado River appears to fit this model, with core populations centered in the alluvial Grand Valley.

To understand the habitat needs of Colorado pikeminnow and razorback sucker, an ecological perspective is required that takes into account all phases of their life cycles and recognizes that population dynamics occur at a scale encompassing hundreds of miles of river. Thus, the relative importance of a particular area, such as the 15-mile reach, cannot be viewed in isolation, but must be viewed in the context of how it fits into the larger life history picture. A river without good adult habitat cannot support a viable population, just as a river without good spawning or nursery habitat cannot. The reach downstream of Moab, Utah is critically important in a similar way, because it contains the best nursery habitat in the Colorado River. Failure to consider these facts can lead to the false conclusion that because the 15-mile reach constitutes only 8% of the 185 occupied miles of the Colorado River (above the Green River confluence), it plays only a small role in maintaining populations of Colorado pikeminnow and razorback sucker. To the contrary, the data suggest that prime adult habitat is restricted to the upper 60 miles of this 185-mile-long Colorado River reach, with the best habitat and greatest concentrations of adults located in the 33-mile-long Grand Valley. With this perspective, the importance of the 15-mile reach becomes apparent.

The Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin has plans to provide fish passage at diversion structures upstream of the 15-mile reach to allow Colorado pikeminnow and razorback sucker access to upstream portions of their historical range. The 15-mile reach, and the short 3-mile reach just upstream, currently constitute the upstream limit of the Colorado pikeminnow's range in the mainstem Colorado River. The Price-Stubb Dam has blocked upstream movements of fishes since its construction in 1911. Razorback sucker have been found upstream of these diversions relatively recently; one was captured in 1991 near Rifle, Colorado, some 55 miles upstream of Palisade (Burdick 1992). However, no similar upstream capture records, either recent or historic, exist for Colorado pikeminnow despite intensive sampling from Price Stubb Dam to Rifle during the past three decades (Kidd 1977, 1979; Valdez et al. 1982; Anderson 1997; Osmundson 1999a). Numbers of pikeminnow in this reach likely diminished over time as a result of the long-term effects of the diversion dams preventing return migration after larvae or adults moved downstream. Providing passage to this area should prove beneficial to the Colorado River population by increasing the amount of adult habitat. Because adult habitat is in short supply, the extent to which this upstream reach will provide suitable habitat has a bearing on the relative importance of the 15-mile reach.

Electrofishing surveys between the Price Stubb Dam and Rifle, Colorado demonstrate that an abundance of native suckers and chubs live in this reach and could serve as forage for adult Colorado pikeminnow (Wydoski 1994, Anderson 1997, Osmundson 1999a). However, because of progressively cooler water temperatures, the margin of the historic range for these warm-water species occurs somewhere within these upstream reaches. Upstream of Palisade, a transition zone begins between a downstream warm-water fish community, historically dominated by chubs, native suckers, and Colorado pikeminnow, and an upstream cold-water fish community, dominated by salmonid species such as trout and mountain whitefish. How the endangered fish utilize this reach once access is again provided remains to be seen. In the interim, predicting habitat suitability for these fish requires an evaluation of the thermal requirements of the species and the thermal regime of the reach.

Relationship Between Temperature and Fish Distribution

Positioning of adults, both locally and along the length of the river, is likely driven by growth maximization (Hughes 1998), and growth is largely dependent on the interaction of food availability and water temperature (Weatherley 1972). Achieving maximum growth potential enhances the ability of the individual to survive and reproduce successfully. In many fish species, large females produce more and larger eggs, thereby enhancing larval survival (Monteleone and Houde 1990; Brandt and Kirsch 1993). Although temperatures in the Palisade-to-Rifle reach are only a few degrees centigrade (C) lower than in the Grand Valley on any given day, this difference can result in a significant reduction in thermal units needed for fish growth over the course of a year.

Controlled laboratory experiments have shown that growth rate of yearling Colorado pikeminnow is maximized at 25°C. At 20°C, growth rate is 54% of the maximum; at 15°C, growth is only 18% (Black and Bulkley 1985a); at 13°C, Colorado pikeminnow cease to grow (Kaeding and Osmundson 1988). Other lab studies demonstrated that 25°C is the preferred temperature of yearling and subadult pikeminnow (Black and Bulkley 1985b) and preferred temperature generally corresponds to the optimum temperature for many physiological processes including growth (e.g. Magnuson et al. 1979). To reveal the effect of low temperature on habitat suitability, annual, accumulated thermal units available for growth can be calculated for various reaches of river. For comparative purposes, Kaeding and Osmundson (1988) developed an index whereby mean daily temperatures are converted to values relative to the maximum potential (1.0) for growth at the optimum temperature (25° C). These thermal units can then be summed to provide an annual value for a specific location.

Using multi-year data from a series of thermographs located at various sites along the river (see Fig. 1), Osmundson (1999a) converted daily temperatures to thermal units for Colorado pikeminnow growth. Average annual thermal units (ATU) at Palisade were 79% of the average at the Colorado/Utah state line (about 48 miles downstream). At Cameo, the average was

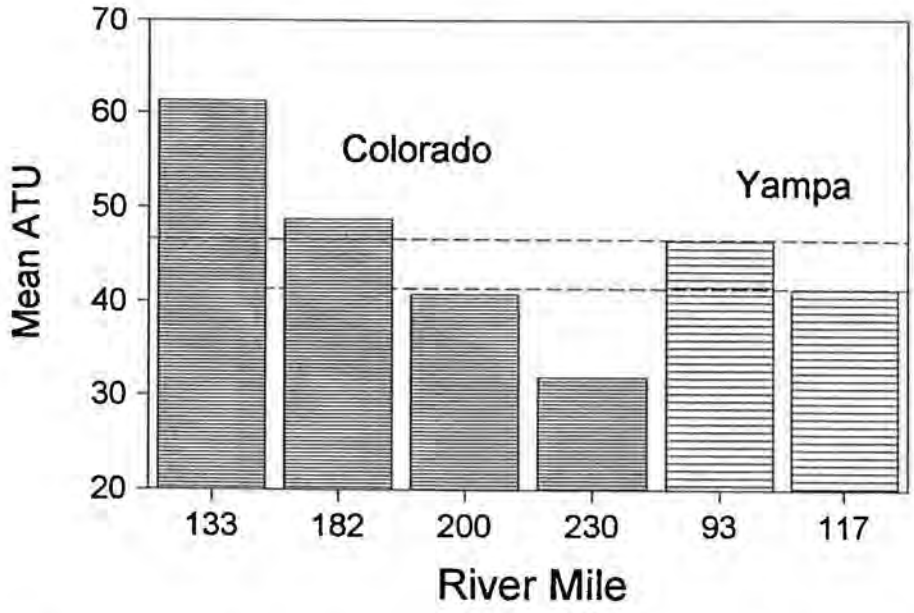


Figure 6. Mean annual thermal units (ATU) available for Colorado pikeminnow growth at four locations on the Colorado River and two on the Yampa River for comparison. Dashed horizontal lines indicate sites on each river with similar thermal regimes. River mile (rm) 133 is near the Colorado/Utah state line; rm 182 is 3 miles downstream of the top of the 15-mile reach; rm 200 is 7 miles upstream of Cameo; rm 230 is at Rulison. On the Yampa River, rm 93 is at Juniper Springs (the Yampa reach where densities of Colorado pikeminnow are highest); rm 117 is near Sheep Creek (the site of Nesler's [1995] most upstream Colorado pikeminnow capture). Data are from Osmundson (1999a).

only 67% of that at the state line, and at Rulison, only 52% (Fig. 6).

Although abundant forage may compensate for slow growth caused by low temperatures, there is a point at which temperatures are so limited that additional food cannot make up for the temperature shortfall and growth slows. What defines the upstream range of this species is likely a temperature threshold, below which annual growth is insufficient. Colorado pikeminnow can likely gauge about where this minimum thermal regime occurs and individual home ranges are therefore established no further upstream of this point.

In the Yampa River, fish have unrestricted upstream access. Nesler (1995) found adult Colorado pikeminnow in the Yampa as far upstream as river mile (rm) 117. This location has an average ATU value of about 41. On the Colorado River, the location with the same mean ATU occurs at approximately rm 199, or about 14 miles upstream of Palisade. Using the Yampa River as a model, Osmundson (1999a) suggested that Colorado pikeminnow in the upper Colorado River should be able to establish home ranges upstream almost as far as De Beque, Colorado, once passage is provided. Also, the thermal regime in the reach where Colorado pikeminnow were most abundant in the Yampa River averaged 46.5 ATU (rm 93). The analogue to this site in the Colorado River

is at the top of the15-mile reach (Fig. 6). Thus, in terms of forage and suitable temperature regime, the 15-mile reach may be located in or near the most optimal part of the Colorado River for Colorado pikeminnow.

Low water temperature might also inhibit successful spawning by pikeminnow in reaches upstream of Palisade. In De Beque Canyon, temperatures necessary for spawning are met, but the overall thermal regime may be less than optimal in some years. The initiation of spawning in the Colorado River generally occurs when river temperatures exceed 18°C and spawning activity lasts 3-8 weeks (Trammell and Chart 1999). Hamman (1981) reported that females held in raceways did not spawn until temperatures exceeded 20°C. In controlled experiments, Marsh (1985) found that for eggs spawned and fertilized at 18°C, hatching success and embryo survival was highest at 20°C. Although some spawning occurs at cooler temperatures (see Bestgen et al. 1998), most spawning in the Colorado, Green, and Yampa rivers occurs at water temperatures between 18-22°C (McAda and Kaeding 1991, Tyus 1990, Bestgen et al. 1998, Anderson 1999, Trammel and Chart 1999). Analyses of temperature records at Cameo (1986-1996) indicate that 18°C is exceeded in both wet and dry years, but in wet years, 20°C may be only briefly attained (Fig. 7). Thus, in some years suitable conditions for spawning may be of short duration. In addition, the delayed annual warming of upstream reaches will likely delay the onset of spawning, resulting in larvae having a shorter first-year growing season than if produced in more downstream reaches.

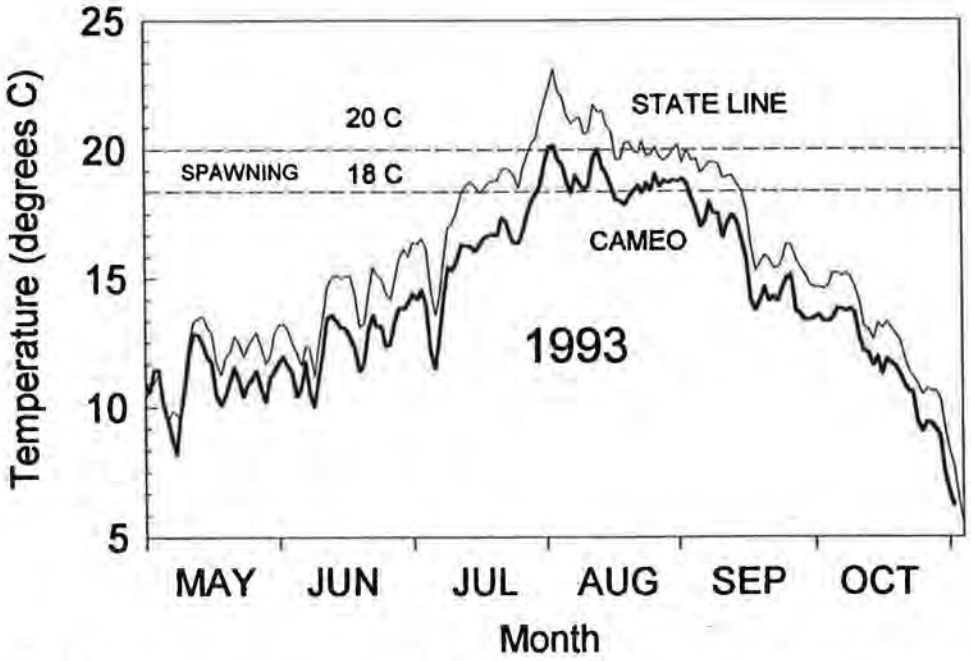


Figure 7. Main channel temperatures (May-October) at two sites in the Colorado River during a wet year, 1993. Measurements are from USGS gauging stations at Cameo and the Colorado-Utah state line. Plotted daily values are the average of the daily maximum and minimum readings. Timing and duration of temperatures in excess of 18° and 20° C (see text) at the two sites are shown for comparison.

It is difficult to predict the success that Colorado pikeminnow might have in spawning or in establishing home ranges upstream of the 15-mile reach. However, from what we currently know about the temperature regime of the river and the temperature requirements of this species, the Grand Valley appears to be located near the upstream limits of the optimal range for this population. Thus, the importance of the 15-mile reach will not be diminished by the reestablishment of access to more upstream reaches.

Clearly, providing passage to reaches upstream of Palisade should be pursued as part of recovery efforts for the razorback sucker and Colorado pikeminnow. Razorback sucker persisted in this reach until recent times suggesting that its thermal requirements may be slightly lower than those for Colorado pikeminnow. Also, razorback sucker typically exploit warm, off-channel ponds and flooded areas. This behavior may serve to offset temperature limitations of the main channel allowing the razorback sucker population to extend upstream farther than the population of Colorado pikeminnow. However, restoring passage is also anticipated to extend the range of year-round use by Colorado pikeminnow upstream an estimated 14 miles into canyon habitat downstream of De Beque. This will provide a much-needed addition to the limited amount of adult habitat currently available to this population. Also, the more upstream De Beque-to-Rifle reach, though perhaps too cool for year-round use, might serve Colorado pikeminnow as a seasonal feeding area during the warm months of late summer (Osmundson 1999a). However, this more upstream reach should not be viewed as a substitute for the high quality habitat found within the warmer, alluvial reaches of the Grand Valley. Nevertheless, all sections of former range in the upper Colorado River are important and must be restored if the long-term viability of these endangered populations is to be assured.

SUMMARY AND CONCLUSIONS

During the course of their lives, individual Colorado pikeminnow may utilize the entire 185 miles of the upper Colorado River to meet the demands of their changing life history needs. Habitat selection involves tradeoffs between the relative availability of various resources. More optimum thermal regimes for Colorado pikeminnow and razorback sucker are located in lower portions of the river, but substrates are unsuitable for spawning and food availability for adults is low. Further upstream, steeper gradient and local geological conditions produce coarser substrate and diverse channel morphology resulting in suitable physical conditions for spawning. In addition, greater nutrient input and light penetration results in greater food production in upstream reaches, particularly in alluvial valleys. However, for warm-water species, like Colorado pikeminnow and razorback sucker, the further upstream an individual ventures, the cooler the thermal regime becomes, and the more the potential for growth declines. The greatest concentrations of adult Colorado pikeminnow are found in the Grand Valley, presumably because the benefit of high food availability outweighs the cost of a cooler thermal regime. Further upstream, food availability remains high but temperatures decline until food availability can no longer offset the negative effects of low temperatures. Thus,

below the Grand Valley, particularly below Westwater Canyon, food is the limiting resource for adult Colorado pikeminnow, whereas at some point upstream of the Grand Valley, temperature becomes limiting. The Grand Valley appears to represent the best available balance between these two constraining resources. Also, floodplain habitats, believed critical in meeting the life history needs of razorback sucker, are more plentiful in the floodplain of the Grand Valley than in more confined reaches downstream.

Based on this understanding of the life history and ecological requirements of Colorado pikeminnow and razorback sucker, it is the position of the U. S. Fish and Wildlife Service that the prime adult habitat found in the Grand Valley, including the 15-mile reach, must be preserved and enhanced. The population of subadult and adult Colorado pikeminnow in the Colorado River currently consists of only about 600-800 individuals (Osmundson and Burnham 1998, Osmundson 1999b). An increase in the frequency of strong year classes is needed to boost the size of this population. For the nearly extirpated razorback sucker, stocking will first be required to establish an effective breeding population; naturalized reproduction and recruitment will then be necessary for the population to become self-sustaining. However, in addition to recruitment limitations, quality adult habitat for both species is currently in short supply. To address this shortfall, not only will access to historically occupied reaches need to be restored, but management efforts must also focus on preserving and enhancing conditions in the Grand Valley (including the 15-mile reach), where the best available habitat for adult Colorado pikeminnow and razorback sucker currently exists.

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  - Member, National Association and Colorado/Wyoming Chapter
- American Water Resources Association
  - Member, National Association and Colorado Chapter
- Instream Flow Council
  - Member, National Instream Flow Program Assessment (NIFPA I (1996) and NIFPA II (1998)) Steering Committee, Co-author of Final USFWS Report
  - Charter Member and First Biennial Meeting Host (2000)
  - Member, Governing Council – Colorado
  - Western Regional Director (2003-04)
  - Chair, Awards and Certifications Subcommittee, FLOW 2015 (Portland)
  - Chair, Local Arrangements Subcommittee, FLOW 2018 (Fort Collins)

Work Experience:

Since December, 2018:

- February – June, 2019: Contract work for the Colorado Water Conservation Board's Stream Protection Section preparing a Field Methods Manual for the collection instream flow data for R2CROSS.
- July, 2019 – Present: Contract work to support Western Resource Advocates' High Priority Streams Project investigating partnership opportunities for the protection of instream flows in western Colorado.
- November, 2019 – September, 2021: NOWCC Position as an ACES Hydrologist with the Arapaho-Roosevelt NF tasked with assisting Forest Service personnel with the review of potential future water projects on NF System Lands and the evaluation of USFS water rights on Colorado's 2020 Proposed Abandonment List.
- August, 2024 – Present: NEWSolutions Aces position with the US Department of Agriculture's Natural Resources Conservation Service. Water rights specialist assisting the Easement Programs Division's work associated with the US Farm Bill land protection programs.

State of Colorado – Retired December 31, 2018

Colorado Parks and Wildlife (2011 – 2018) Positions:

- Instream Flow Program Coordinator
- Water Resources Unit Manager
- Acting Water Resources Section Manager
- Water Resources Section Special Project

Colorado Division of Wildlife (1987 – 2011) Positions:

- Instream Flow Program Coordinator
- Water Resources Unit Manager

Colorado Water Conservation Board (1985 – 1987)

- Water Resources Specialist

Instream Flow Program Coordinator duties and responsibilities:

- Responsible for all aspects relating to the quantification of instream flows in Colorado.
- Responsible for collecting information on the natural environment (fishery, aquatic macroinvertebrates, riparian condition, water quality) and documentation thereof.
- Instream flow modeling (R2CROSS, PHABSIM) for the development of approximately 600 instream flow recommendations and appropriations.
- Planning and prioritizing instream flow data collection efforts with CWCB staff, DOW/CPW regional personnel, and other program partners.
- Participation in annual instream flow work planning workshops; presentation of plans for future data collection and flow recommendations.
- Transmittal of CDOW/CPW instream flow recommendations "with specificity and in writing" to CWCB for consideration and action, participation in public and agency consultation meetings, provided testimony before the CWCB to support flow recommendations developed by DOW/CPW and those formulated by other program partners.

- Provided CWCB with other biological and instream flow expertise when addressing questions of water right injury, mitigation, and inundation. Prepared for and provided water court testimony in a limited number of cases.
- Represented DOW/CPW in all instream flow and flow/habitat related projects such as regulatory actions, land use authorizations, FERC hydropower licensing activities, NEPA processes, and ESA Recovery Programs.
- Additional duties and responsibilities in watershed management, participation in various basin and watershed groups, water quantity-water quality integration and management, CWA Sec. 319 (Nonpoint Source Pollution) hydrologic modification management activities, and training of personnel in field methodologies.
- Success in this position required excellent professional and interpersonal skills to effectively coordinate and collaborate with a variety of internal and external stakeholders – CDOW/CDPOR/CPW, CWCB, DWR, and DNR personnel; staff of the Attorney General's Office; state, federal, and local government officials; water users, water user organizations, water districts, external party attorneys and engineers; and members of the public and various citizen/sportsman's groups.

Water Resources Unit/Section Manager duties and responsibilities:

- Managed and supervised up to 11 professional FTEs responsible for all statewide work associated with agency's water right portfolio and water quality programs.
- Project manager for RiverWatch Program; managed and developed RFPs, contracts, and annual work plans/budgets for RiverWatch contractor(s).
- Established Water Unit's work plans, schedules, assignments, and operating budgets.
- Hired several water resource professional staff members. Conducted performance planning and performance reviews for all full-time staff and contractors.
- Developed and managed an annual budget of approximately $417,000 for Water Resources Unit.
- Supervised and directed the work of water resource engineers, a legal coordinator, and regional water resource specialists in the development, protection, and management of CDOW/CPW's water right holdings – a portfolio with an estimated value of more than $100 million.
- Supervised and directed the work of five statewide program coordinators who had responsibilities for water quality monitoring and protection, the state parks' water program, legal services, climate change/drought/flood programs, and instream flow.
- Provided programmatic review and re-organization recommendations to CPW leadership for the 2011 merger of two state divisions within DNR – the Divisions of Wildlife, and Parks and Outdoor Recreation. Initiated actions to implement the merger plan and new organizational structures.
- This position required excellent professional and interpersonal skills to effectively coordinate and collaborate with a variety of internal and external stakeholders – CDOW/CDPOR/CPW, CWCB, DWR, CDPHE and DNR personnel; Attorney General's Office staff; state, federal, and local government officials; water users, water user organizations, water districts, external party attorneys and engineers; and members of the public and various citizen/sportsman's groups.

Water Resources Section Special Project duties and responsibilities:

- This Special Project position was designed to assist and advise CPW's Assistant Director for Capital, Parks and Trails on the following topics:
  - Lead and coordinate CPW's activities associated with the development and finalization of various sections of the Colorado Water Plan,
  - Coordinate CPW activities with the IBCC and Basin Roundtables, serving as the agency's primary liaison to these groups,
  - Advise and assist the Water Resources Section Manager,
  - Coordinate performance reporting activities for CPW's Operational and Strategic Plans,
  - Revise and update the documents for the Water Section's two federal aid funding projects (Annual Grant Narratives and Performance Reports for Water Quantity Management and Water Quality Management),
  - Monitor and assist in the development of a statewide database to track and manage CPW's water resource assets,
  - Succession Planning for the Water Resources Section - hire, train, and mentor a new ISF Program Coordinator, assist in the development of plans for future vacancies,
  - Draft ISF Program documents – programmatic roles and responsibilities, field methods and techniques, and
  - Initiate a review of ISF Program methodologies.

CWCB Water Resources Specialist duties and responsibilities:

- Prior to moving into the field quantification area of the state's instream flow program (at DOW), spent approximately two years working on administrative aspects of the program at CWCB.
- Responsible for evaluating instream flow recommendations from DOW, conducting water availability and water right analyses.
- Assisted the CDOW Instream Flow Coordinator with the collection of natural environment and cross section data to support new ISF recommendations and to address specific data needs identified by CWCB staff.
- Reviewed water court resumes and applications for potential injury to CWCB water rights. Prepared various CWCB board memoranda documenting these activities.
- Worked on the resolution of water court cases with CWCB staff and staff attorneys from the Colorado Attorney General's Office.
- Processed new instream flow recommendations and prepared them for presentation to CWCB for approval. These duties often required participation in consultation meetings with water users and DWR staff.
- Finalized several water rights acquisitions in Pitkin County.
- Finalized a comprehensive water right and instream flow settlement with the Vail Valley Consolidated Water District which included the development of comprehensive terms and conditions for the water right decrees, the enlargement of an existing CDOW-owned reservoir, the development of an operations plan for the joint-use reservoir, on-going adaptive management of the operating plan, streamflow monitoring requirements, and the development of federal mitigation agreements.

Hydrologic Technician

Bureau of Land Management – Montrose District

May, 1982 – October, 1984 (seasonal)

- Worked under the direction of the District Hydrologist and the District Water Rights Coordinator.
- Worked as a member of a team to complete a district-wide water resource inventory that included field documentation of springs, seeps, and reservoirs on BLM lands.
- Extensive use of field orienteering skills, maps, and aerial photography.
- Streamflow measurement and monitoring.
- Water quality sampling.
- Maintained a district-wide rain gage network.
- Conducted hydrologic and water quality field investigations for baseline data collection efforts for future water supply, erosion control, gain/loss studies, and salinity control projects.
- Prepared and maintained records for all data collection and monitoring activities.

Thomas E. Chart

3945 Evergreen Ave.
Depoe Bay, OR 97341
Mobile: 7208381634
Email: grandriverconsult.llc@gmail.com

Work Experience:

1. Grand River Consulting, LLC
3945 Evergreen Ave.
Depoe Bay, OR 97341

08/ 2021 – Present
Wage: $120.00/hr
Hours per week: ~10
Individual Sole Proprietor
Duties: Primary contract is with San Juan River Water Development Steering Committee. I represent the San Juan River Water Development Interests on the Biology Committee (BC) of the San Juan River Basin Recovery Implementation Program's (SJRRIP). My primary role is to provide input on the development of the SJRRIP's annual workplan and provide technical review of annual and project final reports.

Other pieces of work have included:

- Co-authored: The 15 Mile Reach Study Plan for the Upper Colorado River Endangered Fish Recovery Program (2023-2024).
- Co-authored: Chart, T.E. and D.A. Anderson. 2025. Price River – A Characterization of River Conditions and a Preliminary Assessment of Flows to Support a Healthy Freshwater Environment. Report to The Nature Conservancy (2025)

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2. U.S. Fish and Wildlife Service
44 Union Blvd
Lakewood, CO 80122 United States

08/2009 – 08/2021
Salary: 140,000.00 USD Per Year
Hours per week: 40
Series: 0480 **Pay Plan:** GS **Grade:** 14
Fish and Wildlife Administrator
Duties, Accomplishments and Related Skills:
I served as the Director of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program). The Recovery Program, and its adaptive management framework, was established in 1988. Partners of the Recovery Program include FWS, Bureau or Reclamation, National Park Service, States of Colorado, Utah, and Wyoming, Western Area Power Administration, Colorado River Energy Distributors Association, Water User Organizations, and Environmental Interests (Western Resource Advocates and The Nature Conservancy). Each agency/organization is represented by a member on the Implementation, Management, and technical Committees.

Principal duties included:

- Supervised (4) GS-13 Program coordinators; (1) GS-12 Database Coordinator; (1) GS-11 Public Affairs
- Coordinated with policy-makers and decision-makers from key State and Federal agencies, water user groups, and environmental organizations on a variety of endangered species recovery issues.
- Developed annual work plan

- Formulated solutions through an adaptive management framework and developed new approaches to complex problems that impacted USFWS and Program policies and programs.
- Prepared and administered annual and capital budgets (~$8 - $10M)

Supervisor: Marjorie Nelson (303 236 4258)

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3. U.S. Fish and Wildlife Service
44 Union Blvd
Lakewood, CO 80122 United States

10/2007 - 08/2009
Salary: 90,000.00 USD Per Year
Hours per week: 40
Series: 0482 **Pay Plan:** GS **Grade:** 13
Fish Biologist
Duties, Accomplishments and Related Skills:
Duties: I served as the Instream Flow Coordinator and the Nonnative Fish Coordinator for the Recovery Program. I coordinated with Recovery Program partners to plan and implement biological and physical studies to determine instream flow needs and appropriate nonnative fish control actions to assist in the recovery of four endangered fish species. I wrote and updated action plans and helped develop the annual work plans for these aspects of the Recovery Program.

Supervisor: Dr. Robert Muth (retired)

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4. U.S. Fish and Wildlife Service
Orton Circle
Salt Lake City, UT 84119 United States

05/2004 - 10/2007
Salary: 76,000.00 USD Per Year
Hours per week: 40
Series: 0482 **Pay Plan:** GS **Grade:** 12
Fish Biologist
Duties, Accomplishments and Related Skills:
Duties: Provided advanced planning and formal / informal biological consultations (as per Endangered Species Act Section 7) for federal action agencies in a timely manner [~50% workload]. Represented USFWS as their technical representative on: a) Upper Colorado River Endangered Fish Recovery Program; b) the Virgin River Resource Management and Recovery Program; c) the 3 Species Conservation Team – [20% workload]. Represented the USFWS on the Virgin River Fish recovery Team, the Virgin River Spinedace Conservation Team and the 3 Spp. Conservation Team – [~15% of work load]. Provided technical expertise (fishery and aquatic ecology) on any project where applicable – [~15% of work load].

In this position I gained considerable expertise on all aspects of the Endangered Species Act, primarily Section 4, 7, 9, and 10.

Supervisor: Larry Crist (retired)

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5. U.S. Bureau of Reclamation
125 South State St.
Salt Lake City, UT 84138 United States

07/1999 - 05/2004
Salary: 65,200.00 USD Per Year
Hours per week: 40
Fish Biologist
Duties, Accomplishments and Related Skills:

Duties: I served as regional technical liaison between USBR and other federal and state agencies regarding the Upper Colorado River Endangered Fish Recovery Program, San Juan River Basin Recovery Implementation Program, and the June Sucker Recovery Program. I provided expert technical input and reviewed programs for consistency with USBR policy. I developed and administered service contracts, Cooperative Agreements, Grants and Interagency Acquisitions totaling $5M annually. Coordinated with USBR management to ensure leadership was briefed in a timely manner. I represented USBR on the Colorado River Fish Recovery Team. Authored the Affected Environment and Enviro Consequences sections of multiple USBR Environmental Impact Statements.
Supervisor: Dennis Kubly (retired)

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6. Utah Division of Wildlife Resources
HWY 191
Moab, UT 84532 United States

05/1991 - 07/1999
Salary: 34,000.00 USD Per Year
Hours per week: 40
Fish Biologist III - Project Leader
Duties, Accomplishments and Related Skills:
Supervised threatened and endangered fish recovery activities throughout the Southeastern Region of Utah. Administered up to six research / management projects simultaneously. Projects were funded through the Upper Colorado River Endangered Fish Recovery Program or the San Juan River Basin Recovery Implementation Program. Hired and supervised (3) full time biologists and up to ten seasonal hires. Developed work plans, project scopes of work, and was responsible for all necessary acquisitions. I served as the Principal Investigator on several research projects. Managed an annual budget of ~$500,000.

Education:

Colorado State University Fort Collins, CO United States
Master's Degree 8 /1987
GPA: 3.76 of a maximum 4
Credits Earned: 63 Semester Hours
Major: Fish and Wildlife Biology

Colorado State University Fort Collins, CO United States
Bachelor's Degree 6 /1982
GPA: 2.84 of a maximum 4

Credits Earned: 148 Semester Hours
Major: Fish and Wildlife Biology

DREW PETERNELL
P.O. Box 770450, Steamboat Springs, Colorado 80477 • (303) 204-3057 • andrewpeternell@hotmail.com

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PROFILE

Colorado water policy and water law expert with over 20 years of experience. Proven leader, adept at personnel management, budget oversight, and project planning, especially in the area of climate change adaptation. Skilled advocate and attorney with a deep understanding of government and the legal system. Additional attributes include:

- Commitment to conservation and public service
- Ability to solve complex problems
- Superb communication and interpersonal skills
- Successful track record in fundraising, grant writing, and business development
- High capacity to handle multiple tasks simultaneously and to assimilate new subject matter quickly

PROFESSIONAL EXPERIENCE

Trout Unlimited, Colorado Director: 2023-Present

Primary responsibilities:

- Direct Colorado operations for a national fishery conservation organization, including management of a staff of over fifteen employees and tens of millions of dollars of budgets
- Conceive and implement Colorado program strategy
- Build and maintain partnerships with other nongovernmental organizations, foundations, governmental agencies, water user interests, and others

Primary achievements to date:

- Helped to raise tens of millions of dollars for the organization's Colorado operations
- On-boarded four new staff in less than 12 months, with two additional hires pending
- Maintain high level of hands-on engagement on important Colorado water policy matters, including Colorado River demand management efforts and legislation improving the state's instream flow program

Trout Unlimited, Colorado Water Project Director: 2007-2023

Primary responsibilities:

- Managed Colorado water program for national fishery conservation organization
- Formulated departmental goals, tactics, and project plans
- Raised funds from agencies, foundations, and individual donors
- Oversaw program budgets, dozens of funding contracts, and staff of ten employees
- Advanced organizational mission through public education and legal and policy advocacy on wide-ranging issues including the state's instream flow program, Colorado River demand management, and various legislative matters

Primary achievements:

- Increased program staff from two to ten, thus greatly expanding the program's capacity to deliver conservation results
- Expanded the strategic direction of the program to focus on building cooperative, mutually-beneficial projects with agricultural producers
- Oversaw the completion of scores of successful on-the-ground stream restoration projects designed to increase river system resilience to climate change
- Assisted with drafting and passing several pieces of legislation that strengthen Colorado's instream flow program
- Helped to shape the Colorado Water Plan as a balanced tool for meeting Colorado's future water needs while preserving healthy rivers and recreational opportunities

Trout Unlimited, Staff Attorney: 2002-2007
Primary responsibilities:

- Promoted the preservation and restoration of Colorado's rivers and streams – in a legal and political climate often hostile to this mission – through litigation in federal and state courts and advocacy before legislative bodies and governmental agencies
- Developed expertise in Colorado water law and policy and gained familiarity with basic water engineering, agricultural irrigation techniques, and fisheries science

Primary achievements:

- Successfully argued three times before the Colorado Supreme Court, resulting in instream flow water rights for the Black Canyon National Park and legal precedent limiting unneeded water rights claims for speculative future population growth
- Helped the state water board to acquire and protect scores of instream flow water rights

Hutchinson Black & Cook, LLC, Boulder, CO
Associate Attorney: 2000-2002
Primary responsibilities:
Employed complex analytical reasoning, strategic decision-making and oral and written advocacy to represent individuals and businesses in diverse legal contexts, with particular focus on representation of parties engaged in litigation.

EDUCATION

University of California, Berkeley School of Law
J.D., Certificate of Specialization in Environmental Law.
Honors: Prosser Prize in Environmental Law and Policy; American Jurisprudence Award in Criminal Law.
Activities, Clerkships, and Internships: Earthjustice Legal Defense Fund; Kelly Haglund Garnsey and Kahn, LLC; United States Environmental Protection Agency; East Bay Community Law Center; Ecology Law Quarterly; Environmental Law Society.

Vanderbilt University
B.A., Political Science (major), Business Administration (minor).
Honors: Magna Cum Laude; Phi Beta Kappa; Gamma Beta Phi (Scholarship and Service Honorary); Pi Sigma Alpha (Political Science Honorary).
Activities: Student Government Association; Alternative Spring Break.

SELECTED PRESENTATIONS AND LECTURES

- The Future of Colorado's Instream Flow Program
- The Anti-Speculation Doctrine in Colorado Water Law
- The Urbanization of Colorado's Water Supply: The Fisheye View
- Filling The Gap: How to Meet Colorado's Future Water Shortages
- Protecting Stream Flows for the Black Canyon of the Gunnison National Park
- The Promise of Privatizing Colorado Instream Water Rights
- Agricultural Water Conservation: Opportunities for Agriculture and Conservationists to Work Together

COMMUNITY ACTIVITIES

- Yampa River Fund, Board of Directors, 2022-Present
- Steamboat Springs Winter Sports Club, Coach, 2023-Present
- Central Colorado Conservancy, Board of Directors, 2015-2019
- Arkansas River Basin Roundtable, Recreational Representative, 2015-2017
- FIBArk, Board of Directors, 2015-2018
- Sangre de Christo Acequia Association, Pro Bono Attorney, 2014-2016
- Colorado Water Caucus, Steering Committee Member, 2006-2012

ORLA C. BANNAN

Mobile: (917) 992-9935; orlabannan@gmail.com; Boulder, CO

Overview:
Experienced policy advocate and legal executive. Focused on finding collaborative solutions and providing proactive, solution-oriented advice to effective change. Recognized skills include negotiation, management of legal and regulatory requirements, business acumen and strong capability to collaborate and build consensus to maximize impact. Proven ability to be strategic while working with a broad range of stakeholders.

Experience:
Western Resource Advocates, Boulder, CO, Healthy Rivers Program
Policy Manager for State Policy and Engagement (2024 – Present)
Strategic Engagement Manager (2017-2024)

- Develop and implement key conservation strategies at the state and local level.
- Identify emerging issues and educate decision-makers about the economic and environmental benefits of water conservation, stream protection, and funding for conservation.
- Develop and advocate for policy and programs that will protect and improve Western rivers, including working on the Colorado River Basin Interim Guidelines and Drought Contingency Plans.

Vail Resorts Management Company, Broomfield, CO, Legal, Public Affairs & Sustainability Department
Vice President & Assistant General Counsel January 2011 – December 2016
Senior Real Estate Counsel July 2008 to January 2011

- Supported mountain operations company-wide on legal requirements for environmental compliance including air quality and water quality. Oversight of water rights matters for the company.
- Extensive work with governmental entities, public affairs and government relations to develop solutions, move projects forward, prepare public communications and influence legislative measures.
- Managed all real estate legal matters, including land use approvals, water rights allocations, construction contracts, purchase and sale transactions, establishment and management of common interest communities, dispute resolution, mountain resort development and public and private land use matters.
- Managed complex commercial litigation and claims matters, including construction defect and insurance disputes.

- Managed operational legal matters and transactions for hospitality division, including branded hotels, managed properties, homeowner association management and rental program.
- Led legal work for retail division, including managing contract process, risk management, leasing process and acquisitions.
- Managed legal budget, outside counsel relationships and legal team.

Greenberg Traurig, LLP, New York, NY, Real Estate Department, Associate and Of-Counsel (2003 – 2008)

- Represented property owners and developers in connection with the acquisition, sale, development and financing of commercial, residential, condominium and convention center projects, including negotiating complex transactions and joint venture agreements.

Kutak Rock, LLP, Phoenix, AZ, Real Estate Department, Associate (1999 – 2000)

- Negotiated and drafted mortgage and lease documents for property acquisitions and mortgage financing transactions involving hundreds of businesses across numerous states.

Ashurst Australia, Sydney, Australia, Project Finance/Corporate Department, Associate (1997 – 1999)

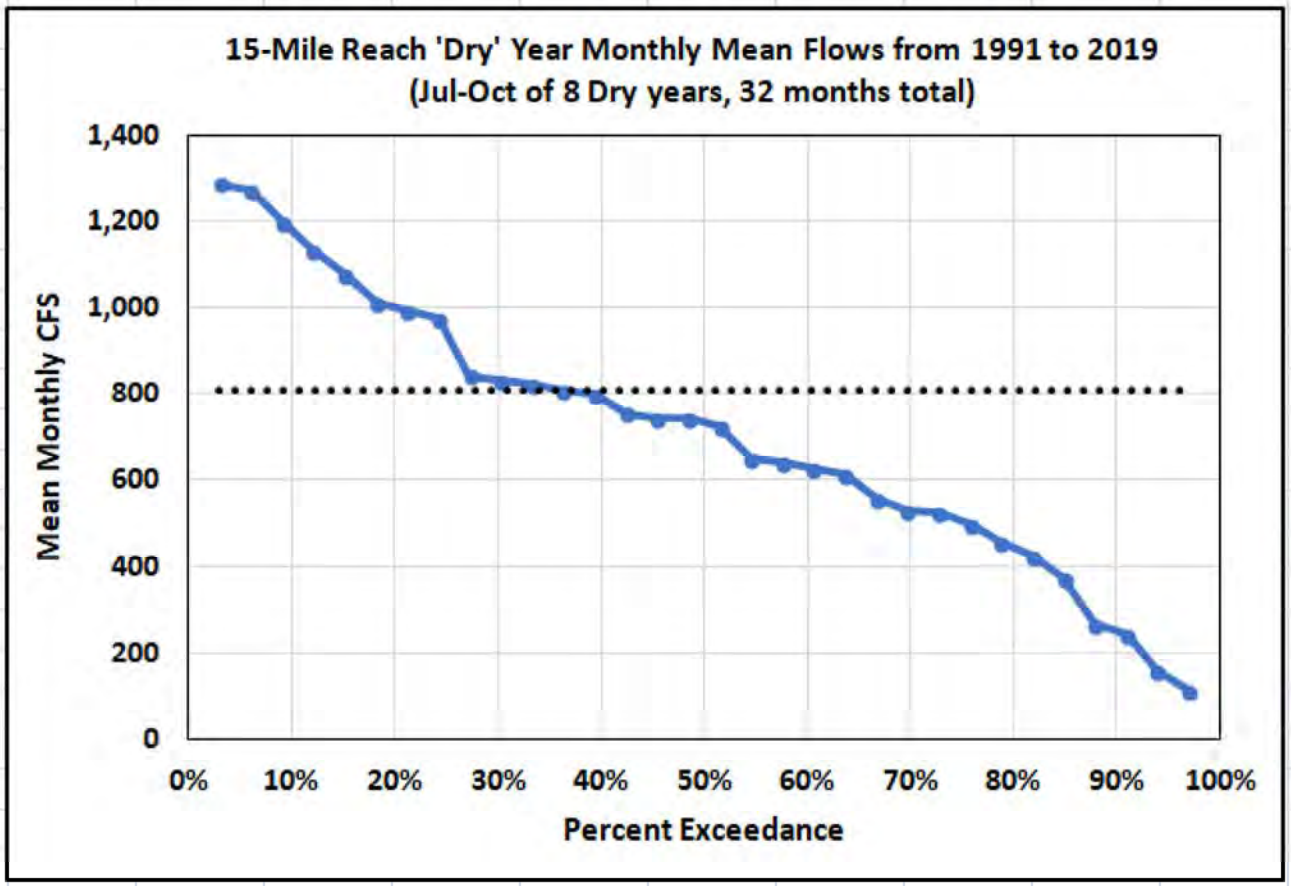
- Negotiated and drafted transaction documents for complex commercial transactions.
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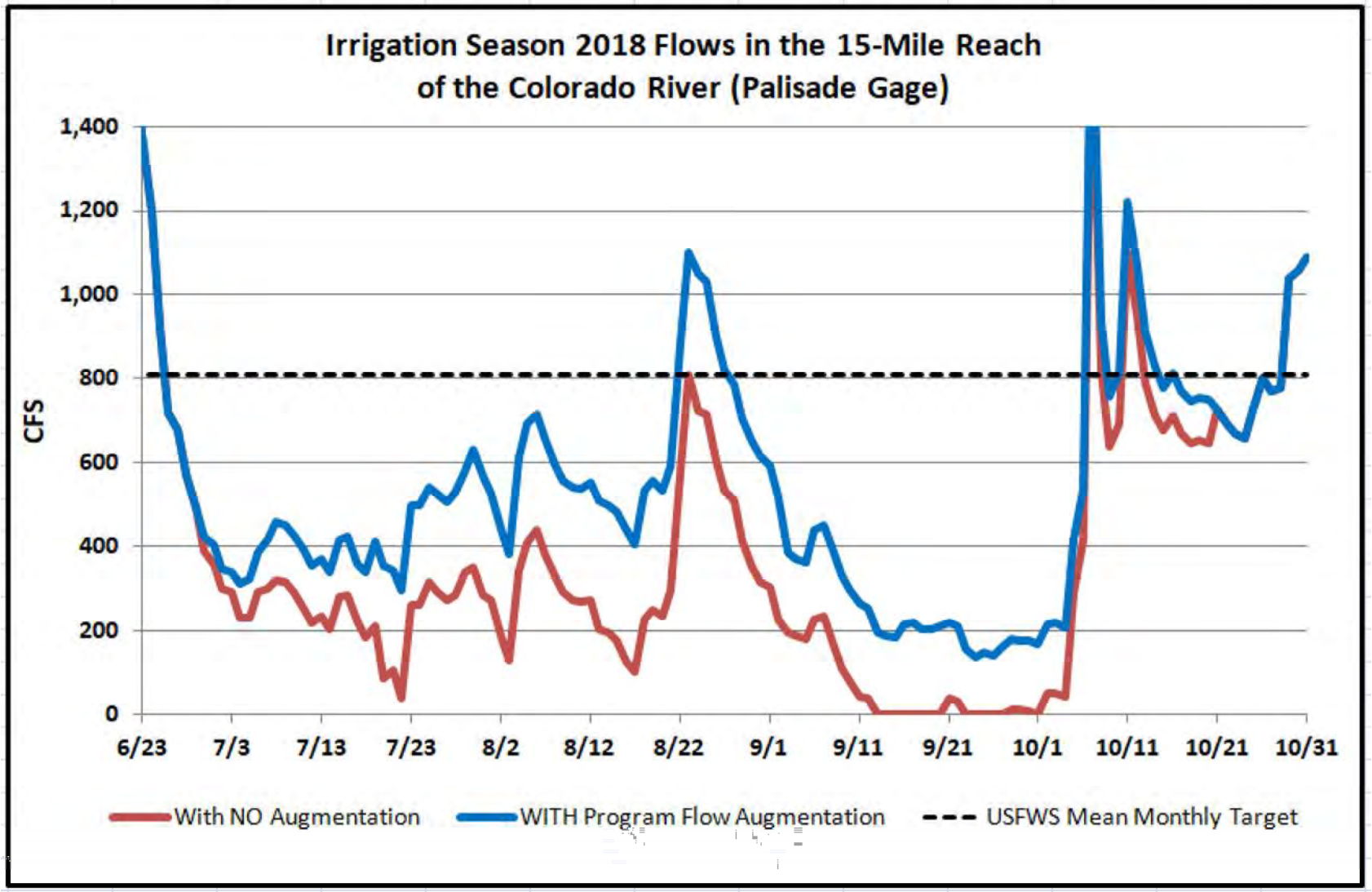
Other information:

- Conservation Finance Network Bootcamp (2025)
- Colorado River Drought Task Force Member (2023)
- Board of Directors, Bachelor Gulch Village Association (2008 – 2016)
- Board of Directors, Beaver Creek Resort Company (2009 – 2016)
- LLB (Honors) University of Sydney 1997; BA (Psychology) University of Sydney 1994.
- Admitted to practice in New York, Arizona, Colorado and New South Wales (inactive).
- Leadership in Energy and Environmental Design – Accredited Professional (LEED – AP).
- Contributing Author “Truth Commissions and Procedural Fairness”, 2006.
- Chapter Author “Caregiver Alliances for At-Risk and Dangerous Youth Establishing School and Agency Coordination and Accountability”, 2004.

- International Center for Transitional Justice, New York, NY, Internship, March 2002 to June 2002.
- Lawyers Committee for Human Rights, International Criminal Court, Preparatory Commission, 2002.
- Center for Human Rights Advocacy/Prosocial Communities Project, Boulder, CO 2000 to 2001.
- Interests include skiing, triathlons, traveling, human rights, health and the environment.

References available on request.


15-Mile Reach 'Dry' Year Monthly Mean Flows from 1991 to 2019
(Jul-Oct of 8 Dry years, 32 months total)
Mean Monthly CFS
1,400
1,200
1,000
800
600
400
200
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Exceedance


Irrigation Season 2018 Flows in the 15-Mile Reach
of the Colorado River (Palisade Gage)
CFS
1,400
1,200
1,000
800
600
400
200
0
6/23
7/3
7/13
7/23
8/2
8/12
8/22
9/1
9/11
9/21
10/1
10/11
10/21
10/31
With NO Augmentation
WITH Program Flow Augmentation
USFWS Mean Monthly Target

AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE
10.1002/2016WR019638

The twenty-first century Colorado River hot drought and implications for the future

Bradley Udall[1,2] **and Jonathan Overpeck**[2,3]

[1]Colorado Water Institute, Colorado State University, Fort Collins, Colorado, USA, [2]Colorado River Research Group, Boulder, Colorado, USA, [3]Department of Geosciences and Department of Hydrology and Atmospheric Sciences, Institute for the Environment, University of Arizona, Tucson, Arizona, USA

Key Points:
- Record Colorado River flow reductions averaged 19.3% per year during 2000–2014. One-third or more of the decline was likely due to warming
- Unabated greenhouse gas emissions will lead to continued substantial warming, translating to twenty-first century flow reductions of 35% or more
- More precipitation can reduce the flow loss, but lack of increase to date and large megadrought threat, reinforce risk of large flow loss

Supporting Information:
- Supporting Information S1

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Bradley.udall@Colostate.edu

Citation:
Udall, B. and J. Overpeck (2017), The twenty-first century Colorado River hot drought and implications for the future, *Water Resour. Res.*, *53*, 2404–2418, doi:10.1002/2016WR019638.

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Abstract Between 2000 and 2014, annual Colorado River flows averaged 19% below the 1906–1999 average, the worst 15-year drought on record. At least one-sixth to one-half (average at one-third) of this loss is due to unprecedented temperatures (0.9°C above the 1906–1999 average), confirming model-based analysis that continued warming will likely further reduce flows. Whereas it is virtually certain that warming will continue with additional emissions of greenhouse gases to the atmosphere, there has been no observed trend toward greater precipitation in the Colorado Basin, nor are climate models in agreement that there should be a trend. Moreover, there is a significant risk of decadal and multidecadal drought in the coming century, indicating that any increase in mean precipitation will likely be offset during periods of prolonged drought. Recently published estimates of Colorado River flow sensitivity to temperature combined with a large number of recent climate model-based temperature projections indicate that continued business-as-usual warming will drive temperature-induced declines in river flow, conservatively −20% by midcentury and −35% by end-century, with support for losses exceeding −30% at midcentury and −55% at end-century. Precipitation increases may moderate these declines somewhat, but to date no such increases are evident and there is no model agreement on future precipitation changes. These results, combined with the increasing likelihood of prolonged drought in the river basin, suggest that future climate change impacts on the Colorado River flows will be much more serious than currently assumed, especially if substantial reductions in greenhouse gas emissions do not occur.

Plain Language Summary Between 2000 and 2014, annual Colorado River flows averaged 19% below the 1906–1999 average, the worst 15-year drought on record. Approximately one-third of the flow loss is due to high temperatures now common in the basin, a result of human caused climate change. Previous comparable droughts were caused by a lack of precipitation, not high temperatures. As temperatures increase in the 21st century due to continued human emissions of greenhouse gasses, additional temperature-induced flow losses will occur. These losses may exceed 20% at mid-century and 35% at end-century. Additional precipitation may reduce these temperature-induced losses somewhat, but to date no precipitation increases have been noted and climate models do not agree that such increases will occur. These results suggest that future climate change impacts on the Colorado River will be greater than currently assumed. Reductions in greenhouse gas emissions will lead to lower future temperatures and hence less flow loss.

1. Introduction

A large number of studies over the last 25 years have considered the future runoff of the Colorado River (Figure 1) under climate change. Nearly all of these studies have cautioned that future warming will deplete the flow of the river, but the results have varied from minor to major [*Nash and Gleick*, 1991; *Christensen et al.*, 2004; *Milly et al.*, 2005; *Brekke et al.*, 2007; *Christensen and Lettenmaier*, 2007; *National Research Council*, 2007; *Seager et al.*, 2007; *Barnett and Pierce*, 2008; *Ray et al.*, 2008; *Barnett and Pierce*, 2009; *Rajagopalan et al.*, 2009; *Cayan et al.*, 2010; *Reclamation*, 2013; *Harding et al.*, 2012; *Seager et al.*, 2012; *Vano et al.*, 2012; *Ficklin et al.*, 2013; *Vano et al.*, 2014; *Ayers et al.*, 2016; *Milly and Dunne*, 2016]. In contrast, the latest U.S. Government assessment implies little or no change is likely because precipitation increases will be sufficient to maintain temperature-depleted flows [*Reclamation*, 2016]. Fifteen years into the twenty-first century, the emerging reality is that climate change is already depleting

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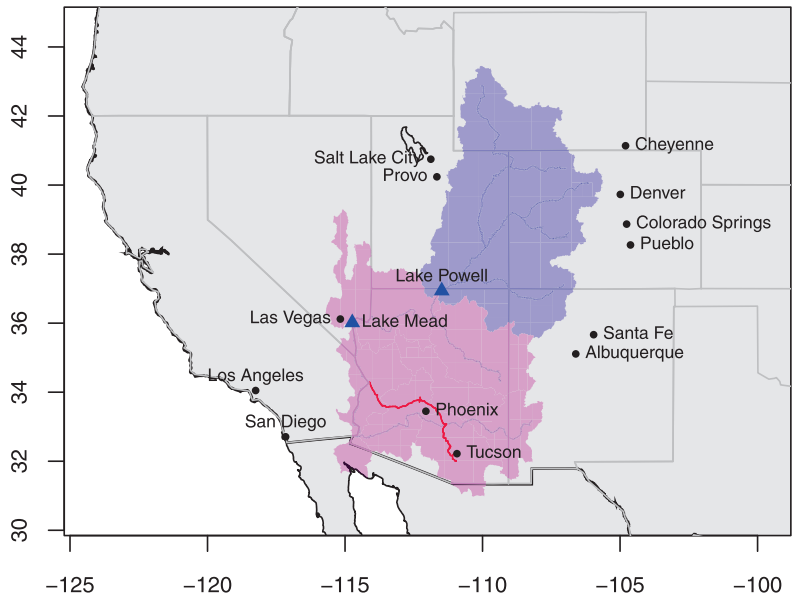


Figure 1. Map of the Colorado River Basin. Lower and Upper Basins, major U.S. cities receiving Colorado River water, major tributaries, and Lakes Mead and Powell are shown. The Central Arizona Project canal in red.

Colorado River water supplies at the upper end of the range suggested by previously published projections. Record setting temperatures are an important and underappreciated component of the flow reductions now being observed.

Between the start of the drought in 2000 and the end of 2014, our analysis period, annual flow reductions averaged 19.3% below the 1906–1999 normal period, and Lakes Mead and Powell, the nation's two largest reservoirs, ended the period at approximately 40% of maximum volume despite starting the period nearly full [*Wines*, 2014; *Colorado River Basin Stakeholders*, 2015] (Figure 2a). This drought has continued into 2015 and 2016 with higher, but still below normal, flows estimated at 94% in 2015 and 94% in 2016 with unusual late season May and June precipitation in both years that raised runoff by nearly 20% [*Alcorn*, 2015, 2016]. Despite these smaller recent reductions, Lake Mead continues to decline and in May 2016 it hit a level not seen since its initial filling in the 1930s [*James*, 2016]. The overall Colorado River reservoir system stores 4 times the annual flow of the river, one of the largest ratios in the world. This storage provides a large drought buffer when full. However, when the reservoirs are low, shortage risk can be high for years because high demands, now equal to twentieth century average flow, make it difficult to refill system storage [*Reclamation*, 2012]. While the multiyear California drought has been garnering more national attention, the more slowly unfolding Colorado River drought is every bit as serious and also has national and international ramifications [*Wines*, 2014].

The Colorado River Basin encompasses seven states and northern Mexico and is home to 22 federally recognized tribes. The river provides municipal and industrial water for 40 m people distributed across every major Southwestern city both within and without the basin, including Los Angeles, San Diego, Las Vegas, Phoenix, Tucson, Salt Lake City, Denver and the entire Front Range of Colorado, Albuquerque, and Santa Fe [*Reclamation*, 2012].

Continued low flows would result in additional declines at Lake Mead, eventually requiring Lower Basin (Arizona, California, Nevada) water delivery shortages with mandatory cutbacks imposed primarily on Arizona, but also Nevada and Mexico [*Verburg*, 2011]. At the same time, Upper Basin (Colorado, New Mexico, Utah, Wyoming) water users would continue to endure physical shortages from a lack of water. These initial Lower Basin Lake Mead delivery shortages and Upper Basin physical shortages are manageable to a point; however, under current operating rules with continued low flows during the next 6 to 8 years Lake Mead would drop to elevation 305 m (1000 feet) above sea level, resulting in a number of serious and unprecedented problems [*Collum and McCann*, 2014].

In the Lower Basin, Arizona could theoretically lose its water allocation for the entire Central Arizona Project canal, a critical $4.4B, 530 km cross-state 2 bcm/yr water source for 4.7 m people, multiple sovereign Indian

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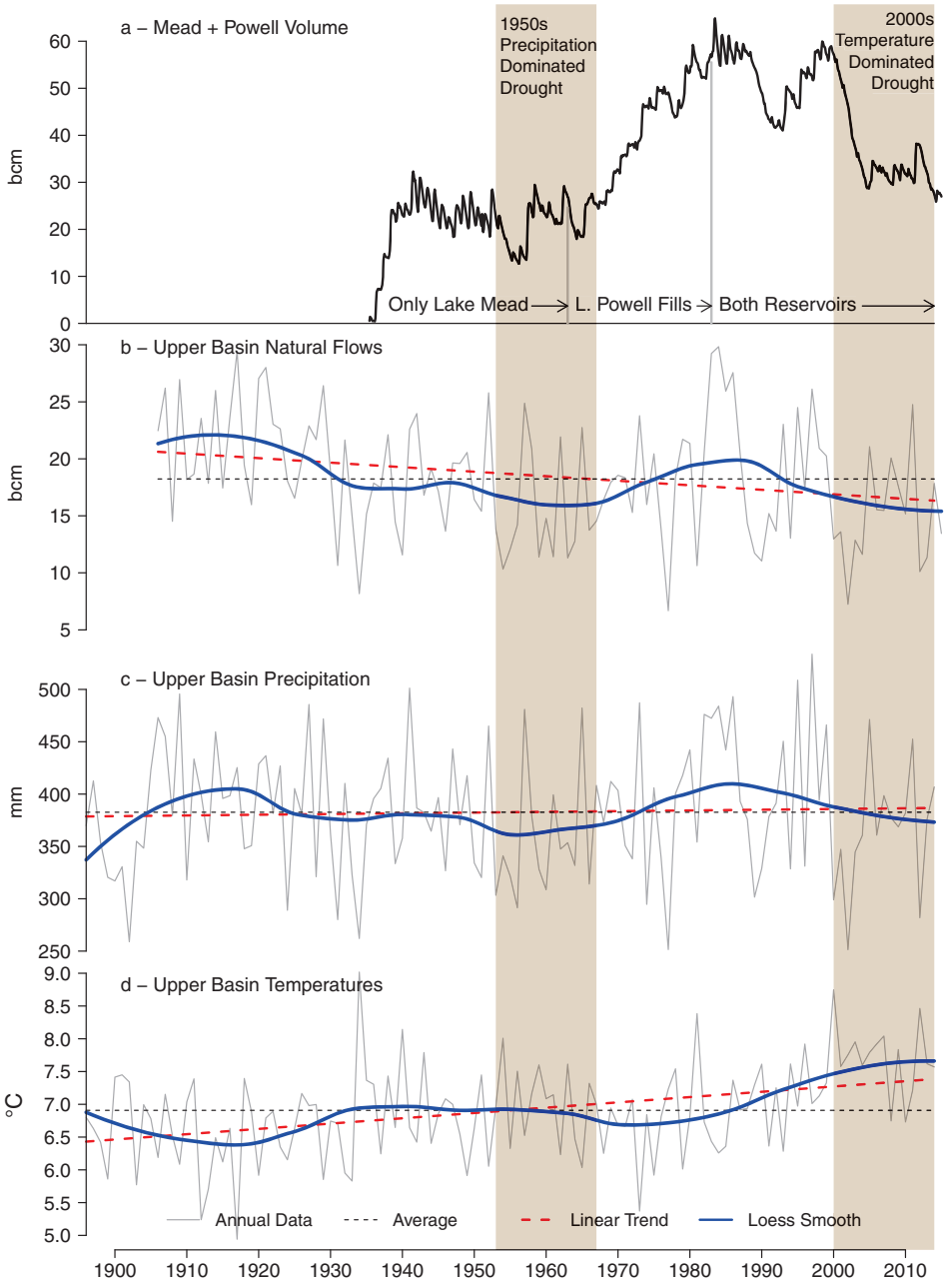


Figure 2. (a) Lakes Mead and Powell combined monthly contents. Upper Basin annual Colorado River (b) runoff at Lees Ferry from 1906 to 2014, (c) precipitation and (d) temperatures from 1896 to 2014. Mead first filled in 1935, Powell in 1963 (supporting information Text S1). Two 15-year drought periods, 1953–1967 and 2000–2014, are highlighted and discussed in main text.

nations, and over 120,000 irrigated hectares [*Glennon*, 1995; *Colorado River Basin Stakeholders*, 2015]. This canal currently relies on occasional but uncertain "equalization" releases from Lake Powell that only occur with irregular and rare large Powell inflows. The extra water is delivered when Lake Powell reaches levels substantially higher than Lake Mead, a use allowed under the 1922 Colorado River Compact section III (e) and formalized most recently under rules established in a 2007 Record of Decision for coordinated operations of Lakes Powell and Mead and for shortage sharing in the Lower Basin [*Department of Interior*, 2007].

Under normal operating rules, without these extra inflows, Lake Mead has excess outflows of 1.5 bcm per year, the so-called Lower Basin "structural deficit" [*Collum and McCann*, 2014]. The structural deficit was created in 1968 when Congress authorized the Central Arizona Project (CAP). In order to obtain the support of

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the large California Congressional delegation, Arizona agreed to rely on this unused, but in the long run unreliable water, because there was not enough remaining unallocated Lower Basin water. The CAP had long been a desire of Arizona and the state was willing to make this bargain despite its flaws [*Johnson*, 1977]. This same water is first available for use by the Upper Basin under the Colorado River Compact, but heretofore has not been developed for Upper Basin use. A plan to augment the Colorado River with flows from outside the basin, discussed during the hearings on the legislation, but not included in the final package due to opposition from potential source areas, was never revisited by Congress. Reclamation in 2011 said that such augmentation was now unlikely.

The structural deficit only became a problem when the CAP was fully completed in the mid-1990s combined with the drought that began in 2000. Upper Basin demand growth has also played a small role, although Upper Basin demands are still much less than forecast in 1968 for the year 2000 [*Tipton and Kalmbach, Inc*., 1965; *Johnson*, 1977]. The recent Lake Mead declines are strongly influenced by this imbalance, and solutions to this deficit have been a recent focus of the Basin states and federal government [*Central Arizona Project*, 2016; *Davis*, 2016].

The Upper Basin also has serious issues, one of which ripples into the Lower Basin. When the surface of Lake Mead declines to an elevation 305 m (1000 feet) above sea level, Lake Powell will also be below its minimum power pool 75% of the time [*Collum and McCann*, 2014]. This occurs in part because low Mead levels make "equalization" releases from Powell more likely thus driving Powell lower. Hydropower losses at Lake Powell could result in substantial rate increases for irrigators who rely on the reservoirs for long term lower cost power contracts, and would also dry up funding for basin-wide programs necessary for water delivery environmental compliance [*Adler*, 2007; *Collum and McCann*, 2014]. Under such low reservoir conditions, there is also a high likelihood that the Upper Basin states would have to curtail existing water deliveries to cities such as Denver, Colorado Springs, Albuquerque and Salt Lake City in order to make required deliveries to Lake Mead. Heretofore, largely because of the structure of the Colorado River Compact, the Upper Basin and Lower Basin have been managed separately. With permanent flow declines of approximately 20%, however, the required deliveries to Lake Mead would become a hardship on the Upper Basin, as well as create Lower Basin delivery shortages [*Reclamation*, 2007; *Barnett and Pierce*, 2009; *Rajagopalan et al*., 2009]. The original compact, signed during one of the wettest periods in the last 450 years [*Woodhouse et al*., 2006], did not envision how large scale flow declines would be managed between the basins, and such declines could cause an allocation crisis between the Upper and Lower Basins [*Adler*, 2008].

Understanding the cause of, and reacting properly to, the ongoing drought is critical to the future of the Southwest. Herein we investigate the role of precipitation versus temperatures as causes of the current drought, provide temperature-based and precipitation-based twenty-first century flow projections and provide policy implications of these findings. Our approach separates the impacts of high-confidence temperature projections from those associated with the much lower-confidence projections of future precipitation using a simple but powerful sensitivity technique. Moreover, we make a novel—and important—case that there is a high likelihood that the impacts of continued atmospheric warming will overwhelm any future increases in precipitation because prolonged dry periods lasting multiple decades are likely to negate the beneficial impacts of additional precipitation during other times.

2. Causes of the 2000–2014 Drought

The 2000–2014 drought is defined by the lowest average annual flows for any 15-year period in the historical record. To analyze this drought, gridded 4 × 4 km temperature and precipitation data from 1896–2014 for the area above Lees Ferry were obtained from the Precipitation-Elevation Regression on Independent Slopes (PRISM) model [*Daly et al*., 1994; *Guentchev et al*., 2010; *Oyler et al.,* 2015a, 2015b; *Rangwala et al.,* 2015]. In addition, we obtained reservoir contents and natural flows at Lees Ferry from the U.S. Bureau of Reclamation (Reclamation) (Text S1). Lees Ferry is situated just below Lake Powell and is the Compact dividing line between the Upper and Lower Basins. Approximately 85% of the flow originates above Lees Ferry [*Christensen and Lettenmaier*, 2007].

Historically, Upper Colorado River Basin precipitation has been the main Colorado River runoff driver such that high flow years (1920s, 1980s) were associated with high precipitation and low flow years (1930s, 1950s) with low precipitation (Figures 2b and 2c). The current drought (our study period is 2000–2014, but

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Table 1. Winter/Summer/Annual Upper Basin Mean Water Year Precipitation

	1953–1967			2000–2014			1896–2014	
	mm			mm			mm	
	Total	Anomaly	Anomaly % of Mean (%)	Total	Anomaly	Anomaly % of Mean (%)	Mm	% Avg
Winter (Oct to Mar)	176	−16	−8.6	187	−5	−2.7	192	100
Summer (Apr to Sep)	184	−7	−3.6	179	−12	−6.4	191	100
Total	359	−23	−6.1	365	−17	−4.6	383	100

the drought is still on-going), with its modest −4.6% precipitation decline and −19.3% flow decline, stands in stark contrast to the second-lowest 15-year flow period (1953–1967), a precipitation-driven drought with averaged precipitation reductions of −6.1% per year and flow reductions of −18.1% per year (Figures 2b and 2c and Table 1). Compared to the 1950s drought, the 2000s feature much more (near normal) winter precipitation (−8.6% 1950s decline versus −2.7% 2000s) and significantly less summer precipitation (−3.6% 1950s decline versus −6.4% 2000s). The 2000s precipitation decline is only 75% of the decline in the 1950s, thus begging the question of why the recent drought was more serious. What has changed is that temperatures in the runoff producing Upper Basin are now 0.9°C above the 1896–1999 average and are the highest in the gaged record; whereas temperatures during the 1953–1967 drought were much cooler and only slightly above the 1896–1999 average (Figure 2d and Table 2). This makes the current drought unprecedented in the gaged record.

In contrast to the more precipitation-driven current California drought [*Diffenbaugh et al*., 2015; *Williams et al*., 2015], lack of precipitation is only partially to blame for the Colorado River runoff declines during the last 15 years. Instead, approximately a third, or more, of the recent Colorado River flow reduction is most likely a result of record-setting warmth. Since 1988 an increase in the frequency of warm years has been strongly associated with lower flows than expected [*Woodhouse et al*., 2016], suggesting an important role for temperature in flow losses. Such temperature-driven droughts have been termed "global-change type droughts" and "hot drought," with higher temperatures turning what would have been modest droughts into severe ones, and also increasing the odds of drought in any given year or period of years [*Breshears et al*., 2005; *Overpeck*, 2013]. Higher temperatures increase atmospheric moisture demand, evaporation from water bodies and soil, sublimation from snow, evapotranspiration (ET) from plants, and also increase the length of the growing season during which ET occurs [*Pitman*, 2003; *Weiss et al*., 2009; *Seneviratne et al*., 2010; *Seager et al*., 2015a]. Warm season (April to September) warming has been identified by models as especially important in reducing Colorado River flows because of the increases in ET from longer growing seasons [*Das et al*., 2011]. Increases in measured vapor pressure deficits in the Southwest caused by warming and a decrease in water vapor provide strong support for higher ET during the recent drought [*Seager et al*., 2015b]. As increasing temperatures drive further drying, additional positive feedbacks are possible in the form of lower humidity and less evaporative cooling, decreased cloudiness and increased incident radiation, as well as decreased snow cover and more radiative heating [*Betts et al*., 1996; *Brubaker and Entekhabi*, 1996; *Pitman*, 2003; *Seneviratne et al*., 2010]. In the twentieth century, droughts were associated almost exclusively with a lack of precipitation. In this century, however, high temperatures alone can lead to anomalously dry conditions.

Table 2. Upper Basin Water Year Flows and Temperatures

	Average Annual Flow		Average Annual Temperature	
Period	bcm	% 1906–1999	°C	°C Anomaly to 1896–1999
1953–1967	15.38	81.9	7.0	0.2
2000–2014	15.15	80.7	7.7	0.9
1906–1999	18.77	100.0	6.8	0.0
1906–2014	18.27	97.3	6.9	0.1

3. Estimates of 2000–2014 Temperature-Induced Flow Loss

Over the last several years several studies specific to the Colorado River Basin have investigated the specific relationships among temperatures, precipitation and flow in the basin using the concepts of temperature

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sensitivity and precipitation elasticity [*McCabe and Wolock*, 2007; *Nowak et al*., 2012; *Vano et al*., 2012, 2014; *Vano and Lettenmaier*, 2014]. Temperature sensitivity is defined as the percent change in annual flow per degree rise in annual temperature. Precipitation elasticity is defined as the fractional change in annual flow divided by the fractional change in annual precipitation [*Vano et al*., 2012]. Note that elasticity has been studied for both increases and decreases in precipitation, whereas sensitivity is typically investigated only for temperature increases. These numbers can be determined empirically and through model studies.

Previous studies on temperature sensitivity and precipitation elasticity show that future impacts to streamflow from increases in temperatures and changes in precipitation can be considered separately using sensitivity and elasticity, and then added together to produce flow estimates [*Vano et al*., 2014; *Vano and Lettenmaier*, 2014]. Considering these effects separately and additively is a powerful conceptual tool for investigating climate change impacts because of the ease in measuring the two variables for current impacts and the wide availability of temperature and precipitation projections from global climate models for assessing future impacts. In addition, the large differences in certainty associated with future changes in the two variables (temperature will surely increase, whereas precipitation may increase or decrease—see below) helps to set apart the risk of future changes in flow associated with each variable.

Vano et al. [2012, 2014], *McCabe and Wolock* [2007], and *Nowak et al*. [2012] provide multiple estimates of the flow sensitivity of the Colorado River flow to temperature using three different methods. *Vano et al*. [2012, 2014] utilized six high-resolution, commonly used hydrology models and two different temperature adjustment methods to obtain Lees Ferry temperature sensitivities. They report an average sensitivity of −6.5%/°C warming with a one standard deviation range from −3.0% to −10.0%/°C for the Upper Basin. Approximately 50% models show increasing sensitivity and 50% decreasing sensitivity as temperatures warm so we elect to use a constant sensitivity over all future temperatures. *McCabe and Wolock* [2007] constructed a simple water balance model that infers an average temperature sensitivity of −8.9%/°C and *Nowak et al*. [2012] found an empirical temperature sensitivity of −13.8%/°C.

We use the complete one standard deviation range (−3%/°C to −10%/°C) of the *Vano et al*. [2012, 2014] temperature sensitivity estimates as they were the most conservative and rigorous of the three studies we investigated. Using this range, we found that recent warming of 0.9°C has likely already reduced river flows from −2.7% to −9% from the mean 1906–1999 flow. This represents approximately one-sixth to one-half (average of one-third) of the total flow loss during the 2000–2014 drought.

The higher temperature sensitivities of the two other studies suggest the actual Colorado River temperature sensitivities are near the upper end and possibly exceed the *Vano et al*. [2012, 2014] estimates. These higher sensitivities imply much greater temperature-induced losses during the current drought (−7.9% to −12.3% versus −2.7% to −9%). Empirical results from the 2000 to 2014 drought also point to mid to high temperature sensitivities. *Vano et al*. [2012] report precipitation elasticities ranging from 2 to 3 at Lees Ferry. Thus, using a midrange precipitation elasticity of 2.5, the 2000–2014 annual −4.6% precipitation decline implies runoff reductions of −11.4%, leaving the remaining −7.9% decline to be explained by other causes. If temperature were the sole cause of this remaining decline, the inferred temperature sensitivity is −8.8%/°C. Using a precipitation elasticity of 3.0 implies a temperature sensitivity of −6.2%/°C, very close to the midrange Vano et al., sensitivity. These temperature sensitivities imply large losses as temperatures rise, the subject of the next section.

4. Twenty-First Century Flow Response to Changing Temperatures and Precipitation

For the analysis on how future temperatures and precipitation would affect runoff, and for investigating how well current linked climate-hydrology models can reproduce the current drought, we used Reclamation's climate projection data sets [*Brekke et al*., 2013, 2014]. These data sets use Coupled Model Intercomparison Project 3 and 5 (CMIP3, CMIP5 after the class of climate models used) climate model projection data linked to the Variable Infiltration Capacity hydrology model to produce flows from 1950 to 2099 (supporting information Text S2, Figures S2, and S3)] [*Liang et al*., 1996; *Meehl et al*., 2007; *Moss et al.,* 2010; *Taylor et al*., 2012].

The same temperature sensitivity and precipitation elasticity numbers discussed above can be used to estimate future flow reductions using climate model outputs under high (business-as-usual, SRES A2 and

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RCP8.5) and moderate (somewhat reduced by mitigation, SRES A1B and RCP4.5) greenhouse gas emissions to the atmosphere. By 2050, moderate and high emissions are projected to yield Upper Basin *mean* warming of 2.6–2.8°C (Figure 3), three times recent warming, and by 2100, warming of 3.6°C under moderate emissions and 5.4°C under high emissions. This warming implies total multimodel mean temperature-induced flow losses at midrange sensitivity of −6.5%/°C of about −17% by midcentury and −25% to −35% at end-century (Figures 4 and 5). The multimodel mean complete flow loss *range* over both periods and both emissions is approximately −8% to −55% using the lower and upper temperature sensitivities (Figures 4 and 5). As discussed above, there is little empirical evidence that the true temperature sensitivity of flow to temperature increase is near the low sensitivity.

Temperature-induced losses may be somewhat buffered by projected additional precipitation that can increase runoff by 2–3% for every 1% change in precipitation [*Vano et al.*, 2012]. At midcentury precipitation increases of +4–+11% given a midrange elasticity of 2.5 would balance the range of temperature-induced flow losses at a midrange—6.5%/°C sensitivity (Figure 5, right *y* axis). At end-century, with the same sensitivity and elasticity, additional precipitation increases of +4–+20% would balance the range of possible temperature-driven losses. At a higher −10%/°C sensitivity, the balancing precipitation would need to be as great as +15% or more at midcentury and +22% or more at end-century. While these may seem like relatively small increases in precipitation, and thus possible, they would represent a major and unprecedented change in precipitation regime compared to the observed historical variation in precipitation (Figure 2c). During the twentieth century, for example, the wettest 10-year period (1983–1997) had only a +8% precipitation increase. This unusual period was marked by major floods downstream of Lakes Powell and Mead due to uncontrolled reservoir spilling and the near catastrophic loss of the spillways at Glen Canyon Dam [*Udall*, 1983].

Vano and Lettenmaier [2014] argue that the sensitivity-based approach used in our projections provides similar estimates of future streamflow to those generated with more computationally intensive coupled-model methods, except for some (i.e., 10%) overstatement of flow reductions at the highest levels of possible warming by 2100 (e.g., the business-as-usual SRES A2 scenario used in the CMIP3 projections and the RCP8.5 in the CMIP5 projections). This would reduce the end of century high emissions mean flow reductions shown in Figure 5 to a still very significant −45% by 2100.

Recent studies have suggested that CO_2 fertilization may increase plant water efficiency thus reducing future evapotranspiration which could serve to mitigate our projected losses [*Milly and Dunne*, 2016; *Swann et al.*, 2016]. Both studies call into question results that show large portions of the globe drying in the twenty-first century [e.g., *Dai*, 2012; *Cook et al.*, 2014]. However, *Milly and Dunne* [2016] and *Swann et al.* [2016] show that, despite this increase in plant water use efficiency, the Southwestern US will still dry, a finding that is consistent with multiple global assessments showing substantial drying risk to midlatitude areas such as the Colorado River Basin. Moreover, a recent Australian study found that higher

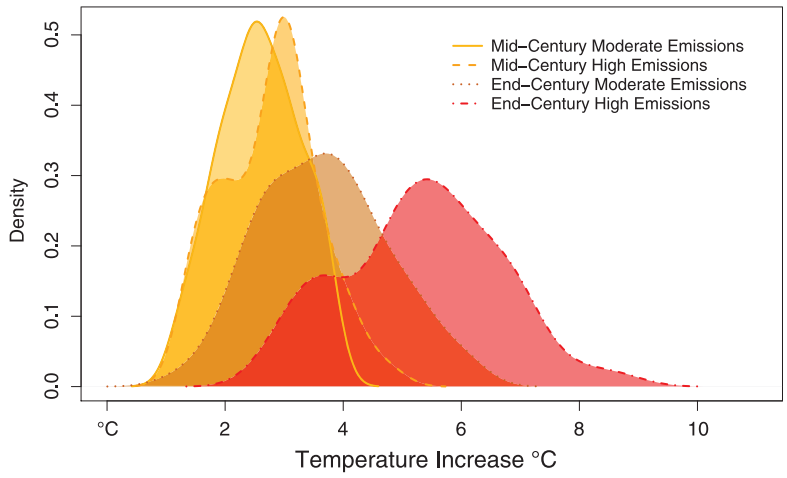


Figure 3. Probability density functions of Upper Colorado River Basin temperature projections for midcentury and end-century under moderate (SRES A1B and RCP4.5) and high (SRES A2 and RCP8.5) emissions.

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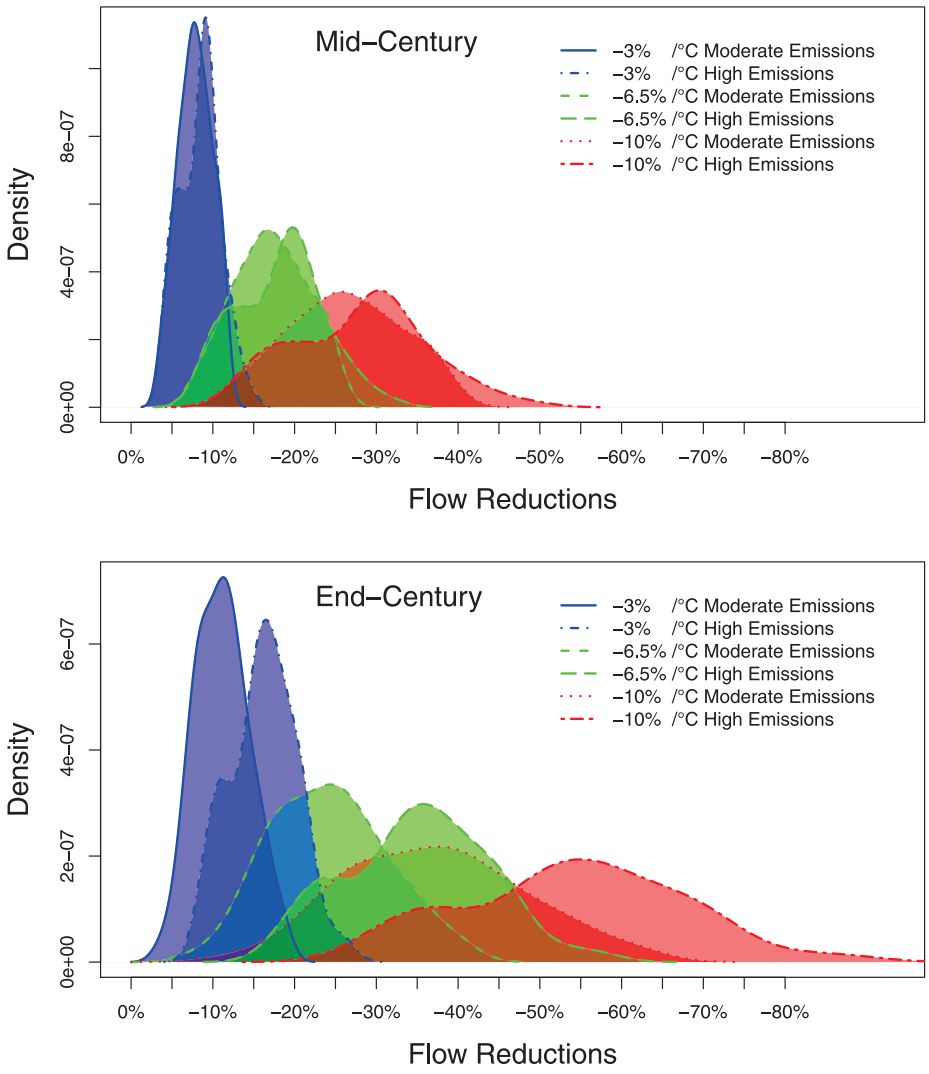


Figure 4. Probability density functions of Upper Colorado River Basin temperature-induced flow reductions for midcentury and end-century with the three temperature sensitivities (−3%, −6.5%, −10%) and the two levels of emissions (Moderate: SRES A1B and RCP4.5 and High: SRES A2 and RCP8.5).

evapotranspiration associated with the increased plant growth stimulated by higher CO_2 outweighed any CO_2-related water-use efficiency effect, and served to reduce streamflows in semiarid regions [*Ukkola et al.*, 2015], a trend that must be exacerbated by the temperature-induced lengthening of the growing season. These results suggest that plant physiological responses are likely consistent with our results, and in any case, do not invalidate them.

5. Megadrought Risks to Flows

Megadroughts lasting decades in the Colorado River Basin have occurred in the past, with resulting substantial flow reductions [*Meko et al.*, 2007]. Multiple papers now suggest there is high twenty-first century risk for megadrought in the American Southwest and that the risk will increase as temperatures rise [*Ault et al.*, 2014; *Cook et al.*, 2015; *Ault et al.*, 2016]. In addition, current GCMs underrepresent the frequency of megadrought [*Ault et al.*, 2012, 2013]. These findings provide additional support for large flow reductions during at least multidecadal drought periods and suggest that current twenty-first century flow projections underrepresent this risk.

Significant Colorado River flow losses occurred during previous multidecadal megadroughts. During the twelfth century, flow reductions of approximately −16% occurred during one 25-year period [*Meko et al.*,

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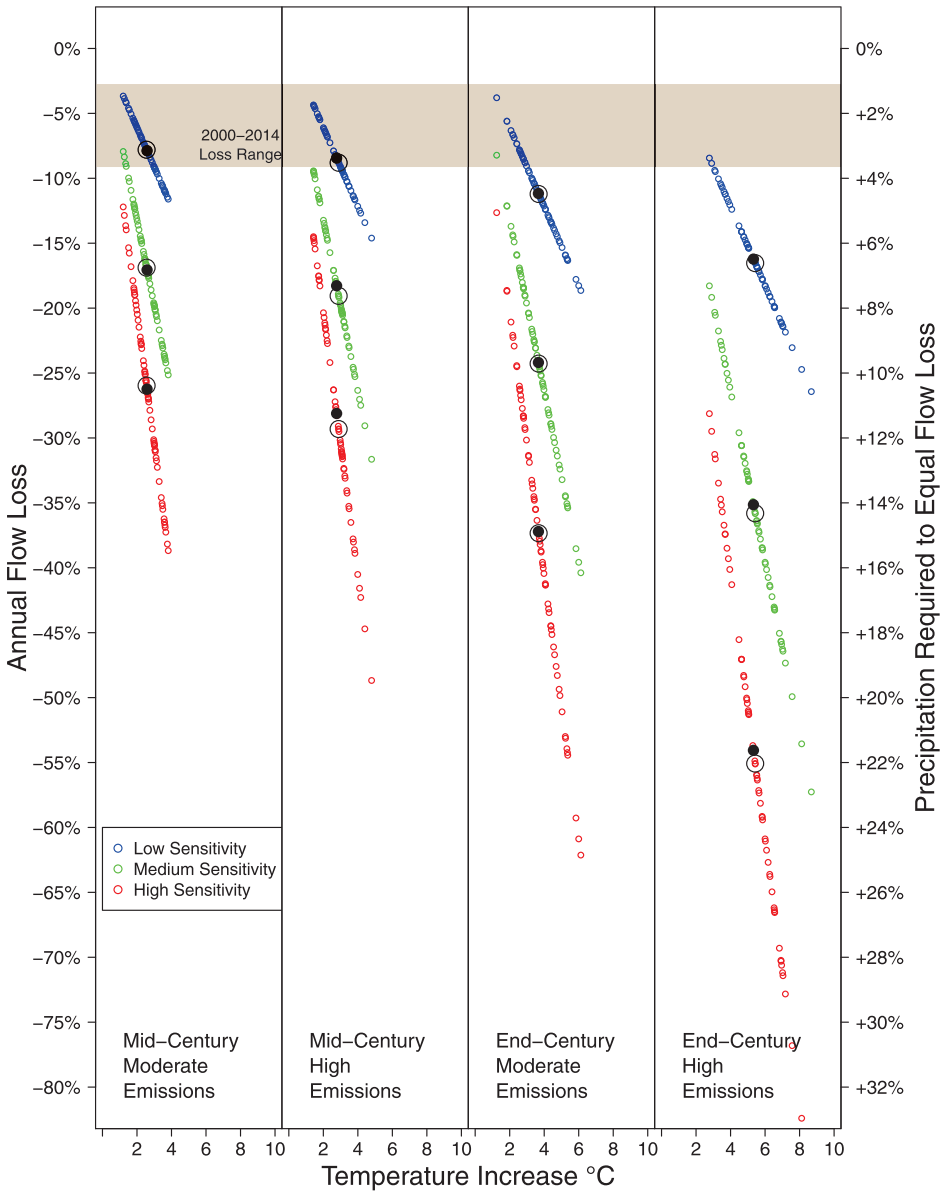


Figure 5. Temperature-induced flow losses by model run (one per dot) with temperature increases shown on horizontal axis. For each period (midcentury, end-century) and emissions type (moderate, high), flow losses for each model run are shown with the 3 (low = −3%/°C, medium = −6.5%/°C, high = −10%/°C) temperature sensitivities. Black dots/circles are averages/medians for each sensitivity. Precipitation increases needed to counteract flow losses at right are based on 2.5 precipitation elasticity. Range for the temperature-induced losses during 2000–2014 drought are shown in shaded brown at the top (supporting information Text S5).

2007]. Evidence indicates that hemispheric and Southwest temperature anomalies were significantly smaller during past megadroughts than the rapid on-going current warming that could easily exceed 4–5°C by the end of century under business-as-usual emissions [*Salzer and Kipfmueller*, 2005; *Mann et al.*, 2009; *Salzer et al.*, 2014] (Figure 5). Using the additivity concepts discussed above, additional warming of 1°C, 2°C, or 3°C beyond the historic twelfth century megadrought temperatures would have reduced the −16% flow declines by an additional −6.5%, −13%, or −19.5% at medium temperature sensitivity. These additional reductions would have thus turned a −16% flow decline into declines of −21.5%, −28%, or −34.5%, losses near the middle of our projections.

There is recent strong evidence that continued warming over the next 80 years could increase the risk of multidecadal drought [*Ault et al.*, 2014, 2016; *Cook et al.*, 2015]. Independent of the added drought risk due

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to continued warming, the risk of a 35-year precipitation-deficit drought later in this century exceeds 15% within a 50-year period [*Ault et al*., 2014]. In contrast, with continued anthropogenic warming, the risk of multidecadal megadrought in the Southwest increases to over 90% over this century if there is no increase in mean precipitation; even if modest precipitation increases do occur, the risk will still exceed 70% [*Ault et al*., 2014, 2016]. At medium warming (4°C), 20–30% precipitation increases will be needed to reduce megadrought risk below 50% and at high amounts of warming (>6°C), it will take a ~40% increase in precipitation to reduce megadrought risk below 50% [*Ault et al*., 2016]. These changes in precipitation are huge and unlikely, and they would still only reduce megadrought risk to below 50%.

Both the CMIP3 and CMIP5 Global Climate Models may not adequately reproduce the frequency of occurrence of known past decadal and multidecadal precipitation droughts [*Ault et al*., 2012, 2013]. In the Colorado River Basin empirical evidence of this problem can be found in the linked GCM-hydrology model results from Reclamation's projections for the basin [*Brekke et al*., 2014]. Approximately half of the CMIP5 models and one-quarter of the CMIP3 models cannot simulate the 2000–2014 drought at any point in the twenty-first century (supporting information Text S3 and Tables S1–S4). This wet bias significantly affects the mean flows of drought-capable and nondrought capable models. At the end of the twenty-first century, the models unable to simulate the current drought are much wetter (109% of twentieth century average Lees Ferry runoff for CMIP3, 113% for CMIP5) than the models that are able to simulate the current drought (85% of average runoff for CMIP3, 91% CMIP5) (supporting information Tables S1–S4). These flow differences are greater than 20%, and represent the difference between serious management challenges and significant oversupply.

6. Risk-Based Framing of Future Runoff Projections

At present, some outputs from global climate models are ready to support reliable risk-based policy while others are not as ready. A key novel aspect of our research is to provide more insight into where confidence is warranted, and where it is not, with respect to projections of future climate and flow change in the Colorado River Basin. In the case of the Basin, every single moderate and high emissions model simulation agrees that temperatures will continue to rise significantly with continued emissions of greenhouse gases to the atmosphere—this result is robust, highly certain and well-suited for informing policy choices. The fact that observations also show substantial warming only strengthens this assertion.

On the other hand, simulated future precipitation change in the Basin is clouded with much greater uncertainty due to substantial disagreement among models and a highly uncertain ability to simulate realistic change in key phenomena such as storm-track position or decadal and longer-scale drought. Whereas climate models are in general agreement that cool season (warm season much less certain) precipitation declines are likely in the Lower Colorado River Basin, these same models disagree when it comes to the sign and amount of precipitation change that is likely in the Upper Basin. This is because precipitation change in the Upper Basin will depend heavily on the exact changes in the position of cool season jet stream and storm-tracks, two aspects of climate change that are not simulated with confidence by global climate models [*Collins et al*., 2013].

Moreover, there is strong evidence that the mean positions of both the jet stream and storm-tracks are likely to push poleward, expanding the area of aridity in the Colorado River Basin, but the amount of this expansion is poorly constrained [*Collins et al*., 2013]. Multiple studies, including some focused on the American Southwest, suggest that the proximate cause of this drying, Hadley Cell expansion, is already well underway and will continue [*Seager et al*., 2007; *Scheff and Frierson*, 2012; *Feng and Fu*, 2013; *Norris et al*., 2016; *Prein et al*., 2016].

Our results regarding future changes in Colorado River flows agree with many previous studies in suggesting climate change translates to flow reductions, although our work is generally not directly comparable because we separate out high confidence temperature-related impacts from the possible effects of much less certain and highly variable precipitation projections. However, our work, as well as this larger body of literature, appears to be at odds with the recent Reclamation projections for the Colorado River Basin, which are widely cited and used. Reclamation's projections use a global climate model output that is downscaled to drive a hydrology model. It is worth understanding why our results emphasize substantially greater risks along with apparently greater flow losses.

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The 2011 CMIP3 climate change flow projections by Reclamation indicate a modest multimodel median flow decline of −9% by 2060 for the river, but with a wide range of outcomes from flow increases to flow decreases [*Reclamation*, 2012] (supporting information Table S1). Reclamation's most recent CMIP5 projections show no change in mean and median basin-wide flow by 2070s [*Reclamation*, 2016], but also embody a wide range of results. Compared to CMIP3, the CMIP5 results show increased precipitation, especially in the northern parts of the basin including Northeast Utah, Northwest Colorado's Yampa River and the Green River in Wyoming [*Brekke et al*., 2014; *Ayers et al*., 2016] (supporting information Tables S1 and S3). The increased precipitation in the CMIP5 model runs compared to CMIP3 can be attributed to more southerly storm tracks in CMIP5 that occur in late spring [*Brekke et al*., 2014].

Another issue arises in both the CMIP3 and CMIP5 data sets when GCM precipitation is adjusted by the downscaling techniques necessary for off-line hydrology models. The first step in Reclamation's downscaling is a bias correction step. This step can add approximately 5% more precipitation to the raw GCM precipitation, and this increase appears to not have a physical basis [*Reclamation*, 2013; *Brekke et al*., 2013]. The final downscaling step, spatial downscaling, also increases GCM precipitation, although there is at least a plausible physical explanation for some of the increase: higher elevations in the Rockies receive large amounts of precipitation, but these elevations are not properly modeled by the GCMs. In one study of the CMIP5 data set after downscaling, dry and average models show precipitation increases of approximately +∼5% from the raw GCM output, but the wettest models show +∼10% increases, doubling future precipitation increases from +10% to +20% [*Lukas et al*., 2014]. This extra precipitation is manifested in a number of hydrology model runs that project huge and implausible flow increases in some years that are 150% of the highest known flows in the twentieth century (supporting information Text S4, Figures S2, and S3). The downscaling wetness problem has been identified, but has not been not resolved [*Lukas et al*., 2014]. Reclamation acknowledges that the newer CMIP5 projections have not been determined to be better or more reliable [*Brekke et al*., 2014]. It is noteworthy that internally consistent GCM-only Southwest runoff projections almost uniformly produce significant declines in both CMIP3 and CMIP5 runs [*Milly et al*., 2005; *Seager et al*., 2007, 2012; *Koirala et al*., 2014; *Milly and Dunne*, 2016].

Our results are generally comparable to Reclamation's most recent results when considering the full range of our analysis when both precipitation and temperatures are included. However, our focus and emphasis is on the large near-certain temperature-induced flow declines with a separate analysis of precipitation. Reclamation, by contrast, has a focused on climate multimodel-ensemble median declines, including medians calculated across emission scenarios [*Reclamation*, 2013, 2012]. Decision makers often treat these median outcomes as a proxy for risk despite the fact that the median obscures the wide range of results and lumps wet and dry, warm and hot, large and small emission increases and, most critically, near certain temperature increases and very uncertain precipitation changes.

We assert that the large precipitation increases necessary to offset substantial temperature-induced flow decreases appear unlikely to occur for a number of reasons. These reasons include the potential for storm tracks to go north of the basin due to Hadley Cell expansion, the high potential for megadrought to increase evaporation while reducing precipitation and runoff for extended periods, the large size of the needed precipitation increases, especially when compared to decadal historical increases, the consistent identification by global assessments of the Southwest as an area likely to dry, and finally the lack of any trend over the last century or last 16 years (Figure 2c). Hence, we choose to focus on highly likely temperature-induced declines with separate analysis of the precipitation needed to offset these declines.

7. Policy Implications and Solutions

The climate science take-home messages for Colorado River managers are thus: (1) there is little doubt (i.e., high confidence) that temperatures will continue to increase as long as the emissions of greenhouse gases to the atmosphere continue; (2) there is also high confidence that continued temperature increases will cause river flows to decline, ranging from −11% to as much as −55% by end of century under moderate to high emissions (Figures 4 and 5); (3) there is only low confidence associated with the possibility of storms and precipitation in the Upper Basin increasing enough to even partially offset the temperature-driven declines in river flows; (4) the risk of multidecadal megadrought in the Basin is significant even in the absence of continued anthropogenic climate change, and this risk rises substantially with continued global

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warming; (5) the likelihood of drought and megadrought means that there will likely be decades-long periods with anomalously low runoff even if there is an increase in precipitation relative to the historical mean during some other periods due to anthropogenic climate change.

Temperature-driven threats to the flows of the Colorado are thus large and real. The only way to curb substantial risk of long term mean declines in Colorado River flow is thus to work toward aggressive reductions in the emissions of greenhouse gases into the atmosphere. Our work shows that modest (e.g., RCP4.5) reductions in greenhouse gas emissions, while having better outcomes than the business-as-usual future (e.g., RCP8.5), still imply large Colorado River flow losses.

The record warm nature of the on-going Colorado River drought indicates that this drought is not just a natural drought, and our work demonstrates that flows are unlikely to return to the twentieth century averages if we only wait. Unusually wet periods like the 1920s and 1990s will still continue to occur, but they will co-occur with higher temperatures that will increase water demand from plants, soil, snow, and humans.

Climate models and theory suggest that flow reductions would be more severe in the Southern portions of the Upper Colorado Basin affecting tributaries such as the San Juan, Dolores, and Gunnison more severely, with smaller impacts to more northerly tributaries such as the Yampa and Green [*Ayers et al*., 2016]. Such spatial distribution would provide additional water management challenges in that the more southerly basins have in general more people, infrastructure, and uses. Such a distribution would create new localized water supply shortages in addition to the overall basin-wide issues.

Other known threats to streamflows include the potential large scale loss of conifers [*Breshears et al*., 2005; *Adams et al*., 2009; *Allen et al*., 2010, 2015], and the impacts of dust on snow [*Painter et al*., 2010; *Deems et al*., 2013]. These factors along with the observed and projected temperature-induced Colorado River flow declines, the inability of many linked climate-hydrology models to simulate persistent droughts, and the increasing likelihood of hot drought and megadrought, all imply that future Colorado River water supply risk is high. It is imperative that decision-makers begin to consider seriously the policy implications of potential large-scale future flow declines. Stable twentieth century Colorado River flow regimes may not reoccur for many centuries—the time scale of climate system readjustment to the complete cessation of greenhouse gas emissions [*Solomon et al*., 2009; *Collins et al*., 2013].

The Colorado River declines do not stand alone as the only warming-related threat to Southwestern water supplies. The Rio Grande also has a grim prognosis [*Reclamation*, 2013; *Elias et al*., 2015]. The drought in California has garnered national attention, and multiple studies have strongly implicated increasing temperatures as a contributor to these woes [*Griffin and Anchukaitis*, 2014; *Belmecheri et al*., 2016; *Diffenbaugh et al*., 2015; *Mann and Gleick*, 2015; *Seager et al*., 2015a]. Southern California is particularly at risk, with a critical economy and a very large population, all coupled with a large reliance on both climate-threatened in-state, as well as Colorado River, water.

Adjusting to the new reality of rapid climate change will not be an easy or fast task; water management and water policy change slowly. The Colorado River is managed by a complex set of agreements, interstate compacts approved by Congress, international agreements, legislation, and court decrees set in place over the last 100 years [*Verburg*, 2011]. Most agreements were derived from twentieth century state-based negotiations with win/lose policy prescriptions that minimized basin-wide considerations of economic prosperity and potential harm [*Adler*, 2008]. None expressly includes climate change risk management, nor the provision for flow reductions that will be relentless on decadal timescales. New agreements often take years to put in place [*Department of Interior*, 2007]. The recently proposed structural deficit solution [*Central Arizona Project*, 2016], while important and laudable for the short term, will not solve the problem of large scale flow losses. With reduced water supplies, much will have to change in these agreements to address equity, economics, and social concerns on regional, state, basin-wide, and even national levels. Climate change threats to western water supplies are very real, and should prompt great concern and urgency among both water managers and the citizens of the Southwest.

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FINAL PROGRAMMATIC BIOLOGICAL OPINION

FOR BUREAU OF RECLAMATION'S OPERATIONS AND DEPLETIONS, OTHER DEPLETIONS, AND FUNDING AND IMPLEMENTATION OF RECOVERY PROGRAM ACTIONS IN THE UPPER COLORADO RIVER ABOVE THE CONFLUENCE WITH THE GUNNISON RIVER

DECEMBER 1999

TABLE OF CONTENTS

Consultation History 3
Scope of the Biological Opinion 5

BIOLOGICAL OPINION 5
DESCRIPTION OF THE PROPOSED ACTION 5
STATUS OF THE SPECIES AND CRITICAL HABITAT 19
Colorado Pikeminnow 19
Species/Critical Habitat Description 19
Status and Distribution 20
Life History 22
Population Dynamics 25
Analysis of Species/Critical Habitat Likely to be Affected 25
Razorback Sucker 28
Species/Critical Habitat Description 28
Status and Distribution 29
Life History 30
Populations Dynamics 32
Analysis of Species/Critical Habitat Likely to be Affected 32
Humpback Chub 32
Species/Critical Habitat Description 32
Status and Distribution 33
Life History 33
Population Dynamics 34
Analysis of Species/Critical Habitat Likely to be Affected 34
Bonytail 34
Species/Critical Habitat Description 34
Status and Distribution 35
Life History 35
Population Dynamics 35
Analysis of Species/Critical Habitat Likely to be Affected 35
IMPORTANCE OF THE 15-MILE REACH 36
FLOW NEEDS FOR ENDANGERED FISHES 37
ENVIRONMENTAL BASELINE 39
Status of the Species Within the Action Area 42
Factors Affecting Species Environment within the Action Area 44
EFFECTS OF THE ACTION 44
Factors to be Considered 44
Analyses for Effects of the Action 45
Species and Critical Habitat Response to the Proposed Action 63
CUMULATIVE EFFECTS 67
CONCLUSION 67

INCIDENTAL TAKE 68
AMOUNT OR EXTENT OF TAKE 69
Adult and Subadult Fish 69
Young Fish 70
EFFECT OF THE TAKE 70
REASONABLE AND PRUDENT MEASURES 70
TERMS AND CONDITIONS 71

INDIVIDUAL CONSULTATIONS UNDER THE UMBRELLA OF
THIS PROGRAMMATIC BIOLOGICAL OPINION 72

REINITIATION NOTICE 73

LITERATURE CITED 78

APPENDIX A - Description of Reclamation Projects

APPENDIX B - Depletion Accounting

APPENDIX C -Water Users' Commitment Letter and Agreement for the Interim Provision of Water to the 15-Mile Reach

APPENDIX D - Endangered Fish Population Status Assessment

APPENDIX E - Recovery Agreement

APPENDIX F - Hydrology

United States Department of the Interior

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Southern Geographic Area

Memorandum

To: Geographic Assistant Regional Director, Southern Geographic Area, Region 6, Regional Office, Denver, Colorado, Mail Stop 60140

Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

Regional Director, Bureau of Reclamation, Great Plains Regional Office, Billings, Montana

Colorado River Storage Project Manager, Western Area Power Administration, Salt Lake City, Utah

From: Regional Director, Region 6
Fish and Wildlife Service
Denver, Colorado

Subject: Final Programmatic Biological Opinion for Bureau of Reclamation's Operations and Depletions, Other Depletions, and Funding and Implementation of Recovery Program Actions In the Upper Colorado River Above the Gunnison River.

This is the Fish and Wildlife Service's final programmatic biological opinion on the following Federal actions, hereinafter referred to as the "Federal action:"

- The continuation of all of the Bureau of Reclamation's operations, including all existing and authorized depletions, in the Upper Colorado River Basin above the confluence with the Gunnison River;

- Reclamation's portion of 120,000 acre-feet/year of new depletions in the Upper Colorado River Basin above the confluence with the Gunnison River; and

- Actions undertaken by the Service, Reclamation, and the Western Area Power Administration in the funding and carrying out of recovery actions for the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin that affect the Colorado River from Rifle, Colorado, to Lake Powell, Utah, including the 15-Mile Reach of the Colorado River.

Treated as interrelated for purposes of this biological opinion in the analysis of the Federal action is the continuation of all non-Federal existing depletions in the Upper Colorado River Basin above the confluence with the Gunnison River, and the non-Reclamation portion of 120,000 acre-feet/year of new depletions in the Upper Colorado River Basin above the confluence with the Gunnison River. The 15-Mile Reach is a river reach that extends from the confluence of the Gunnison River upstream 15 miles to the Grand Valley Irrigation Company Diversion Dam near Palisade, Colorado. The subject water depletions occur above the confluence with the Gunnison River, but they affect flows in critical habitat from Rifle to Lake Powell. This biological opinion was prepared in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) and the Interagency Cooperation Regulations (50 CFR 402).

Reclamation, WAPA, and the Service contribute Federal funds to the Recovery Program which may affect listed species, therefore, section 7 consultation is required on such agencies' funding and implementation of the Recovery Program. However, all Recovery Program participants are both individually and collectively responsible for implementing the recovery actions identified in this biological opinion. While all Recovery Program participants and other entities who are responsible for actions identified in this biological opinion are committed to implementing the recovery actions, nothing contained in this opinion alters or amends the voluntary and discretionary nature of the Recovery Program as described in the document that initiated the Recovery Program (September 29, 1987), the 1988 Cooperative Agreement implementing the Recovery Program and the Section 7 Sufficient Progress and Historic Projects Agreement (USFWS 1993). If the Recovery Program fails to carry out any activities which are part of the proposed action or the terms and conditions of the Incidental Take Statement, it will not become the Service, Reclamation, nor WAPA's responsibility to do so. If this opinion becomes invalid because the Recovery Program were to cease to exist and consultation was reinitiated, the Service, Reclamation and WAPA's only responsibility will be that which results from section 7 consultations on their individual Federal actions. However, section 7 (a)(1) of the Endangered Species Act provides that the Secretary shall review programs administered by him and utilize such programs in furtherance of the purposes of the Act and requires Federal agencies to utilize their authorities to carry out programs for the conservation of endangered species; therefore, if the Recovery Program fails, the Federal Agencies are still obligated to take measures to conserve the endangered fishes. The participation in the Recovery Program and the facilitation of implementing the recovery actions as discussed in this biological opinion address the participating Federal Agencies' application of section 7 (a)(1). This biological opinion is not a precedent for

determining the degree of agency discretion in the operations of Federal water projects in other subbasins that are subject to review for compliance with the Act or for the combination of recovery actions needed to achieve such compliance.

The Service received three requests for initiation of section 7 consultation on the subject action from the following offices: 1) Bureau of Reclamation, Eastern Colorado Area Office (September 24, 1999), 2) Bureau of Reclamation, Western Colorado Area Office (September 27, 1999), and 3) Western Area Power Administration (October 15, 1999). The Service concludes that the implementation of the recovery actions identified herein and all existing and some new depletions of water from the Upper Colorado River Basin above the confluence of the Gunnison River "may affect" the endangered Colorado squawfish[1] (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*Gila elegans*), and razorback sucker (*Xyrauchen texanus*) and their critical habitat. The Service concludes that the subject action is not likely to adversely affect the bald eagle (*Haliaeetus leucocephalus*) or the southwestern willow flycatcher (*Empidonax traillii extimus*). In recent years, the number of wintering and nesting bald eagles have increased in the Colorado River within the action area, with historic water depletions in place. It is not likely that any of the proposed actions will adversely affect bald eagles. The Service does not believe that historic water depletions on the Colorado River have adversely affected the southwestern willow flycatcher because in many areas there is more habitat (riparian vegetation - willow, tamarisk, cottonwood) now than there was historically. Graf (1978) used photographic evidence, map analysis, and field surveys to show the spread of tamarisk throughout the Colorado River system and described its effects of enlarging and stabilizing islands, bars, and restricting channel width. Many islands and shoreline habitats were not historically vegetated when spring flows were higher and prior to the establishment of tamarisk along the Colorado River.

Consultation History

Implementation of the Endangered Species Act in the Colorado River Basin started with section 7 consultation on Reclamation projects in the late 1970's. At this time, the Service determined that a jeopardy situation existed for the subject endangered fishes. Subsequently, the Act was amended to direct Federal Agencies to work with State and local agencies to resolve water resource issues in concert with conservation of endangered species.

In 1984, the Department of the Interior, Colorado, Wyoming, Utah, water users, and environmental groups formed a coordinating committee to discuss a process to recover the endangered fishes while new and existing water development proceeds in the Upper Colorado River Basin in compliance with Federal and State law and interstate compacts. After 4 years of negotiations, the Recovery Implementation Program for the Endangered Fish Species in the Upper Colorado River Basin was developed.

---

[1]The American Fisheries Society has changed the common name of this species to Colorado pikeminnow (Nelson et al. 1998), therefore, it will be referred to as the Colorado pikeminnow in this document.

On January 21-22, 1988, the Secretary of the Interior; Governors of Wyoming, Colorado, and Utah; and the Administrator of the Western Area Power Administration cosigned a Cooperative Agreement to implement the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (USFWS 1987). Current participants in the Recovery Program include: the Service, Reclamation, WAPA, Colorado, Utah, Wyoming, Environmental Defense Fund, The Nature Conservancy, Colorado Water Congress, Utah Water Users Association, Wyoming Water Development Association, and the Colorado River Energy Distributors Association. The goal of the Recovery Program is to recover the listed species while providing for new and existing water development in the Upper Colorado River Basin. All participants agreed to cooperatively work toward the successful implementation of a recovery program that will provide for recovery of the endangered fish species, consistent with Federal law and all applicable State laws and systems for water resource development and use. Each signatory assumed certain responsibilities in implementing the Recovery Program.

In order to further define and clarify processes outlined in sections 4.1.5, 4.1.6, and 5.3.4 of the Recovery Program, a Section 7 Agreement and a Recovery Implementation Program Recovery Action Plan were developed (USFWS 1993). The Agreement established a framework for conducting section 7 consultations on depletion impacts related to new projects and impacts associated with existing projects in the Upper Basin. Procedures outlined in the Agreement are used to determine if sufficient progress is being accomplished in the recovery of endangered fishes to enable the Recovery Program to serve as a reasonable and prudent alternative to avoid the likelihood of jeopardy and/or adverse modification of critical habitat. The Recovery Action Plan was finalized on October 15, 1993, and has been reviewed and updated annually.

Since the implementation of the Recovery Program, over 200 biological opinions have been issued on water depletions to the Upper Colorado River Basin. The Recovery Program and implementation of the Recovery Action Plan have served as the reasonable and prudent alternative for these jeopardy opinions.

On March 11, 1996, the Recovery Program's Implementation Committee directed the Management Committee to develop a strategy to provide and protect flows in the 15-Mile Reach of the Colorado River. The Service's Regional Director then provided a letter (April 5, 1996) to the chair of the Management Committee detailing the request from the Implementation Committee. The letter requested that the strategy contain a discussion of how the flow and nonflow activities in the Colorado River sub-basin work together. At the same time there were discussions on whether the Section 7 Agreement was working in the 15-Mile Reach and on legislation for long-term funding of recovery actions. The Management Committee formed a workgroup to further identify the issues and recommend a strategy for their resolution. By the end of 1996, the workgroup recommended that the issues could be best resolved through a biological opinion on Recovery Program activities in the 15-Mile Reach. However, many issues regarding flow needs, options for providing and legally protecting water, the importance of nonflow actions in recovering the fish, and a framework for conducting future section 7 consultations remained unresolved. To resolve these issues, the State of Colorado convened a

larger workgroup of interested parties in August of 1997. The workgroup included water users, environmental groups, and State and Federal agencies. This programmatic biological opinion represents the Service's consideration of the Federal action described on page 1.

Scope of the Biological Opinion

The Federal action described on page 1 is addressed in this biological opinion. This biological opinion addresses impacts related to water depletions that occur above the confluence with the Gunnison River and impact critical habitat from Rifle to Lake Powell and recovery actions designed to offset these impacts. Therefore, the subject recovery actions affect the Colorado River between Rifle and Lake Powell. Impacts related to water depletions and recovery actions in the Green River are addressed in the consultations for Flaming Gorge Dam and the Duchesne River. Programmatic consultations for the Gunnison and Yampa Rivers are planned to address similar issues. Issuance of this programmatic biological opinion does not create an administrative priority concerning Upper Colorado River Basin depletions. The opinion neither prejudices nor determines the amount of depletions allowable under the Colorado River Compact or under the Endangered Species Act in other subbasins of the Upper Colorado River Basin.

The Recovery Program does not cover direct physical impacts of new actions (projects constructed after January 22, 1988); effects of transbasin diversions on Platte River endangered species; introduction of nonnative fish species; or discharges of pollutants and therefore, this biological opinion does not address such impacts. This biological opinion does not address impacts of future actions authorized by the participating Federal Agencies that are not associated with water depletions or operation of Reclamation facilities to carry out recovery actions.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The proposed action is described on page 1. The Reclamation projects included in this consultation are the past, existing, and continued operation of the Colorado-Big Thompson Project, Fryingpan-Arkansas Project, Collbran Project, Grand Valley Project, and Silt Project, including all existing, historic, and authorized depletions associated with these projects. These projects are operated in accordance with various laws and policies such as the authorizing legislation for each project, operating policies, criteria, and principles, and various court decrees. For detailed descriptions of the physical features of each projects, see Appendix A.
Non-Reclamation projects associated with the continuation of existing depletions and 120,000 acre-feet/year of new depletions above the confluence with the Gunnison River which have or are likely to have a Federal nexus are anticipated to choose to rely on the implementation of the Recovery Action Plan, which is the responsibility of all of the Program participants, to avoid the likelihood of jeopardy and adverse modification of critical habitat. Therefore, this biological opinion is treating these projects as interrelated. The participating Federal Agencies contribute approximately $3.3 million annually for implementation of recovery actions under the base

funding component of the Recovery Program. Additionally, Reclamation contributes approximately $7 million annually for Capital Projects. However, to complete the actions described in this project description it will require the cost sharing by non-Federal partners. Capital Projects consist of construction of facilities and acquisition of land and water interests required to recover the endangered fish. These recovery actions are described below and in the most recent Recovery Action Plan (April 1,1999). The purpose of the Recovery Program and its Recovery Action Plan is to recover the four listed fish species and provide a means to avoid the likelihood of jeopardy and adverse modification of critical habitat for new and existing water projects. Recovery actions within the Recovery Program fall under five elements: 1) habitat protection; 2) habitat development and maintenance; 3) native fish stocking; 4) nonnative fish control; and 5) research, monitoring, and data management. Recovery (downlisting and delisting under ESA) of the fish species is dependent upon implementation of Recovery Program elements in the various river basins (USFWS 1987). Recovery in a single river would not achieve full recovery of the species, rather full recovery is dependent on self-sustaining populations in various locations as described in the Recovery Plans for each species (USFWS 1990a, 1990b, 1991, 1998). The Recovery Program " . . . is intended to go considerably beyond offsetting water depletion impacts by providing for the full recovery of the four endangered fishes in the Upper Colorado River Basin, excluding the San Juan River Basin" (USFWS 1993).

Under the Recovery Program, the Recovery Program Director's office annually sends a request to all participants for recommended changes to the Recovery Program's Recovery Action Plan. These changes include revised due dates, additions and deletions of recovery actions, additional steps to complete a recovery action, or a change in the lead agency responsible for ensuring completion of a recovery action item. Once the recommended changes are received, they are consolidated and sent to the technical committees for review and recommendations. Justifications for making the change are also provided. The Recovery Program's Management Committee then prepares a recommendation for the Implementation Committee, based on input from the Program Director's office and the technical committees. Final changes to the Recovery Action Plan require consensus by all Implementation Committee members. If consensus is not reached on a proposed change, the subject item in the Recovery Action Plan remains unchanged. The Implementation Committee routinely makes changes to the schedule for completing recovery actions when the delay is due to uncontrollable circumstances.

As described in the Federal action on page 1, this biological opinion addresses certain Reclamation operations and new and existing depletions, and treats as interrelated certain other depletions.

Existing depletions, as of September 30, 1995, have been estimated by modeling. Model results show existing depletions to be approximately 1-million acre-feet/year. This estimate is the approximate average annual depletion value modeled for water years 1975 to 1991. The minimum depletion value was approximately 877,000 acre-feet/year for 1983 and the maximum was approximately 1,172,000 acre-feet/year for 1978.

The 120,000 acre-feet/year of new depletions represents the amount of additional Reclamation and non-Reclamation water that the Service believes could be depleted from the Upper Colorado River Basin above the confluence with the Gunnison River using new or existing facilities (including depletions that have already occurred since September 1995) and not result in the likelihood of jeopardy or adverse modification of critical habitat so long as the recovery actions are implemented as described herein.

The 120,000 acre-feet/year depletion includes non-Reclamation projects and/or facilities that have current biological opinions but have not yet depleted the full amount covered by those biological opinions and water that could be depleted in the near future from facilities without a current Federal nexus. However, non-Reclamation facilities are treated as interrelated because of the likelihood that they will have a Federal nexus at some future point and want to rely on the Recovery Program to avoid the likelihood of jeopardy and adverse modification of critical habitat. The Federal nexus will likely come in the form of facility repairs requiring Army Corps of Engineers permits, Federal Energy Regulatory Commission relicensing, Federal agency authorization of right-of-ways, or some other Federal involvement. This 120,000 acre-foot reduction in flows is expected to have the same effect on endangered fish and their critical habitat if removed by existing or new projects. However, we cannot make a judgement on exactly where this 120,000 acre-feet/year of depletion will come from and anticipate that some of it will come from facilities that have yet to be constructed.

In recognition of the extreme variability of hydrology and water use demand patterns, the 120,000 acre-feet of new depletions will be calculated as a 10 year moving average as determined by the Colorado Water Conservation Board in consultation with Reclamation and concurred with by the Service (Appendix B).

The following elements of the Recovery Action Plan are measures completed, ongoing, or future actions which are part of the action subject to this consultation. As part of the action, the beneficial effects of these recovery actions are taken into consideration in the jeopardy and incidental take analysis. It is the Recovery Program's responsibility to ensure that all elements of the Recovery Action Plan affecting the Colorado River and other rivers are completed and/or implemented consistent with Recovery Program schedules (contained in the April, 1999, "Section 7 Consultation, Sufficient Progress, and Historic Projects Agreement and Recovery Action Plan" and subsequent revisions).

The following elements of the Recovery Action Plan address the biological and habitat needs of the endangered fishes, each element involves several recovery actions. These needs are described in the "Status of the Species and Critical Habitat" section of this document.

1. Habitat Protection Element

General protection

The Service and the Colorado Water Conservation Board entered into a Memorandum of Agreement on September 21, 1993, wherein the Board agreed to ". . . take such actions under state law, including requesting administration by the State Engineer and the appropriate division engineer and initiating water court proceedings, as may be necessary to fully exercise its water rights or to obtain delivery of acquired water or interest in water. Such water shall be protected within the entire stream reach for which the appropriation or acquisition is made." This agreement (commonly called the Enforcement Agreement) provided a legal mechanism to protect water obtained for the endangered fish under the Recovery Program. Categories of water this could apply to include contract deliveries, water leases, and acquired water rights.

Late Summer and Fall Base flow period augmentation

On September 2, 1997, the Colorado Water Court granted the CWCB an instream flow decree for 581 cfs in the 15-Mile Reach during July, August, and September. This decree protects the Orchard Mesa Pumping and Power Plant return flows that enter the river at the top of the 15-Mile Reach. In addition, the Colorado Water Court has granted the CWCB a 300 cfs instream flow right for water accretions occurring in the 15-Mile Reach during July, August, and September. These two instream flow rights provide protection from future diversions of water in the 15-Mile Reach. Additionally, 5,000 acre-feet annually plus an additional 5,000 acre-feet, 4 out of 5 years, is made available from Ruedi Reservoir by Reclamation, in consultation with the Service and the CWCB when needed by the fish. Protection of these releases is accomplished pursuant to the terms of an agreement between Reclamation, the CWCB, and the Service, which provides for the delivery and protection of that water in stream to and through the 15-Mile Reach. Typically the Service requests deliveries during July, August, and September.

In accordance with a 1995 biological opinion for Ruedi Reservoir Round II Water Sales, which was amended January 6, 1999, Reclamation, Colorado Water Conservation Board and the Service have signed 1-year agreements for 21,650 acre-feet/year of water (in addition to the 5,000 acre-feet/year plus 5,000 acre-feet 4 out of 5 years mentioned above) from Ruedi Reservoir. Under the amended Ruedi opinion, Reclamation is to provide the 21,650 acre-feet of water from Ruedi Reservoir for a period of 15 years through short- or long-term agreements beginning the first year the Recovery Program pays associated operation and maintenance costs, which costs were first paid for water released in 1998. Also, under the amended opinion, Reclamation proceeded with immediately contracting for up to 6,135 acre-feet of 17,000 acre-feet of Ruedi Round II water sales.

This programmatic biological opinion will take precedence over the amended Ruedi opinion, but does not require additional commitments of water from Ruedi Reservoir. Reclamation's 21,650 acre-foot/year commitment is reduced by half, when the water users provide 10,825

acre-feet/year. Reclamation's reduced commitment (21,650 minus 10,825) will continue for the 15-year period referenced in the Ruedi amendment (through the year 2012). Once Reclamation provides the reduced commitment through a long-term agreement (rather than the 1-year agreements), and this programmatic biological opinion is finalized, Reclamation may, as demand materializes, contract for the remainder of the 17,000 acre-feet of Ruedi Round II water (17,000 minus 6,135 equals 10,865) discussed in the Service's opinion dated May 26, 1995, as amended on January 6, 1999. A long term agreement will be finalized five months from the date of this final biological opinion or by a later date if it is specified in modifications to the Recovery Action Plan.

The water users' commitment for 10,825 acre-feet/year is divided equally between east and west slope water user entities. The water users' commitment was formalized in a letter dated September 16, 1998, and through the proposed Agreements for the Interim Provision of Water to the 15-Mile Reach of the Colorado River (Appendix C). Reclamation will participate in the process of deciding how to meet this commitment.

Once this programmatic biological opinion is finalized and the water users have provided their 10,825 acre-feet/year, Reclamation may contract under this consultation for the other half (10,825 acre-feet/year subtracted from its 21,650 acre-feet/year commitment equals 10,825 acre-feet/year), described above, provided the demand materializes and new depletions allowable under this programmatic biological opinion will not be exceeded. Under this consultation Reclamation may contract for the Ruedi water, which was committed in the long-term agreement through the year 2012, beginning in the year 2013, provided the demand materializes and new depletions covered by this programmatic biological opinion will not be exceeded.

The east and west slope water users' commitment of 10,825 acre-feet annually, referred to in the previous paragraph, will be dedicated by water user entities from existing or new Colorado Water Division Number 5 Facilities. Initially, this water will be provided on an interim basis as described in the proposed Agreements for the Interim Provision of Water, and then, it will be provided on a permanent basis for delivery, as needed by the fish. The water user entities will determine which facilities the water will be released from and will execute any necessary agreements. Until the permanent source(s) of this water are determined by the water user entities, 10-year Agreements for the Interim Provision of Water to the 15-Mile Reach of the Colorado River will be entered into by the Colorado River Water Conservation District, the City and County of Denver, acting by and through its Board of Water Commissioners, and the Service. Denver Water and the River District have agreed to provide the water for 10 years. This programmatic opinion does not restrict the water user entities from securing for Ruedi Reservoir water as a source for meeting their commitment. These leases and agreements are for delivery of water to be used in late summer/early fall beginning in 2000 to meet base flow needs. The agreements are to be signed concurrently with this final programmatic biological opinion. No later than the end of the 10 years, an agreement is to be executed by the water entities and the Service to furnish a permanent source of water to be provided annually to the 15-Mile Reach to benefit endangered fishes.

Also, the Service and the Colorado River Water Conservation District executed a Memorandum of Understanding in January 1998, pursuant to the Wolford Mountain biological opinion for storage and delivery of water to the 15-Mile Reach. Each year the River District makes available up to 6,000 acre-feet of water from Wolford Mountain Reservoir to benefit endangered fish habitat in the 15-Mile Reach of the Colorado River. The Wolford water is released by the River District at the discretion and direction of the Service. Protection of the releases is accomplished pursuant to the terms of an agreement between the River District, the CWCB, and the Service which provides for the delivery and protection of that water instream to and through the 15-Mile Reach pursuant to the Enforcement Agreement.

Additionally, the Recovery Program will construct features of the Grand Valley Water Management Project by the dates specified in the Recovery Action Plan. A study of canal operations from 1992-1994 showed the amount of water spilled from the Government Highline Canal in August, September, and October averaged 31,400 acre-feet. Once this project is completed, canal spills will be reduced by 19,400 acre-feet and approximately 9,000 acre-feet will be redirected to return to the Colorado River, through the Palisade Pipeline, above the 15-Mile Reach. In average and below average runoff years, the majority of the reduced canal spills will contribute to an increased surplus storage condition in Green Mountain Reservoir's Historic User Pool. "Surplus HUP water" is water in excess of the needs of the HUP beneficiaries as defined in paragraph 8 of the Green Mountain Reservoir Operating Policy (Federal Register, Volume 48, Number 247, December 22, 1983, as amended in Federal Register, Volume 52, Number 176, September 11, 1987) and the Stipulation and Agreement of the Orchard Mesa Check Case (Colorado Water Division 5, 91CW247). Surplus HUP water can be released from Green Mountain Reservoir and legally protected to indirectly improve flow conditions in the 15-Mile Reach. Therefore, implementation of the Grand Valley Water Management Project will result in up to 28,400 acre-feet (19,400 plus 9,000) of additional flows in the 15-Mile Reach. The project consists of adding 7 new check structures to the canal system, automation of the new and existing check structures, construction of the 1,000-foot Palisade Pipeline and the construction of the Highline Lake Pumping Station. Construction is to begin when this biological opinion is finalized and contracts with the Grand Valley Water Users Association have been completed. The August 2002 construction completion date is dependent on finalization of the biological opinion in December 1999.

Recovery Program participants have agreed to execute contracts, agreements, or other acceptable legal protection mechanism for delivery of surplus HUP water, including surplus water made available by Grand Valley Water Management Plan, to and through the 15-Mile Reach. Protection will occur in two phases. The first phase will protect water to and through the 15-Mile Reach up to the excess capacity of the Grand Valley Power Plant pursuant to the Orchard Mesa Check Settlement and will be completed in accordance with the schedule in the current RAP. The second phase will legally release and protect additional surplus HUP water to the degree it is deemed available and needed for enhancement of flows in the 15-Mile Reach. The amount of available surplus HUP water will be increased through improvements to the Grand Valley Project accomplished under Grand Valley Water Management Plan, as described in the above paragraph.

These improvements will reduce releases from the HUP to the Grand Valley Project for irrigation and result in additional surplus in the HUP. Additional surplus HUP water to be delivered and protected in the second phase is in excess of the capacity of the Grand Valley Power Plant canal system. This protection will be in place by the end of April 2000, or by a later date if subsequently modified in the RAP. The Recovery Program is working with Reclamation, the State of Colorado, and water users to legally protect and deliver additional surplus HUP water for nonconsumptive municipal/recreational uses and thereby indirectly benefit endangered fish habitat in the 15-Mile Reach. Recent studies for the Grand Valley Water Management Plan biological assessment have demonstrated that substantial water could be made available if flow protection agreements are put in place (Table 1). This water may not be available every year and it would not be released in years when it is not needed for the fish.

Spring peak enhancement

The Recovery Program implemented Coordinated Reservoir Operations for the Colorado River in 1997 and augmented spring peak flows by 2,000 cfs. In 1998, Coordinated Reservoir Operations added 2,500 cfs to the peak. Augmentation of the peak is to occur in all but extremely dry or extremely wet years or when peak flows are between 12,900 cfs and 26,600 cfs in the 15-Mile-Reach. During extremely wet years the peak exceeds this range without augmentation. Current plans are to augment spring peak flows by as much as possible for up to 10 days, by bypassing reservoir inflows during the peak. Although Coordinated Reservoir Operations is required to meet Recovery Program goals, participation by individual facility operators on a year-to-year basis is voluntary. A goal of Coordinated Reservoir Operations is to increase both the magnitude and duration of the spring peak.

This year, the Recovery Program initiated Phase II of spring peak augmentation through a "Coordinated Management of Colorado Water Division Number 5 Facilities - Phase II Study." The study is intended to assess water management facilities and operations that can be coordinated to benefit fish habitat primarily during the spring peak. The goal is for project sponsors to satisfy project purposes, but to utilize any flexibility that may exist to enhance spring flows for endangered fish. Possible options include new projects, long- and short-term leases or delivery agreements and using or moving winter water in excess of fish needs to meet water demand or fish needs during the spring. The intent is to provide additional water up to approximately 20,000 acre-feet/year of water for spring peak flow enhancement, without diminishing project yield or causing project sponsors to incur significant costs. When additional water of approximately 20,000 acre-feet is available, it could provide 1,008 cfs per day for a 10 day period.

2. Habitat Development and Maintenance Element

Floodplain habitats have been identified as important for endangered fishes, especially the razorback sucker. These habitats have been lost over time due to channelization, dikes, bank

Table 1. The estimated benefits in acre-feet made available from the Grand Valley Water Management Project and the Orchard Mesa Check Settlement (Grand Valley Water Management Project Environmental Assessment, September 1998).

Years Hydrologic Type	Water provided at Palisade Pipeline - not protected	Legally protected up to canal capacity	Made available through Municipal/ Recreation Agreements	Natural flow water not protected
Normal	9,000	16,257	28,779	1,803
Wet	9,000	0	65,500	6,827
Dry	9,000	19,551	37,348	4,640

stabilization, and lower spring flows. One element of the Recovery Program involves enhancing, restoring, and protecting natural floodplain habitats. An inventory of these habitats was completed for 871 miles of the Colorado, Green, Gunnison, Yampa, and White Rivers. Floodplain habitats are being restored along the Colorado River to prepare the ecosystem for reintroduction and reestablishment of razorback sucker populations. Two sites along the Colorado River have been restored by connecting bottomland habitat to the river and shaping the habitat to facilitate draining during low flow periods to avoid harboring nonnative fishes. One project, at 29⅝ Road (also known as Gardner Pond) involved partially filling in an old gravel pit and constructing a connection to the Colorado River. Ongoing studies are evaluating the use of gravel pit ponds that have been reshaped to drain and behave as ephemeral floodplain habitats for adult Colorado pikeminnow and razorback sucker. The spring of 1998 was the first of a 3-year evaluation period. Intensive sampling was done at Gardner Pond and an adjacent pond, known as Pickup Pond. A total of 376 native fish including adult Colorado pikeminnow were captured in these two ponds.

The second project is a partnership effort between the Recovery Program, the Service, the City of Grand Junction, the Riverfront Commission, and the Mesa County Soil Conservation District located near the confluence with the Gunnison River at the Jarvis site. Prior to the 1950's this site was a northern side channel to the Colorado River. In the 50's it was diked off from the river and mined for gravel, then the gravel pit was used as a municipal dump and disposal site for uranium mill tailings. After the pit was filled in, the site was used as an auto salvage yard. In the late 1980's, the City of Grand Junction purchased the site and removed all the junk cars, then the Department of Energy removed all the radiological contaminated waste, leaving the site close to the original river elevation. To restore the site, a notch has been constructed in the dike between the river and the excavated area and the site has been shaped to drain during low water. A set back dike was constructed to protect adjacent property. During high water, the site is inundated with water from the river and provides habitat for endangered fishes, and as the river drops, the

site drains, so it is not a year round pond that supports nonnative fishes. This site will provide shallow warm water habitat for prespawning conditioning for Colorado pikeminnow and razorback sucker. It provides a quiet water refuge and an abundant food supply during spring runoff.

Adobe Creek and Walter Walker State Wildlife Area are two floodplain sites used in an evaluation of contaminant impacts on razorback sucker reproduction. Water control structures were constructed in a tertiary channel at Adobe Creek, enabling a section of this channel to be isolated and controlled for this evaluation and for possible use as a grow-out area for larval razorback suckers in the future. A water control structure also was constructed at Walter Walker allowing 100 cfs of fresh water from the river to enter in an attempt to help lower selenium levels at this site. This appears to have been successful.

Two properties (181 acres) have been acquired along the Colorado River for restoring endangered fish habitat in the floodplain. Approximately 13 properties are currently in various stages of the pre-acquisition process. The priorities along the Colorado River include several gravel pit ponds and partnerships with local private, county, State, and Federal entities. The Recovery Program will continue to support funding and acquisition of interest in bottomlands identified by the Service as needed for recovery of the endangered fish along the Colorado River. Current plans are to acquire interest in up to 3,500 acres of bottomland habitat along the Upper Colorado River in the Grand Valley and along the Gunnison River. Properties will be purchased on a willing seller basis.

A second component of habitat restoration is construction of fish passageways on dams and diversions that have blocked endangered fish access to important historical habitat. These barriers have fragmented habitat and prevented access to spawning, feeding , and winter habitats. Construction of a passageway was completed in January 1998 at the Grand Valley Irrigation Company Diversion Dam. It consists of a notch in the dam and a series of pools and riffles immediately below. This configuration of rocks creates pools and riffles in ascending increments, and allows fish to swim upstream and over the dam during periods of low flow. Two additional fish passages at Price-Stubb and Grand Valley Project Diversion Dams are currently in the planning and evaluation stage. Colorado pikeminnow no longer occur above the Price-Stubb Dam. Passage at the Price-Stubb Diversion Dam is currently scheduled to be completed in September 2000. If the dam removal option is chosen, the schedule could be delayed until April 2002 to accommodate completion of the Plateau Creek Pipeline Project by Ute Water Conservancy District. Restoration of passage at the Government Highline Diversion Dam is tentatively scheduled for completion during 2001.

3. Native Fish Stocking Element

To achieve recovery it is important to maintain the genetic integrity of wild and captive-reared endangered fishes and to prevent irreversible losses of genetic diversity. The genetic management goals of the Recovery Program are to prevent immediate extinction; to conserve genetic diversity

through recovery efforts that will reestablish viable wild stocks by removing or significantly reducing factors that caused population declines; to maintain genetic diversity in captive-reared endangered fish broodstock that is similar to that of the wild stock used as founders; and to produce genetically diverse fish for augmentation efforts.

The razorback sucker is the highest priority for placing in refuge and developing broodstock because of continued population decline and low recruitment. A refuge broodstock of upper Colorado River razorback sucker stock is being developed and augmentation stocking has been implemented in the Gunnison River and in the Colorado River between Rifle and Palisade. The Recovery Program maintains razorback suckers at the Horsethief facility in the Grand Valley as a refugia and for developing broodstock. Bonytail broodstock are currently maintained at the Service's Dexter National Fish Hatchery and Technical Center. One stock of the Colorado pikeminnow is being developed for the augmentation of the upper Colorado River. The hatchery facilities in the Grand Valley consist of buildings for hatching eggs and rearing young, and holding and growout ponds. Expansion of existing facilities to be completed in 1999 included a building to hatch and rear young Colorado pikeminnow. The Recovery Program is in the process of obtaining additional ponds that will be used to grow both razorback suckers and Colorado pikeminnow to a size suitable for stocking.

The Recovery Program has approved a stocking plan for the Colorado River that calls for stocking 102,100 6- to 8-inch and 30,600 12-inch razorback sucker in the spring and fall for 5 years in the Rifle to De Beque Canyon reach and from Palisade to Stateline. The approved plan also calls for stocking 25,600 4-inch and 12,800 8-inch bonytail in the spring and fall for 5 years in the Colorado River from Palisade to Loma. Additionally, in the spring and fall, 800 6-inch and 400 10-inch Colorado pikeminnow are scheduled for stocking for 5 years in the Colorado River from Rifle to De Beque Canyon. Numbers to stock will likely be modified after the first 3 years based on an evaluation of stocking effectiveness. To date, 10,381 bonytail have been stocked in the Colorado River in Professor Valley, Utah, and this stocking will continue for at least 1 more year. Based on approved stocking plans, the Recovery Program intends to stock a total of 7,200 Colorado pikeminnow; 1,030,000 razorback sucker; and 33,400 bonytail into the mainstem Colorado River from Rifle, Colorado, to Lake Powell, Utah. Stocking will proceed in accordance with dates established by the Recovery Program and/or included in the Recovery Action Plan.

4. Nonnative Fish Control

Regulations and agreements

Nonnative fish in the Colorado River system have been identified as a major factor in the decline of the endangered fishes because they compete for food and space and prey on endangered fishes. To prevent further introduction of nonnative fish into the system and to reduce the number of nonnative fish in critical habitat, stocking regulations and bag limits in the State of Colorado have been changed.

In 1996, Procedures for stocking nonnative fish species in the Colorado River were approved by the Recovery Program (USFWS 1996). A Memorandum of Agreement implementing the Procedures was signed September 5, 1996, between the Service and the States. The purpose of the Procedures is to ensure that all future stocking of nonnative fish will be consistent with the recovery of the endangered fishes. This agreement remains in effect through the life of the Recovery Program.

On January 14, 1999, the Colorado Wildlife Commission adopted regulations that limit the stocking of private ponds. The intent and restrictions in these regulations are identical to the Procedures adopted in 1996. Regulations restricting stocking of private ponds will remain in effect for 4 years, at which time the Wildlife Commission will determine if the procedures were effective. If the regulations restricting the stocking of private ponds are rescinded, then other nonnative control/removal efforts will have to be put in place.

Colorado has removed bag limits on all nonnative warmwater sportfishes within the critical habitat reach of the Colorado River. Bag limits had been in place for all warmwater sportfish. The removal of bag limits may increase the numbers of nonnative fish removed from endangered fish habitat. Colorado also has agreed to close river reaches to angling where and when angling mortality is determined to be significant to native fish.

Removal efforts

In order to reduce the number of nonnative fishes in the Colorado River system, several removal programs have been put in place. One effort removes nonnative fish from ponds along the Colorado and Gunnison Rivers where many species of nonnative fishes reproduce and grow. During high water events, these nonnative fishes have access to or get washed into the river where they complete with and prey on native fishes. Off channel ponds along the Colorado River have been identified as the source of many of the nonnative sportfishes that occur in the river and in endangered fish nursery areas. Ponds in critical habitat in the Colorado River are being identified for reclamation. Pond reclamation can include complete removal of nonnative fish, screening ponds to prevent escapement to the river, and/or reshaping ponds so that they no longer support year round habitation by nonnative fish. The most effective and practicable of these alternatives will be implemented on a case by case basis. The Recovery Program is reclaiming up to 25 ponds each year until all public and private ponds that can be reclaimed are completed. The actual number of ponds to be reclaimed each year will be determined through revision of the current Pond Reclamation scope-of-work as part of the Recovery Action Plan. In 1998, the Colorado Division of Wildlife reclaimed 25 surface acres of ponds; negotiated water management for 5 ponds to facilitate seasonal drying; and reduced depth in 1 pond to promote winter kill. This activity will continue as long as deemed appropriate by the Recovery Program.

Backwaters have been identified as important nursery habitat for Colorado pikeminnow and other native fishes. The majority of the fishes found in backwaters are nonnative cyprinids and centrarchids, and biologists believe that these nonnative fishes compete for food and space with

native fishes. Also, some species of nonnative fishes eat the native fishes and this is believed to be a reason for the decline in native fishes. The Recovery Program has implemented nonnative fish removal efforts for small nonnative cyprinids and centrarchids from backwaters and other low velocity habitats. Removal efforts focus on trying to achieve a decrease in numbers of small minnows prior to spawning by Colorado pikeminnow. Some removal may need to occur during razorback spawning. Centrarchids such as green sunfish and largemouth bass are predacious and impact endangered fish populations. These fish will be removed by contractors for the Colorado Division of Wildlife from low velocity habitats during the summer of each year for as long as needed to attain viable endangered fish populations. Other nonnative fish collected while targeting cyprinids and centrarchids also will be removed when encountered. The Colorado Division of Wildlife will prepare and adopt a Colorado River Fisheries Management Plan that will implement a more detailed nonnative fish control effort. The plan will be reviewed and approved by the Recovery Program and Colorado Wildlife Commission. The Plan will be finalized and implemented by the dates specified in the Recovery Action Plan.

5. Research, Monitoring, and Data Management Element

Monitoring the status and trends in fish populations has been an integral component of the Recovery Program. An interagency standardized monitoring program was established in 1988. The ISMP was designed to annually measure the catch per unit of effort of humpback chub and Colorado pikeminnow at different life stages. Young-of-the- year Colorado pikeminnow are sampled by using a seine in backwaters (zero velocity habitat) in four large reaches of the Green and Colorado Rivers during the fall. Subadult and adult Colorado pikeminnow are sampled by electrofishing in 13 reaches of the Yampa, Green, White, and Colorado Rivers during April or May. Humpback chubs are monitored less intensively every 3 years in Black Rocks and Westwater Canyons of the Colorado River. Trammel nets are used in the early fall to sample subadult/adults. More recently, ISMP has been expanded to estimate population sizes. A population estimate of Colorado pikeminnow in the upper Colorado River was around 600 adults in 1991-1994 (Osmundson and Burnham 1996); a preliminary estimate conducted in 1998 yielded over 700 adults (USFWS unpublished data). Preliminary population estimates for humpback chub are 1,500 adults in Black Rocks (Pfeifer et al. 1998) and approximately 7,000 adults in Westwater Canyon. A basin wide razorback sucker monitoring plan has been developed and will include reaches of the Colorado River coincident with augmentation of these populations. Monitoring will continue until the fish are delisted.

The Service anticipates the implementation of the Recovery Actions will provide a positive population response for each species. Information from the ISMP will be used to determine population responses. Population status and trends will be determined by the population indicators outlined in Appendix D. The Recovery Program is currently developing recovery goals for the four endangered fish species. If a population meets or exceeds the recovery goals or the goals described in Appendix D for that species, it will be considered to exhibit a positive

population response. However, until these recovery goals are established, trends in certain population indices (Appendix D) will provide an interim assessment of a species' progress toward recovery.

6. Long-Term Funding

The Recovery Program participants will pursue and support introduction of long-term funding legislation in the Senate and House of Representatives during the 106th Congress. The legislation is to authorize cost shared funding for both the San Juan River and Colorado River Recovery Programs. The purpose of the legislation is to authorize and provide funding for the implementation of all the Recovery Activities of the Recovery Program within the currently established time schedule. This legislation is essential to the implementation of the Recovery Actions described above. The legislation will include authorization for both capital and base funding.

The Recovery Program participants also will continue to pursue and support annual Federal and State appropriations and revenues, as needed, that fund full implementation of the Recovery Actions identified within this opinion. This includes both capital funding and annual base funding.

Capital funding is for planning, design, permitting or other compliance, construction, construction management, replacement of facilities, and the acquisition of interests in land or water, as necessary to carry out the Recovery Program. These capital items include hatchery additions for the genetic conservation and propagation of the endangered fishes, the restoration of floodplain habitat, fish passage, acquisition of water for instream flows (water leases), and the removal or translocation of nonnative fishes. Capital funding of up to $62,000,000 for the Recovery Program is to continue through the year 2005. These activities are substantially cost shared with non-Federal contributions by Upper Basin States and power users.

Base funding is for the operation and maintenance of capital projects, implementation of Recovery Actions other than capital projects, monitoring and research to evaluate the need for or effectiveness of any recovery action, and program management, as necessary to carry out the Recovery Program. Base funding also includes annual funding provided by the Service, Reclamation, Colorado, Utah, and Wyoming under the terms of the 1988 Cooperative Agreement. Base funding for the Recovery Program from power revenues will be up to $4,000,000 per year, adjusted for inflation.

Existing and New Depletions

Existing depletions anticipated to continue into the future, addressed in this biological opinion, consist of Reclamation and non-Federal depletions as described in the Federal action on page 1. Existing project depletions are defined below. Only the amount of water that was depleted as of September 30, 1995, is considered an existing use or depletion of water, except as defined for Green Mountain and Ruedi Reservoirs below. Project depletions above this level are considered

"new" depletions. This would include depletions from new, as yet unbuilt projects, and additional depletion occurring after September 30, 1995, from existing projects. Existing depletions shall remain characterized as "existing depletions" regardless of any subsequent change, exchange, or abandonment of the water rights resulting in such depletions. Also, existing depletions transferred to other facilities remain existing depletions so long as there is no increase in the amount of total depletions attributable to existing depletions.

Existing depletions are defined as follows[2]:

> a) existing depletions anticipated to continue into the future from the Upper Colorado River Basin above the confluence with the Gunnison River are those that actually occurred on or before September 30, 1995 (approximately 1 million acre-feet/year);
>
> b) depletions associated with the total 154,645 acre-feet volume of Green Mountain Reservoir, including the power pool (which includes but is not limited to all of the 20,000 acre-feet contract pool and Historic User's Pool), and the Colorado Big-Thompson Project replacement pool; and
>
> c) depletions associated with Ruedi Reservoir including but not limited to, Round I sales of 7,850 acre-feet, Round II sales of 17,000 acre-feet as discussed in the Service's biological opinion to Reclamation dated May 26, 1995, and as amended on January 6, 1999, and the Fryingpan Arkansas Project replacement pool as governed by the operating principles for Ruedi Reservoir, but excluding 21,650 acre-feet from the marketable yield.

New depletions are defined as average annual depletions from new or existing projects occurring after September 30, 1995, and excludes existing depletions as defined above. New depletions will be calculated as a 10 year moving average as determined by the CWCB and reported to the Service and Recovery Program by January 1 of every odd numbered year (beginning January 1, 2001) as described in Appendix B.

Water users that choose to use the implementation of Recovery Actions under the Recovery Program for Endangered Species Act compliance will be required to sign a Recovery Agreement (Appendix E), except Reclamation will not be required to sign these agreements as discussed later in this opinion. In the Recovery Agreements, individual water users will agree not to take any action which would probably prevent the implementation of the recovery actions of the Recovery Program and to take reasonable actions required to implement the recovery actions. The Service anticipates that water user entities controlling a majority of existing depletions above the Gunnison River will sign Recovery Agreements within 120 days of issuance of this biological opinion, pending review of the opinion and approval of the recovery agreement by their governing

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[2]This definition is for the purpose of defining depletions, a part of the Federal action subject to consultation, and includes as "existing depletions" some water from Reclamation facilities that is not currently being depleted or water that has not actually been depleted.

bodies. Signing of the Recovery Agreement will indicate support for the implementation of recovery actions identified in this opinion, and will provide immediate coverage to those water users for incidental take. If water users choose not to sign a recovery agreement, they could not rely on the Recovery Program for Endangered Species Act compliance. Reasonable and prudent alternatives outside the Recovery Program would have to be developed.

Monetary charges for projects to fund Recovery Actions which choose to rely on the Recovery Program will be assessed consistent with documents establishing the Recovery Program (USFWS 1987). Existing and future Reclamation projects remain exempt from the charge because they contribute annually to the Recovery Program. All other new project proponents undergoing individual section 7 consultations for depletions greater than 100 acre-feet/year are to pay the 1-time charge. New projects pay 10 percent at the time Federal funds or authorizations are obtained and the remainder prior to depletions occurring. Existing projects are to pay the charge for new depletions which have occurred since January 22, 1988. As additional new depletions occur from existing facilities that will have undergone section 7 in accordance with this biological opinion, a depletion charge will be assessed and paid prior to the actual depletion.

The Service will continue to work with proponents of new water projects to minimize project impacts and look for mutually agreeable opportunities to provide conditions that benefit the endangered fishes. The Service intends to coordinate with the lead Federal Agency during the National Environmental Policy Act process and conduct informal section 7 consultation, as appropriate. This will reduce the likelihood of reinitiation of consultation on existing and other new projects that precede the subject project.

STATUS OF THE SPECIES AND CRITICAL HABITAT

Colorado Pikeminnow

Species/Critical Habitat Description

The Colorado pikeminnow is the largest cyprinid fish (minnow family) native to North America and it evolved as the main predator in the Colorado River system. It is an elongated pike-like fish that during predevelopment times, may have grown as large as 6 feet in length and weighed nearly 100 pounds (Behnke and Benson 1983). Today, fish rarely exceed 3 feet in length or weigh more than 18 pounds; such fish are estimated to be 45-55 years old (Osmundson et al. 1997). The mouth of this species is large and nearly horizontal with long slender pharyngeal teeth (located in the throat), adapted for grasping and holding prey. The diet of Colorado pikeminnow longer than 3 or 4 inches consists almost entirely of other fishes (Vanicek and Kramer 1969). Males become sexually mature earlier and at a smaller size than do females, though all are mature by about age 7 and 500 mm (20 inches) in length (Vanicek and Kramer 1969, Seethaler 1978, Hamman 1981). Adults are strongly countershaded with a dark, olive back, and a white belly. Young are silvery and usually have a dark, wedge-shaped spot at the base of the caudal fin.

Based on early fish collection records, archaeological finds, and other observations, the Colorado pikeminnow was once found throughout warmwater reaches of the entire Colorado River Basin down to the Gulf of California, and including reaches of the upper Colorado River and its major tributaries, the Green River and its major tributaries, and the Gila River system in Arizona (Seethaler 1978). Colorado pikeminnow apparently were never found in colder, headwater areas. Seethaler (1978) indicates that the species was abundant in suitable habitat throughout the entire Colorado River Basin prior to the 1850's. No historic records exist that would indicate how far upstream Colorado pikeminnow once occurred in the Colorado River. The only reliable account of the species occurring upstream of the Price Stubb Dam near Palisade, Colorado, is from a Service biologist who reports having captured Colorado pikeminnow 2-3 miles up Plateau Creek while angling there around 1960 (Bob Burdick pers. com.).

Critical habitat was designated in 1994 within the 100-year floodplain of the Colorado pikeminnow's historical range in the following area of the upper Colorado River (59 F.R. 13374).

Colorado, Mesa and Garfield Counties; and Utah, Grand, San Juan, Wayne, and Garfield Counties. The Colorado River and its 100-year floodplain from the Colorado River Bridge at exit 90 north off Interstate 70 in T. 6 S., R. 93 W., section 16 (6th Principal Meridian) to North Wash, including the Dirty Devil arm of Lake Powell up to the full pool elevation, in T. 33 S., R. 14 E., section 29 (Salt Lake Meridian).

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of critical habitat. This includes a quantity of water of sufficient quality that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment.

Status and Distribution

Colorado pikeminnow were historically distributed throughout warmwater reaches of the Colorado River Basin from Wyoming and Colorado south to the Gulf of California. By the 1970's they were extirpated from the entire lower basin (downstream of Glen Canyon Dam) and from portions of the upper basin as a result of major alterations to the riverine environment. Having lost some 75-80 percent of its former range, the Colorado pikeminnow was federally listed as an endangered species in 1967 (Miller 1961, Moyle 1976, Tyus 1991, Osmundson and Burnham 1998).

Colorado pikeminnow are presently restricted to the Upper Colorado River Basin and inhabit warmwater reaches of the Colorado, Green, and San Juan Rivers and associated tributaries. The

species inhabits about 350 miles of the mainstem Green River from its confluence with the Colorado River upstream to the mouth of the Yampa River. In the Yampa River, its range extends upstream an additional 160 miles. Colorado pikeminnow also occur in the lowermost 104 miles of the White River, another tributary to the Green River. In the mainstem Colorado River, distribution of the species extends 201 miles upstream from the upper end of Lake Powell to Palisade, Colorado (Tyus 1982).

Major declines in Colorado pikeminnow populations occurred during the dam-building era of the 1930's through the 1960's. Behnke and Benson (1983) summarized the decline of the natural ecosystem, pointing out that dams, impoundments, and water use practices drastically modified the river's natural hydrology and channel characteristics throughout the Colorado River Basin. Dams on the mainstem broke the natural continuum of the river ecosystem into a series of disjunct segments, blocking native fish migrations, reducing temperatures downstream of dams, creating lacustrine habitat, and providing conditions that allowed competitive and predatory nonnative fishes to thrive both within the impounded reservoirs and in the modified river segments that connect them. The highly modified flow regime in the lower basin coupled with the introduction of nonnative fishes decimated populations of native fish.

Major declines of native fishes first occurred in the lower basin where large dams were constructed from the 1930's through the 1960's. In the upper basin, the following major dams were not constructed until the 1960's: Glen Canyon Dam on the mainstem Colorado River, Flaming Gorge Dam on the Green River, Navajo Dam on the San Juan River, and the Aspinall Unit Dams on the Gunnison River. To date, some native fish populations in the Upper Basin have managed to persist, while others have become nearly extirpated. River segments where native fish have declined more slowly than in other areas are those where the hydrologic regime most closely resembles the natural condition, where adequate habitat for all life phases still exists, and where migration corridors are unblocked and allow connectivity among life phases.

In the mainstem Colorado River, the magnitude of spring flows has declined by 30-45 percent since the early part of the century (Osmundson and Kaeding 1991, Van Steeter 1996, Pitlick et al. 1999). Such flow reduction negatively affects Colorado pikeminnow in four ways: (1) reducing the river's ability to build and clean cobble bars for spawning; (2) reducing the dilution effect for waterborne contaminants from urban and agricultural sources that may interfere with reproductive success; (3) reducing the connectivity of main-channel and bottomland habitats needed for habitat diversity and productivity; and (4) providing a more benign environment for nonnative fish and invasive nonnative, bank-stabilizing shrubs (salt cedar) to persist and flourish (Osmundson and Burnham 1998). In general, the existing habitat has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering.

Osmundson and Burnham (1998) summarized the status and trend of the Colorado River population of Colorado pikeminnow. They found that numbers were low but new individuals were actively recruiting to the adult population, and recruitment largely occurs in pulses from infrequent strong year classes. These investigators concluded that low adult numbers and

infrequent pulsed recruitment make this population vulnerable to extirpation over time from both natural fluctuations in numbers as well as from continued changes in habitat.

Life History

The life-history phases that appear to be most critical for the Colorado pikeminnow include spawning, egg hatching, development of larvae, and the first year of life. These phases of Colorado pikeminnow development are tied closely to specific habitat requirements. Natural spawning of Colorado pikeminnow is initiated on the descending limb of the annual hydrograph as water temperatures approach or exceed 20° C (Vanicek and Kramer 1969, Hamman 1981, Haynes et al. 1984, Tyus 1990, McAda and Kaeding 1991). Temperature at initiation of spawning varies somewhat by river: in the Green River, spawning begins as temperatures exceed 20-23° C; in the Yampa River, 16-23° C (Bestgen et al. 1998); in the Colorado River, 18-22° C (McAda and Kaeding 1991). Spawning, both in the hatchery and under natural riverine conditions, generally occurs in a 2-month time frame between late June and late August. However, in the natural system, sustained high flows during wet years may suppress river temperatures and extend spawning into September (McAda and Kaeding 1991). Conversely, during low flow years, when the water warms earlier, spawning may commence in mid-June.

Temperature also has an effect on egg development and hatching success. In the laboratory, egg development was tested at five temperatures and hatching success was found to be highest at 20° C, lower at 25° C, and mortality was 100 percent at 5, 10, 15, and 30° C. In addition, larval abnormalities were twice as high at 25° C than at 20° C (Marsh 1985).

Experimental tests of temperature preference of yearling (Black and Bulkley 1985a) and adult (Bulkley et al. 1981) Colorado pikeminnow indicated that 25° C was the most preferred temperature for both life phases. Additional experiments indicated that optimum growth of yearling Colorado pikeminnow also occurs at temperatures near 25° C (Black and Bulkley 1985b). Although no such tests were conducted using adults, the tests with yearlings supported the conclusions of Jobling (1981) that the final thermal preferendum provides a good indication of optimum growth temperature, i.e., 25° C.

Most information on Colorado pikeminnow reproduction was gathered from spawning sites on the lower 20 miles of the Yampa River and in Gray Canyon on the Green River (Tyus and McAda 1984; Tyus 1985; Wick et al 1985; Tyus 1990). Colorado pikeminnow spawn after peak runoff subsides and is probably triggered by several interacting variables such as photoperiod, temperature, flow level, and perhaps substrate characteristics. Spawning generally occurs from late June to mid-August with peak activity occurring when water temperatures are between 18° and 23° C (Haynes et al. 1984; Archer et al. 1985; Tyus 1990, Bestgen et al. 1998).

Spawning has been confirmed in the Colorado River by the presence of Colorado pikeminnow larvae in all years sampled. Larvae are distributed throughout the river although most have been

found downstream of Grand Junction (McAda and Kaeding 1991, Osmundson and Burnham 1998). Aggregations of ripe adults have been found near Clifton and Grand Junction, Colorado and near the Colorado-Utah state line (Osmundson and Kaeding 1989, McAda and Kaeding 1991, USFWS unpublished data). Suitable spawning habitat (defined below) in the Colorado River near Cataract Canyon, Professor Valley, and upstream from the Dolores River confluence indicate spawning may occur in or near these areas as well (Archer et al. 1985; Valdez 1990).

Known spawning sites in the Yampa River are characterized by riffles or shallow runs with well-washed coarse substrate (cobble containing relatively deep interstitial voids (for egg deposition) in association with deep pools or areas of slow laminar flow used as staging areas by adults (Lamarra et al. 1985, Tyus 1990). Recent investigations at a spawning site in the San Juan River by Bliesner and Lamarra (1995) and at one in the upper Colorado River (USFWS unpublished data) indicate a similar association of habitats. The most unique feature at the sites actually used for spawning, in comparison with otherwise similar sites nearby, is the degree of looseness of the cobble substrate and the depth to which the rocks are devoid of fine sediments; this appears consistent at the sites in all three rivers (Lamarra et al. 1985, Bliesner and Lamarra 1995).

Data indicates that clean cobble substrates that provide interstitial spaces for eggs are necessary for spawning and egg incubation (Tyus and Karp 1989). Several studies on the cobble cleaning process have been conducted at a known spawning location in Yampa Canyon. O'Brien (1984) studied the hydraulic and sediment transport dynamics of the cobble bar within the Yampa River spawning site and duplicated some of its characteristics in a laboratory flume study. O'Brien (1984) concluded that incipient motion of the cobble bed is required to clean cobbles for spawning and estimated that this takes discharges of about 21,500 cfs. However, Harvey et al. (1993) concluded that since flows required for incipient motion of bed material are rare (20 year return period event) and spawning occurs annually, another process must be cleaning the cobbles. Their study found that in Yampa Canyon recessional flows routinely dissect gravel bars and thereby produce tertiary bars of clean cobble at the base of the riffles. These tertiary bars are used by Colorado pikeminnow for spawning. The importance of high magnitude, low frequency discharges is in forming and maintaining the midchannel bars. Dissection of bars without redeposition by high magnitude flows would lead to conditions where spawning habitat is no longer available (Harvey et al. 1993).

It is unknown whether tertiary bars similar to those used for Colorado pikeminnow spawning in Yampa Canyon are available in the 15-Mile Reach of the Colorado River. There, significant motion of bed material occurs at near bankfull discharge of 22,000 cfs (Van Steeter 1996). These flows occur on average once in 4 years. Van Steeter (1996) concluded that flows of this magnitude are important because they generally remove fine sediment from the gravel matrix which maintains the invertebrate community and cleans spawning substrate.

Although the location of spawning areas in the Colorado River is not as defined as in the Yampa River, the annual presence of larvae and young-of-the-year downstream of the Walker Wildlife

Area, in the Loma to Black Rocks reach and near the confluence of the Dolores River, demonstrates that spawning occurs every year. Osmundson and Kaeding (1989, 1991) reported that water temperatures in the Grand Junction area were suitable for Colorado pikeminnow spawning. In 1986, a year of high runoff, suitable temperatures for spawning (20° C) occurred in mid-August; in 1989, a year of low runoff, the mean temperature reached 20° C during the last week of June. Tyus (1990) demonstrated that Colorado pikeminnow often migrate considerable distances to spawn in the Green and Yampa Rivers, and similar though more limited movement has been noted in the mainstem Colorado River (McAda and Kaeding 1991).

Collections of larvae and young-of-year downstream of known spawning sites in the Green and Yampa Rivers indicates that downstream drift of larval Colorado pikeminnow occurs following hatching (Haynes et al. 1984; Nesler et al. 1988; Tyus 1990, Tyus and Haines 1991). During their first year of life, Colorado pikeminnow prefer warm, turbid, relatively deep (averaging 1.3 feet) backwater areas of zero velocity (Tyus and Haines 1991). After about 1 year, young are rarely found in such habitats, though juveniles and subadults are often located in large deep backwaters during spring runoff (USFWS, unpublished data; Osmundson and Burnham 1998).

Larval Colorado pikeminnow have been collected in the Gunnison River up- and downstream of the Redlands Diversion Dam (Anderson 1998; Osmundson and Burnham 1998). Burdick (1997) reports that the capture of larval Colorado pikeminnow in 1995 and 1996 upstream of the Redlands Diversion Dam coupled with aggregations of adult fish during the spawning season confirms that spawning occurs upstream of the dam.

Information on radio-tagged adult Colorado pikeminnow during fall suggests that fish seek out deep water areas in the Colorado River (Miller et al. 1982, Osmundson and Kaeding 1989), as do many other riverine species. River pools, runs, and other deep water areas, especially in upstream reaches, are important winter habitats for Colorado pikeminnow (Osmundson et al. 1995).

Very little information is available on the influence of turbidity on the endangered Colorado River fishes. Osmundson and Kaeding (1989) found that turbidity allows use of relatively shallow habitats ostensibly by providing adults with needed cover; this allows foraging and resting in areas otherwise exposed to avian or land predators. Tyus and Haines (1991) found that young Colorado pikeminnow in the Green River preferred backwaters that were turbid. Clear conditions in these shallow waters might expose young fish to predation from wading birds or introduced, sight-feeding, piscivorous fish. It is unknown whether the river was as turbid in the past as it is today. For now, it is assumed that these endemic fishes evolved under natural conditions of high turbidity; therefore the retention of these highly turbid conditions is probably an important factor in maintaining the ability of these fish to compete with nonnatives that may not have evolved under similar conditions.

Population Dynamics

Osmundson and Burnham (1998) estimated the population of adult and subadult Colorado

pikeminnow in the Colorado River (from Palisade to the confluence with the Green River) to be 600-650 individuals during 1991-1994. This estimate equates to an average of 4.0-4.2 fish per mile above Westwater Canyon, and 3.1-3.4 fish per mile below Westwater Canyon but the fish are not distributed equally in all parts of the river. Preliminary estimates from a 1998 survey indicate that the population has increased to about 750 subadults and adults in the Colorado River (USFWS unpublished data).

Colorado pikeminnow reproduce each year; however, strong year classes are relatively rare (Osmundson and Burnham 1998). A distinct increase of subadult fish was found below Moab in 1991 and within a few years these fish were distributed throughout the Colorado River. Osmundson and Burnham (1998) concluded that these fish were the result of one or more strong year classes produced during the mid-1980's. McAda and Ryel (1999) have identified another strong year-class that occurred in 1996. In both cases, the common hydrologic conditions that led to successful reproduction and first year survival was a spring and summer of moderately high flows following a year of exceptionally high flood flows (McAda and Ryel 1999).

Analysis of Species/Critical Habitat Likely to be Affected

The Grand Valley area is occupied year round by Colorado pikeminnow. The 15-Mile Reach is the section of the Colorado River extending from the confluence of the Gunnison River upstream to the Grand Valley Irrigation Company Diversion Dam. It has been identified as important habitat for Colorado pikeminnow. Not only are densities of pikeminnow especially high there (Figure 1), but the average size of the fish there is larger than in any other portion of the Colorado River (Figure 2).

Radio-telemetry studies show upstream and downstream movement of adult Colorado pikeminnow in the mainstem Colorado River (McAda and Kaeding 1991). The most dramatic movement was exhibited by a fish implanted with a radio transmitter at Gypsum Canyon in upper Lake Powell on April 5, 1982. The fish was contacted next in the lower Cataract Canyon area on July 9, 1982. The next contact was made above the Black Rocks area of Ruby Canyon, some 160 miles upstream. The movement was accomplished in 41 days and is believed to be related to spawning. At the end of September 1982, this fish was located in the 15-Mile Reach (river mile 178), nearly 200 river miles from its furthest documented downstream location.

Other radio-tagged fish in the Colorado River have not displayed such dramatic migratory behavior. Radio-telemetry studies conducted during 1982-1989, which focused on upstream reaches of the Colorado River in and around the Grand Valley, provide the best indication of use of the 15-Mile Reach above the confluence of the Gunnison River. Movement of these fish during a field season was generally limited to 25-30 miles (Osmundson and Kaeding 1989, McAda and Kaeding 1991).

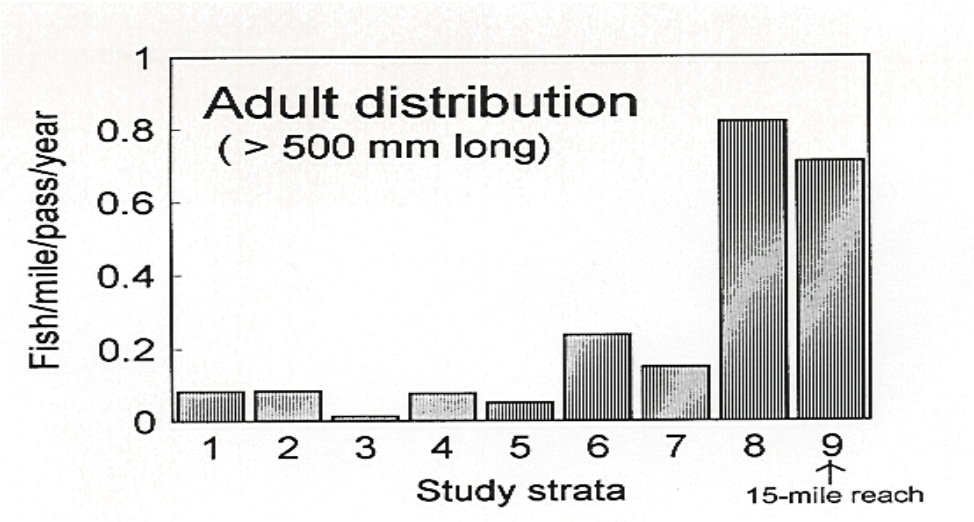


Figure 1. Distribution of adult Colorado pikeminnow (>500 mm long) in the Colorado River. Catch rates (fish per mile) were averaged across sampling (electrofishing and trammel netting) passes in each year and these values from 5 years (1991-1994 and 1998) were averaged. See Osmundson and Burnham (1998) for sampling methodology and Osmundson (1999) for strata locations. The 15-Mile Reach is strata 9.

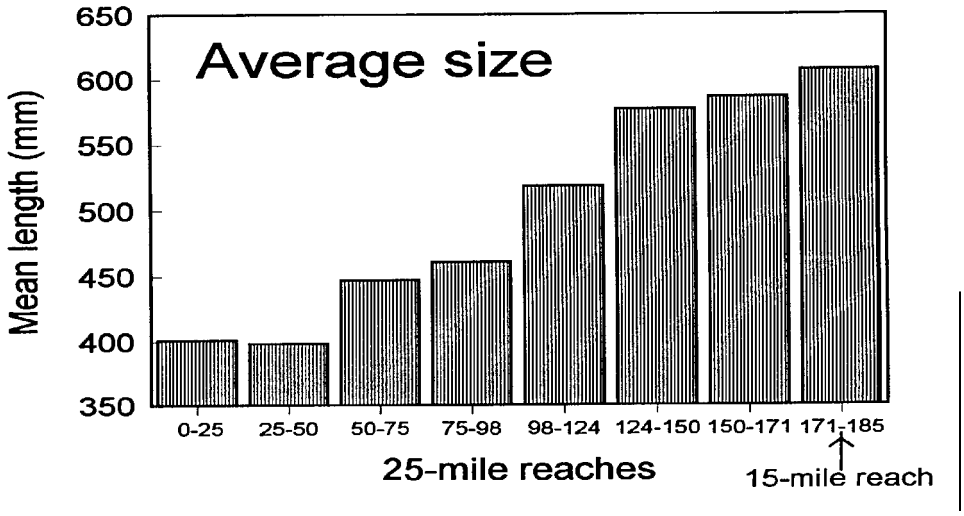


Figure 2. Size distribution of subadult and adult Colorado pikeminnow in the Colorado River based on electrofishing and trammel netting results. Lengths were averaged by 25-Mile Reach within years and reach means were then averaged across years (1991-1994 and 1998). The 15-Mile Reach is miles 171 - 185.

During 1986-1988, 17 adult Colorado pikeminnow were captured in the 15-Mile Reach during April-June and radio-tagged. The fish exhibited a diversity of localized movements throughout the Grand Valley but spent a major part of their time in the 15-Mile Reach. Two remained in the reach throughout the estimated spawning period (Osmundson and Kaeding 1989).

In a study by McAda and Kaeding (1991), a suspected prespawning aggregation of adult Colorado pikeminnow was observed in mid-July of 1982 at river mile 178.3 in the 15-Mile Reach. In the first observation, three radio-tagged fish were tracked to one riverine pool area, and nine adults at or near spawning condition were then captured there after limited net sampling efforts. The aggregation occurred a few days after mean daily water temperature had reached 20° C and during a time when runoff flows were dropping off sharply. A second aggregation was noted at river mile 175.3, 12 days after the initial observation. Drifting trammel nets through an area occupied by two fish equipped with transmitters yielded an additional male Colorado pikeminnow in spawning condition. During this same time period, an adult female was captured near river mile 175 that weighed nearly 1 pound more than when previously captured a month earlier, suggesting the development of spawning (gravid) condition. Two Colorado pikeminnow larvae were subsequently collected within the 15-Mile Reach.

During 4 years (1982-1985) of larval sampling throughout the Grand Valley, 100 larval pikeminnow were collected with fine-mesh hand nets from the two Colorado River reaches immediately upstream and downstream of its confluence with the Gunnison River (McAda and Kaeding 1991). Although the sampling effort was similar in the two river reaches, 98 percent of the larval captures occurred downstream of the Gunnison River confluence. Only two (2 percent) of the larvae were collected from the upstream reach. These observations may indicate that most fish were spawned in the downstream reach or that the larvae were deposited in the upstream reach and drifted downstream to the area where most of the captures were recorded. In 1995, drift nets set in the lower portion of the 15-Mile Reach captured 3 Colorado pikeminnow larvae (Anderson 1998).

No postlarval young-of-year Colorado pikeminnow greater than 25 mm total length were collected from above the Gunnison River confluence in fall collections from 1986-1994; however, one yearling-sized individual was captured there in 1986 (Osmundson and Burnham 1998). A total of 122 Colorado pikeminnow were collected in the 31-Mile Reach downstream of the confluence of the Gunnison River during 1982-1996 (McAda and Ryel 1999). The 1982-1984 catch rate of young-of-year Colorado pikeminnow in the 10-Mile Reach immediately downstream of the confluence of the Gunnison River (river miles 160-170) warranted classification of this reach as a "Young-of-Year Nursery Area" by the Basin Biology Subcommittee (USFWS 1984).

Catch rates of adult (> 500 mm long) Colorado pikeminnow in the 15- and 18-Mile Reaches of the Grand Valley are significantly higher than in any other portion of the Colorado River (Figure 1). In the 15-Mile Reach, adults are most abundant during spring in a 1.3-mile segment between river miles 174.4 and 175.7, particularly in two gravel-pit ponds that were accessible

during high flows. Some of the pikeminnow captured from one pond in 1986 were well tuberculated by June 3, when nearby river temperatures were only 10-13° C (L. Kaeding pers. com.). It has been hypothesized by some investigators that additional thermal units, above those provided in the mainstream, are important in increasing annual growth rates and perhaps in gonadal maturation. If this is true, then access to these sheltered off-channel pools may be very important in increasing rates of survival and successful spawning in the upper reaches of the Colorado River. Historically, bottomlands that routinely flooded during the spring runoff period would have provided these warm productive habitats; in recent years, flooded gravel pits may provide the only comparable habitat.

Although the river downstream of the Grand Valley also supports adult Colorado pikeminnow, the primary importance of these downstream reaches is in providing nursery areas for larvae and rearing areas for juveniles. Concentrations of larvae and young-of-year occur in backwaters in the 65-mile, low-gradient reach between Moab, Utah, and the confluence with the Green River (McAda et al. 1994). These backwaters are especially important during the Colorado pikeminnow's critical first year of life. Juveniles dwell in these downstream reaches until they are 5 or more years old. Then many begin extensive upstream migrations seeking habitats more suited to needs of subadults and adults (Osmundson et al. 1998). The entire river, from the confluence with the Green River upstream to Palisade, Colorado, provides important habitat for sub- and young adults.

Razorback Sucker

Species/Critical Habitat Description

The razorback sucker, an endemic species unique to the Colorado River Basin, was historically abundant and widely distributed within warmwater reaches throughout the Colorado River Basin. The razorback sucker is the only sucker with an abrupt sharp-edged dorsal keel behind its head. It has a large fleshy subterminal mouth that is typical of most suckers. Adults often exceed 3 kg (6 pounds) in weight and 600 mm (2 feet) in length.

Historically, razorback suckers were found in the mainstem Colorado River and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming, and in Mexico (Ellis 1914; Minckley 1983). Bestgen (1990) reported that this species was once so numerous that it was commonly used as food by early settlers and, further, that commercially marketable quantities were caught in Arizona as recently as 1949. In the Upper Basin, razorback suckers were reported in the Green River to be very abundant near Green River, Utah, in the late 1800's (Jordan 1891). An account in Osmundson and Kaeding (1989) reported that residents living along the Colorado River near Clifton, Colorado, observed several thousand razorback suckers during spring runoff in the 1930's and early 1940's. In the San Juan River drainage, Platania and Young (1989) relayed historical accounts of razorback suckers ascending the Animas River to Durango, Colorado, around the turn of the century.

A marked decline in populations of razorback suckers can be attributed to construction of dams and reservoirs, introduction of nonnative fishes, and removal of large quantities of water from the Colorado River system. Dams on the mainstem Colorado River and its major tributaries have segmented the river system, blocking migration routes. Dams also have drastically altered flows, temperatures, and channel geomorphology. These changes have modified habitats in many areas so that they are no longer suitable for breeding, feeding, or sheltering. Major changes in species composition have occurred due to the introduction of numerous nonnative fishes, many of which have thrived due to man-induced changes to the natural riverine system.

Critical habitat was designated in 1994 within the 100-year floodplain of the razorback sucker's historical range in the following area of the upper Colorado River (59 F.R. 13374). The primary constituent elements are the same as critical habitat for Colorado pikeminnow described previously.

> Colorado, Mesa and Garfield Counties. The Colorado River and its 100-year floodplain from Colorado River Bridge at exit 90 north off Interstate 70 in T. 6 S., R. 93 W., section 16 (6th Principal Meridian) to Westwater Canyon in T. 20 S., R. 25 E., section 12 (Salt Lake Meridian) including the Gunnison River and its 100-year floodplain from the Redlands Diversion Dam in T. 1 S., R. 1 W., section 27 (Ute Meridian) to the confluence with the Colorado River in T. 1 S., R. 1 W., section 22 (Ute Meridian).
>
> Colorado, Delta and Mesa Counties. The Gunnison River and its 100-year floodplain from the confluence with the Uncompahgre River in T. 15 S., R. 96 W., section 11 (6th Principal Meridian) to Redlands Diversion Dam in T. 1 S., R. 1 W., section 27 (Ute Meridian).
>
> Utah, Grand, San Juan, Wayne, and Garfield Counties. The Colorado River and its 100-year floodplain from Westwater Canyon in T. 20 S., R. 25 E., section 12 (Salt Lake Meridian) to full pool elevation, upstream of North Wash, and including the Dirty Devil arm of Lake Powell in T. 33 S., R. 14 E., section 29 (Salt Lake Meridian).

Status and Distribution

The current distribution and abundance of the razorback sucker have been significantly reduced throughout the Colorado River system, due to lack of recruitment to the adult population (McAda 1987; McAda and Wydoski 1980; Holden and Stalnaker 1975; Minckley 1983; Marsh and Minckley 1989; Tyus 1987). The only substantial population exists in Lake Mohave with an estimated population of 25,000 adult razorback suckers in 1995 (Chuck Minckley pers. com.) down from an earlier estimate of 60,000 adult razorback suckers (Minckley et al. 1991). They do not appear to be successfully recruiting. While limited numbers of razorback suckers persist in other locations in the lower Colorado River, they are considered rare or incidental and may be continuing to decline.

In the Upper Basin, above Glen Canyon Dam, razorback suckers are found in limited numbers in both lentic and lotic environments. The largest population of razorback suckers in the Upper Basin is found in the upper Green River and lower Yampa River (Tyus 1987). Lanigan and Tyus (1989) estimated that from 758 to 1,138 razorback suckers inhabit the upper Green River. Modde et al. (1996) report no significant decrease in the population between 1982 and 1992, and the continued presence of fish smaller than 480 mm during the study period suggest some level of recruitment. In the Colorado River, most razorback suckers occur in the Grand Valley area near Grand Junction, Colorado; however, they are increasingly rare. Osmundson and Kaeding (1991) report that the number of razorback sucker captures in the Grand Junction area has declined dramatically since 1974. In 1991 and 1992, 28 adult razorback suckers were collected from isolated ponds adjacent to the Colorado River near De Beque, Colorado (Burdick 1992). The existing habitat has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering.

Razorback suckers are in imminent danger of extirpation in the wild. The razorback sucker was listed as endangered October 23, 1991 (56 FR 54957). As Bestgen (1990) pointed out:

> "Reasons for decline of most native fishes in the Colorado River Basin have been attributed to habitat loss due to construction of mainstream dams and subsequent interruption or alteration of natural flow and physio-chemical regimes, inundation of river reaches by reservoirs, channelization, water quality degradation, introduction of nonnative fish species and resulting competitive interactions or predation, and other man-induced disturbances (Miller 1961, Joseph et al. 1977, Behnke and Benson 1983, Carlson and Muth 1989, Tyus and Karp 1989). These factors are almost certainly not mutually exclusive, therefore it is often difficult to determine exact cause and effect relationships."

The virtual absence of any recruitment suggests a combination of biological, physical, and/or chemical factors that may be affecting the survival and recruitment of early life stages of razorback suckers. Within the Upper Basin, recovery efforts endorsed by the Recovery Program include the capture and removal of razorback suckers from all known locations for genetic analyses and development of discrete brood stocks if necessary. These measures have been undertaken to develop refugia populations of the razorback sucker from the same genetic parentage as their wild counterparts such that, if these fish are genetically unique by subbasin or individual population, then separate stocks will be available for future augmentation. Such augmentation may be a necessary step to prevent the extinction of razorback suckers in the Upper Basin.

Life History

McAda and Wydoski (1980) and Tyus (1987) reported springtime aggregations of razorback suckers in off-channel habitats and tributaries; such aggregations are believed to be associated with reproductive activities. Tyus and Karp (1990) and Osmundson and Kaeding (1991) reported off-channel habitats to be much warmer than the mainstem river and that razorback suckers

presumably moved to these areas for feeding, resting, sexual maturation, spawning, and other activities associated with their reproductive cycle. Prior to construction of large mainstem dams and the suppression of spring peak flows, low velocity, off-channel habitats (seasonally flooded bottomlands and shorelines) were commonly available throughout the Upper Basin (Tyus and Karp 1989; Osmundson and Kaeding 1991). Dams changed riverine ecosystems into lakes by impounding water, which eliminated these off-channel habitats in reservoirs. Reduction in spring peak flows eliminates or reduces the frequency of inundation of off-channel habitats. The absence of these seasonally flooded riverine habitats is believed to be a limiting factor in the successful recruitment of razorback suckers in their native environment (Tyus and Karp 1989; Osmundson and Kaeding 1991). Wydoski and Wick (1998) identified starvation of larval razorback suckers due to low zooplankton densities in the main channel and loss of floodplain habitats which provide adequate zooplankton densities for larval food as one of the most important factors limiting recruitment.

While razorback suckers have never been directly observed spawning in turbid riverine environments within the Upper Basin, captures of ripe specimens, both males and females, have been recorded (Valdez et al. 1982; McAda and Wydoski 1980; Tyus 1987; Osmundson and Kaeding 1989; Tyus and Karp 1989; Tyus and Karp 1990; Osmundson and Kaeding 1991; Platania 1990) in the Yampa, Green, Colorado, and San Juan Rivers. Sexually mature razorback suckers are generally collected on the ascending limb of the hydrograph from mid-April through June and are associated with coarse gravel substrates (depending on the specific location).

Outside of the spawning season, adult razorback suckers occupy a variety of shoreline and main channel habitats including slow runs, shallow to deep pools, backwaters, eddies, and other relatively slow velocity areas associated with sand substrates (Tyus 1987; Tyus and Karp 1989; Osmundson and Kaeding 1989; Valdez and Masslich 1989; Osmundson and Kaeding 1991; Tyus and Karp 1990).

Habitat requirements of young and juvenile razorback suckers in the wild are not well known, particularly in native riverine environments. Prior to 1991, the last confirmed documentation of a razorback sucker juvenile in the Upper Basin was a capture in the Colorado River near Moab, Utah (Taba et al. 1965). In 1991, two early juvenile (36.6 and 39.3 mm TL) razorback suckers were collected in the lower Green River near Hell Roaring Canyon (Gutermuth et al. 1994). Juvenile razorback suckers have been collected in recent years from Old Charley Wash, a wetland adjacent to the Green River (Modde 1996). Between 1992 and 1995 larval razorback suckers were collected in the middle and lower Green River and within the Colorado River inflow to Lake Powell (Muth 1995). No young razorback suckers have been collected in recent times in the Colorado River.

Populations Dynamics

There are no current population estimates of razorback sucker in the upper Colorado River due to low numbers captured in recent years.

Analysis of Species/Critical Habitat Likely to be Affected

Osmundson and Kaeding (1989) found that 76 percent of the razorback suckers captured in the Colorado River between 1979 and 1985 were captured in the Grand Valley area. Results of surveys conducted during May and June of 1986-1988 indicate that areas within the 15-Mile Reach may be concentration points for the razorback sucker during spring runoff. Male and female razorback suckers in spawning condition have been found in the 15-Mile Reach, although no larvae or juveniles have been found. Although data is limited, radio-telemetry studies led Osmundson and Kaeding (1989) to conclude that razorback suckers may move into the 15-Mile Reach to spawn in the spring, but most spend the remainder of the year in a 18-Mile Reach downstream from the confluence of the Gunnison River.

The current range of the razorback sucker in the Colorado River extends upstream to Rifle, Colorado. Most razorback suckers captured in the Grand Valley area have been located in flooded gravel-pit ponds adjacent to the river. However, Osmundson and Kaeding (1989) documented razorback sucker movement in various river habitats in the Grand Valley area. They documented razorback suckers in the 15-Mile Reach as far upstream as river mile 183.6. Additional surveys since 1988 have documented razorback suckers in riverside ponds as far upstream as river mile 235 near Rifle, Colorado (Burdick 1992).

Humpback Chub

Species/Critical Habitat Description

The humpback chub is a medium-sized freshwater fish (less than 500 mm) of the minnow family. The adults have a pronounced dorsal hump, a narrow flattened head, a fleshy snout with an inferior-subterminal mouth, and small eyes. It has silvery sides with a brown or olive colored back.

The humpback chub is endemic to the Colorado River Basin and is part of a native fish fauna traced to the Miocene epoch in fossil records (Miller 1946; Minckley et al. 1986). Humpback chub remains have been dated to about 4000 B.C., but the fish was not described as a species until the 1940's (Miller 1946), presumably because of its restricted distribution in remote white water canyons (USFWS 1990b). Because of this, its original distribution is not known. The humpback chub was listed as endangered on March 11, 1967.

Until the 1950's, the humpback chub was known only from Grand Canyon. During surveys in the 1950's and 1960's humpback chub were found in the upper Green River including specimens from

Echo Park, Island Park, and Swallow Canyon (Smith 1960, Vanicek et al. 1970). Individuals were also reported from the lower Yampa River (Holden and Stalnaker 1975b), the White River in Utah (Sigler and Miller 1963), Desolation Canyon of the Green River (Holden and Stalnaker 1970) and the Colorado River near Moab (Sigler and Miller 1963).

Critical habitat was designated in 1994 within the humpback chub's historical range in the following sections of the upper Colorado River (59 F.R. 13374). The primary constituent elements are the same as those described for the Colorado pikeminnow.

> Utah, Grand County; and Colorado, Mesa County. The Colorado River from Black Rocks in T. 10 S., R. 104 W., section 25 (6th Principal Meridian) to Fish Ford in T. 21 S., R. 24 E., section 35 (Salt Lake Meridian).
>
> Utah, Garfield and San Juan Counties. The Colorado River from Brown Betty Rapid in T. 30 S., R. 18 E., section 34 (Salt Lake Meridian) to Imperial Canyon in T. 31 S., R. 17 E., section 28 (Salt Lake Meridian).

Status and Distribution

Today the largest populations of this species occur in the Little Colorado and Colorado Rivers in the Grand Canyon, and in Black Rocks and Westwater Canyon in the upper Colorado River. Other populations have been reported in De Beque Canyon of the Colorado River, Desolation and Gray Canyons of the Green River, Yampa and Whirlpool Canyons in Dinosaur National Monument (USFWS 1990b). One individual was recently captured in the Gunnison River (Burdick 1995).

In general, the existing habitat has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering.

Life History

It is known that these chubs spawn soon after the highest spring flows when water temperatures approach 68° F (Kaeding et al. 1990; Karp and Tyus 1990; USFWS 1990b). The collection of ripe and spent fish indicated that spawning occurred in Black Rocks during June 2-15, 1980, at water temperatures of 11.5° to 16° C; in 1981, spawning occurred May 15-25, at water temperatures of 16° to 16.3° C (Valdez et al. 1982). Humpback chub spawned in Black Rocks on the Colorado River in 1983 when maximum daily water temperatures were 12.6° to 17° C (Archer et al. 1985). In the Grand Canyon, humpback chub spawn in the spring between March and May in the Little Colorado River when water temperatures are between 16° and 22° C. Swimming abilities of young-of-year humpback chub were determined to be significantly reduced when laboratory water temperatures were reduced from 20° to 14° C. Many young-of-year humpback chub are displaced from the Little Colorado River into the mainstem by monsoonal floods from July through September (Valdez and Ryel 1995). Young humpback chub are found

in low velocity shorelines and backwaters. Survival rates are extremely low and believed to be less than 1 in 1,000 to 2 years of age. Low water temperatures and predation are believed to be the primary factors. Valdez and Ryel (1995) estimate that 250,000 young humpback chub are consumed by brown trout, rainbow trout, and channel catfish.

Backwaters, eddies, and runs have been reported as common capture locations for young-of-year humpback chub (Valdez and Clemmer 1982). These data indicate that in Black Rocks and Westwater Canyon, young utilize shallow areas. Habitat suitability index curves developed by Valdez et al. (1990) indicate young-of-year prefer average depths of 2.1 feet with a maximum of 5.1 feet. Average velocities were reported at 0.2 feet per second.

Population Dynamics

Based on data collected during the first year of a three year study, Pfeifer et al. (1998) estimated the Black Rocks populations to be about 1,500 adults (95 percent confidence interval 890-2,750). This estimate will undoubtedly be adjusted before the study is completed. Chart and Lentsch (1999) provided annual estimates for Westwater Canyon in 1994-1996 that ranged from 5,186 to 10,148 adults (mean of 6,985).

Analysis of Species/Critical Habitat Likely to be Affected

Valdez et al. (1982) and Wick et al. (1979, 1981) found adult humpback chub in Black Rocks and Westwater Canyons in water averaging 50 feet in depth with a maximum depth of 92 feet. In these localities, humpback chub were associated with large boulders and steep cliffs.

Generally, humpback chub show fidelity for canyon reaches and move very little (Miller et al. 1982; Archer et al. 1985; Burdick and Kaeding 1985; Kaeding et al. 1990). Movements of adult humpback chub in Black Rocks on the Colorado River were usually restricted to 1 mile or less. However, a few fish have moved between Black Rocks and Westwater Canyon, a distance of 14 miles (Valdez and Clemmer 1982, Kaeding et al. 1990, Chart and Lentsch 1999).

Bonytail

Species/Critical Habitat Description

Bonytail are medium-sized (less than 600 mm) fish in the minnow family. Adult bonytail are gray or olive colored on the back with silvery sides and a white belly. The adult bonytail has an elongated body with a long, thin caudal peduncle.

Critical habitat was designated in 1994 within the bonytail's historical range in the following sections of the upper Colorado River (59 F.R. 13374). The primary constituent elements are the same as those described for the Colorado pikeminnow.

Utah, Grand County; and Colorado, Mesa County. The Colorado River from Black Rocks (river mile 137) in T. 10 S., R. 104 W., section 25 (6th Principal Meridian) to Fish Ford in T. 21 S., R. 24 E., section 35 (Salt Lake Meridian).

Utah, Garfield and San Juan Counties. The Colorado River from Brown Betty Rapid in T. 30 S., R. 18 E., section 34 (Salt Lake Meridian) to Imperial Canyon in T. 31 S., R. 17 E., section 28 (Salt Lake Meridian).

Status and Distribution

The bonytail is the rarest native fish in the Colorado River. It was listed as endangered on April 23, 1980. Formerly reported as widespread and abundant in mainstem rivers (Jordan and Evermann 1896), its populations have been greatly reduced. The fish is presently represented in the wild by a low number of old adult fish in Lake Mohave and perhaps other lower basin reservoirs (USFWS 1990a). The last known riverine area where bonytail were common was the Green River in Dinosaur National Monument, where Vanicek (1967) and Holden and Stalnaker (1970) collected 91 specimens during 1962-1966. From 1977 to 1983, no bonytail were collected from the Colorado or Gunnison Rivers in Colorado or Utah (Wick et al. 1979, 1981; Valdez et al. 1982; Miller et al. 1984). However, in 1984, a single bonytail was collected from Black Rocks on the Colorado River (Kaeding et al. 1986). Several suspected bonytail were captured in Cataract Canyon in 1985-1987 (Valdez 1990).

The existing habitat has been modified to the extent that it impairs essential behavior patterns, such as breeding, feeding, and sheltering.

Life History

The bonytail is considered a species that is adapted to mainstem rivers, where it has been observed in pools and eddies (Vanicek 1967; Minckley 1973). Spawning of bonytail has never been observed in a river, but ripe fish were collected in Dinosaur National Monument during late June and early July suggesting that spawning occurred at water temperatures of about 18° C (Vanicek and Kramer 1969).

Population Dynamics

The number of bonytail in the upper Colorado River are so low that it is not possible to do a population estimate.

Analysis of Species/Critical Habitat Likely to be Affected

Black Rocks and Cataract Canyon are the only areas where bonytail have been found in the Upper Colorado River in the last 20 years. So few fish have been captured that it is difficult to determine species and habitat needs.

IMPORTANCE OF THE 15-MILE REACH

The Service finds that all four species and their critical habitat on the Colorado River are and will be affected by water depletions and recovery actions. However, the 15-Mile Reach is affected more than any of the other reaches by water depletions because it is located downstream of several large diversions and upstream of the Gunnison River confluence. Extremely low water conditions that occur during the late summer and early fall months reduce habitat for Colorado pikeminnow and razorback sucker. Reduced flows during spring runoff reduces the ability for many habitats to be created and maintained. Therefore, many of the recovery actions are targeted for the 15-Mile Reach. Colorado pikeminnow and razorback sucker occur in the 15-Mile Reach, humpback chub and bonytail currently are not known to occur there. The 15-Mile Reach is a particularly important section of river for Colorado pikeminnow and razorback sucker; it is critical to the recovery of each species' Colorado River populations (Osmundson 1999b). The following section summarizes the attributes of this reach and puts in context its importance in relation to the rest of the river.

Colorado pikeminnows require a variety of specific habitat types to fulfill their life history needs. Some of these required habitats are found only in certain areas of the river and are separated from other required habitats by long distances. The 15-Mile Reach provides spawning habitat; spawning by Colorado pikeminnow was documented within the 15-Mile Reach in 1982 and in 1995 by the capture of pikeminnow larvae. The cleaner cobble bars found in upstream reaches, such as the 15-Mile Reach, provide the most suitable sites for spawning. Larvae hatched from eggs deposited in these upstream reaches drift downstream with the current. In downstream reaches, primarily below Moab, Utah, deposits of silt and sand provide many warm backwater sites where young Colorado pikeminnow feed upon the abundant zooplankton and chironomid larvae. When they become piscivorous, young Colorado pikeminnow feed upon the abundant small fishes found in these areas.

Osmundson et al. 1995 reported that backwater area in the 15-Mile Reach is the greatest when the river is flowing around 7,620 cfs. Adult Colorado pikeminnow use backwaters in the 15-Mile Reach all year long, however, backwaters are used most frequently during spring runoff. Backwaters provide warm, off-channel, quiet water when main-channel velocities are high and temperatures are low (Osmundson et al. 1995).

Osmundson et al. (1998) documented the upstream dispersal of subadult and adult Colorado pikeminnow. As the young fish in the downstream nursery areas grow and approach adulthood, they require larger forage fish to maintain growth rates. However, larger forage fish are scarce in these downstream reaches and maturing Colorado pikeminnow begin to move up and down the river seeking better feeding grounds. Eventually, adult Colorado pikeminnow discover the abundant supplies of native fish, primarily bluehead and flannelmouth sucker, in the upper river including the 15-Mile Reach and remain in these upper reaches for the remainder of their lives. Forage fish are generally more abundant in these upper reaches because food for these fishes, algae and aquatic insects, is more abundant (Lamarra 1999). Algae, phytoplankton (free-floating

algae) and periphyton (algae that grows on rock surfaces), is more abundant because the higher water clarity allows deeper light penetration necessary for its growth. Aquatic insects are more abundant because the swifter currents resulting from generally higher gradients flush gravel and cobble substrates providing silt-free crevices required by many aquatic insects. Because of the increasing abundance of forage fish as one moves up river, the average size of Colorado pikeminnow increases upstream with the 15-Mile Reach containing the greatest proportion of large adult Colorado pikeminnow.

The 15-Mile Reach appears to provide the optimum balance between temperature and food abundance for adult Colorado pikeminnow (Osmundson et al. 1998, Osmundson 1999a).

Razorback suckers also are found in the 15-Mile Reach and use the reach as a spawning area (Osmundson and Kaeding 1989, 1991). The complete life cycle of the razorback sucker, in terms of its entire river habitat use pattern, is largely unknown but may be similar to that of Colorado pikeminnow because adults are generally concentrated in upstream reaches of the Colorado and Green Rivers and larvae from spawning sites in the upper Green River have been found to drift long distances down river. Other evidence suggests that bottomlands in both upstream and downstream reaches historically served as nursery areas for larvae when these habitats flooded during the historically higher spring runoff period.

The 15-Mile Reach also is important for the survival and recovery of Colorado pikeminnow and razorback sucker because it provides a refuge for the Colorado River Basin populations should a catastrophic event such as an oil spill or chemical spill affect the Gunnison River or the Colorado River below the Gunnison River confluence.

In summary, the 15-Mile Reach is important for several reasons:

1. The 15-Mile Reach provides valuable spawning habitat for Colorado pikeminnow and razorback sucker.

2. The 15-Mile Reach provides an optimum balance between temperature and food availability for adult Colorado pikeminnow in the Colorado River.

3. The 15-Mile Reach provides an important refuge for endangered fishes should a catastrophic event cause a loss of populations in the Gunnison River or in the Colorado River below the Gunnison River confluence.

FLOW NEEDS FOR ENDANGERED FISHES

The 15-Mile Reach has experienced major water depletions for many years. During late summer and early fall, this reach can be severely dewatered. Although it experiences major water depletions, the 15-Mile Reach is viewed as critical to the recovery of Colorado River populations of Colorado pikeminnow and razorback sucker (humpback chub and bonytail do not currently

occur in the 15-Mile Reach). Providing adequate flows in the 15-Mile Reach, in combination with other recovery actions, has been identified as important to achieving recovery of these species. Flows in the 15-Mile Reach combined with flows from the Gunnison River provide the majority of water downstream to Lake Powell. Flow recommendations for the Gunnison River and the Colorado River downstream of the 15-Mile Reach are currently being developed for the section 7 consultation on the Aspinall Unit. Osmundson and Kaeding (1991) recommended spring peak flows in the reach downstream of the Gunnison River confluence to the Colorado-Utah state line. Mean monthly flows during spring or the rest of the year and recommendations for flows in the nursery areas downstream of Moab, are being developed as part of the Aspinall Unit consultation.

The Service first developed flow recommendations for the 15-Mile Reach in 1989 and 1991. The summer flow recommendations (Kaeding and Osmundson 1989) were developed using the Instream Flow Incremental Methodology. The spring and winter flow recommendations (Osmundson and Kaeding 1991) were based on other methodologies. Stanford (1994) was contracted by the Recovery Program to review these and other flow recommendations in the basin and generally supported the basic recommendations, in addition to recommending further studies. He noted that a high spring peak to base flow ratio is strongly implied by available science and not simply professional judgement. Serious shortcomings of the IFIM approach in developing flow recommendations for endangered fish in the upper Colorado River led the Service to initiate a new study for determining recommended summer and winter flows. Using new information obtained from this study as well as that collected by other researchers, the Service updated and refined its earlier flow recommendations (Osmundson et al. 1995).

The Service's 1989 flow recommendations for summer were developed by modeling microhabitats based on depth, velocity, and substrate measurements at a site thought to be representative of the reach. The Service's 1991 flow recommendations for winter consisted of a tentative recommendation that flows not fall below historic levels; this recommendation was based on the assumption that historic conditions provided adequate winter habitat for adult fish. In refining these flow recommendations for summer and winter, the Service determined which habitat types (pools, riffles, etc.) were preferred by the fish during these seasons and then determined the flow level at which the preferred habitat types are maximized in area. This approach, as with other instream flow methodologies, assumes that increases in the amount of preferred or optimum habitat increases carrying capacity and, barring other potentially limiting factors, results in an increase in population size.

Earlier Service flow recommendations for spring were based on information on how the decrease in magnitude of spring flows could negatively affect endangered fish reproduction and survival. Data were provided which showed that low spring runoff resulted in lower pikeminnow larval production. The explanation for this relationship was that high flows are periodically needed to build cobble bars and flush fine sediment from the gravel/cobble substrates used by pikeminnow for spawning. Data were also provided which showed that razorback sucker spawning coincides with the peak runoff and occurs in warm, off-channel ponds and inundated floodplain habitats.

The explanation for low razorback sucker reproduction was that, currently, flows often do not reach levels high enough to inundate low-lying floodplain features where spawning takes place. The Service also reported that in the absence of high spring flows, important backwater habitats filled with silt and sand, tamarisk colonized sand and cobble bars, and nonnative minnows capable of preying on or competing with larval endangered fishes greatly increased in numbers.

The Service's earlier flow recommendations for spring identified the magnitude and frequency of a range of minimum peak flows and the mean monthly flows capable of producing these peaks and of maintaining the natural shape of the hydrograph. Refinement of these earlier flow recommendations for spring was based on the results of new streambed monitoring studies. The results of one study showed that the spring runoff in 1993, which peaked at 25,900 cfs, was capable of moving coarse bed materials thereby winnowing accumulated fines from the channel substrate. Based on preliminary results from hydrologic modeling (Pitlick and Van Steeter 1994), Osmundson et al. (1995) assumed that the earlier recommended peak of 23,500 cfs would also be capable of moving bed materials. The results of another study (Pitlick et al.1996) showed that a spring runoff with a peak of about 12,900 was capable of flushing accumulated fine sediments from the bottoms of backwaters thereby restoring their depth. Based on this information, the Service refined the earlier recommendations for spring peak day flows as follows:

Target Peak Day Spring Flows in the 15-Mile Reach:

>23,500 cfs (5 in 20 years)
21,750 cfs (10 in 20 years)
16,700 cfs (16 in 20 years)
12,900 cfs (20 in 20 years)

The Service's 1995 year-round flow recommendations are summarized in Table 2 as mean monthly discharges. Spring (April-July) recommendations are further subdivided into 10-day increments and are reported in Table 3 as volumes of water needed for each of twelve 10-day time periods. The mainstem Colorado River above the 15-Mile Reach does not have a large reservoir that controls flows. Therefore, variation in precipitation levels from year to year is taken into account and recommendations are provided for years of high, above-average, below-average, and low snow fall. With the exception of winter, recommendations are for flows considerably lower than historic levels (1902-1942) but somewhat higher than recent levels.

ENVIRONMENTAL BASELINE

Regulations provide that the environmental baseline includes the past and present impacts of all Federal, State, and private actions and other human activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal section 7 consultation; and the impact of State or private actions contemporaneous with the consultation process. Environmental baselines do not include the effects of the Federal action under review in the consultation.

Applying the above regulations, the environmental baseline for this project includes the past and present effects of Reclamation operations, Federal and non-Federal depletions as well as the past and present actions of funding and implementing the Recovery Plan, but does not include the future effects of the Federal action previously described on page 1. This baseline is used to evaluate the future effects of the Federal action. The environmental baseline for this consultation is not typical, because for the purposes of this analysis, all of the subject existing water depletions including those treated as interrelated, are part of the action. Typically, only impacts from actions with no Federal discretionary authority would be included in the baseline; however, because of the large scope of this programmatic biological opinion, it was not possible to determine the extent of existing or future Federal discretion for all existing and new Federal actions covered by this opinion. Also, it is likely that most water depletion projects have or will have a Federal action associated with them and would rely on the Recovery Program to avoid the likelihood of jeopardy and adverse modification of critical habitat. Because the environmental baseline does not include the project being consulted on, and all water depletions are part of the project being consulted on as described in the Federal action on page 1, the environmental baseline conditions, solely for the purpose of this analysis, represent the river with the impacts of human depletion actions taken out and shall be referred to in this biological opinion as "baseline flow conditions." Other impacts such as nonnative fish, dams, fish barriers, and bank stabilization are assumed to be in place under baseline conditions. The only purpose of using the "baseline flow conditions" is for comparison with existing depletions. This baseline is not appropriate for individual section 7 consultations, nor does it confer any obligation on the Federal action agencies to restore the river to a condition similar to that existing prior to human depletion actions. Baseline flow conditions were modeled as described below.

Table 2. Recommended mean monthly flows for the top of the 15-Mile Reach in cubic feet per second. Rate is the percent of years recommended for identified flows based on winter snowpack levels. For example, in the wettest 25 percent of years, flows in June should average at least 15,660 cfs; stated another way, this recommendation should be met in 5 of every 20 years. During low-water years, June flows should average no less than 6,850 cfs, and such a minimum should occur at a rate of no more than 4 in 20 years (20 percent). Table from Osmundson et al. 1995.

Rate	25 percent	25 percent	30 percent	20 percent
Exceedance	25 percent	50 percent	80 percent	100 percent
JAN	1,630	1,630	1,630	1,240
FEB	1,630	1,630	1,630	1,240
MAR	1,630	1,630	1,630	1,240
APR	3,210	2,440	2,260	1,860
MAY	10,720	9,380	7,710	7,260

JUN	15,660	14,250	11,350	6,850
JUL	7,060	5,370	3,150	1,480
AUG	1,630	1,630	1,240	810
SEP	1,630	1,630	1,240	810
OCT	1,630	1,630	1,240	810
NOV	1,630	1,630	1,630	1,240
DEC	1,630	1,630	1,630	1,240

Table 3. Volumes of water (in hundreds of acre-feet) needed per 10-day period to produce hydro-graphs recommended for the 15-Mile Reach during the spring runoff period (April, May, June and July). AP-1 represents the first 10 days in April; AP-2, the second 10 days, etc. Table from Osmundson et al. 1995.

Rate	25 percent	25 percent	30 percent	20 percent
Exceedance	25 percent	50 percent	80 percent	100 percent
AP-1	317	276	295	245
AP-2	563	450	416	343
AP-3	1,029	726	634	519
MA-1	1,573	1,104	957	892
MA-2	2,073	1,817	1,516	1,488
MA-3	2,944	2,846	2,267	2,085
JN-1	3,197	2,770	2,566	1,778
JN-2	3,209	3,066	2,368	1,404
JN-3	2,914	2,643	1,818	893
JL-1	2,060	1,617	990	470
JL-2	1,328	977	578	246
JL-3	955	707	372	194

The Colorado River Decision Support System includes the State of Colorado's Stream Simulation Model which is a monthly or daily water allocation and accounting model capable of making comparative analyses for the assessment of various historic and future water management policies

in a river basin. While the model is capable of doing daily operations, daily data does not exist in sufficient quantity to operate on a daily basis. It is designed to be applied to any river basin by inputting appropriate data. The State Model's operation, like the stream itself, is governed by its hydrology, water rights, and the associated structures and operating rules. The State Model is capable of simulating stream diversions, instream demands, reservoir operations and river flows on a monthly basis for any stream system using user specified data. One major component of the model is the Base Flow module, which produces a set of stream flows that would have occurred in the basin without a user specified level of human development. When the effects of depletions are removed, the base flow developed would represent baseline flow conditions, as discussed above. The baseline flow conditions for a wet, average and dry year are displayed in Figure 3. Baseline flow conditions provided higher spring peaks and lower base flows. In wet years, average monthly peak in May or June exceeded 26,000 cfs in the 15-Mile Reach. Appendix F describes modeling assumptions used to make the model runs. The results of these runs were used to develop the following figures and tables.

Status of the Species Within the Action Area

It is difficult to determine the status of the species under baseline conditions because baseline conditions assume baseline flow conditions but other factors, such as nonnative fish, dams, fish barriers, dikes, and bank stabilization are assumed to still be in place. These other factors have all been identified as negatively impacting the endangered fishes. There is limited information regarding the four species under more natural flow conditions, but this information would not necessarily include the negative impacts of nonnative fish, dams, fish barriers, dikes, or bank stabilization. Information regarding the four fish species under more natural flow conditions is limited to a few technical papers (Abbott 1861, Baird and Girard 1853, Chamberlain 1904, Cope and Yarrow 1875, Ellis 1914, Everman and Rutter 1895, Girard 1856, Jordan 1891, Jordan and Evermann 1896) and historical photos and accounts of senior citizens interviewed in 1991 (Quartarone 1995). The technical papers generally document the wide spread distribution and report some endangered species common throughout the Colorado River Basin (humpback chub were not even described until 1946 (Miller 1946)). However, this historical information is limited to taxonomic and distributional data. Very little was known about the life history of these species prior to the 1960's (Miller 1964).

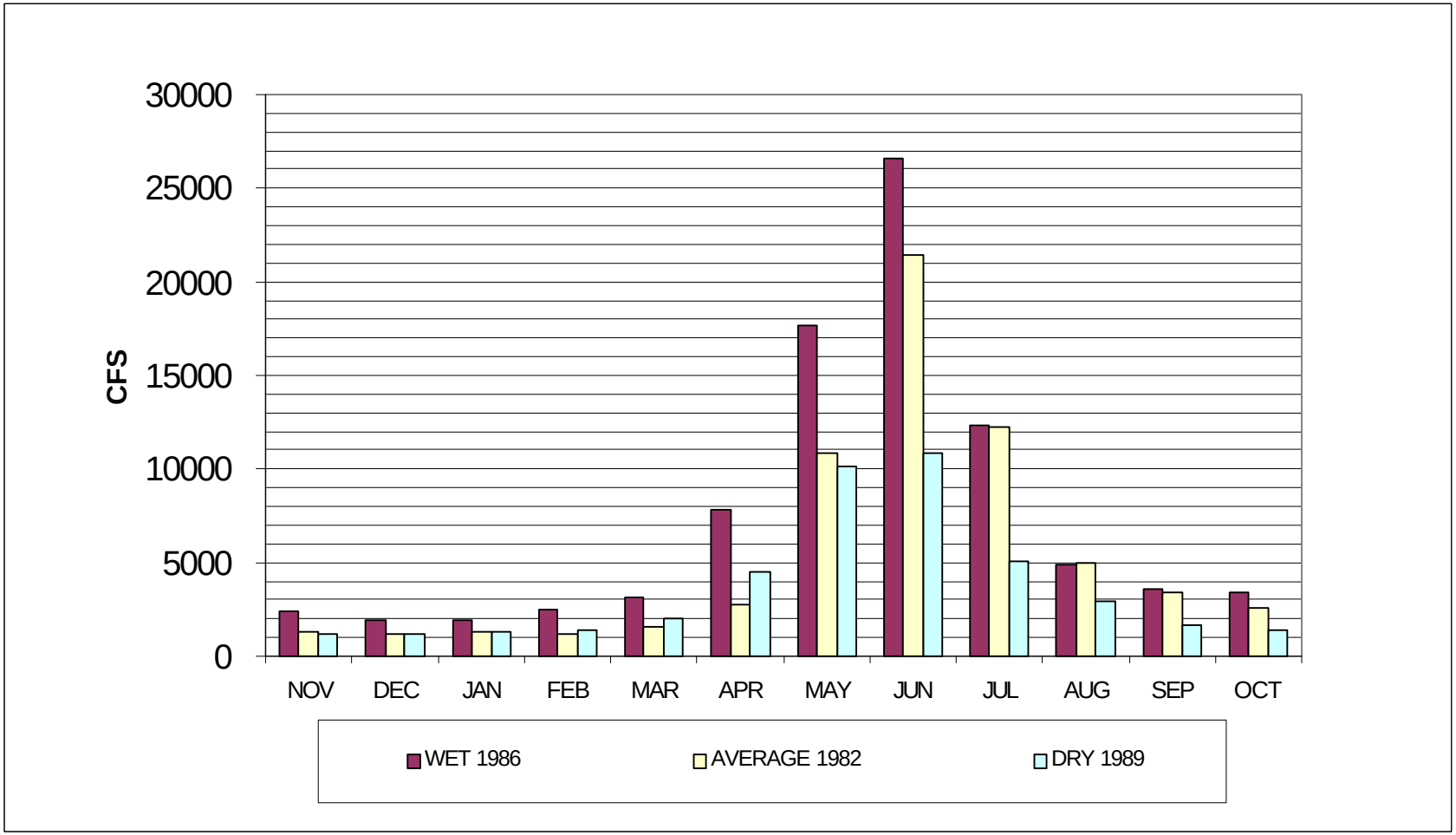


FIGURE 3. Baseline Flow condition in the Colorado River near Palisade below the GVIC Diversion as Modeled by CRDSS.

Factors Affecting Species Environment within the Action Area

The Service assumes that baseline flow conditions would provide improved habitat for the endangered fishes compared to existing flow conditions. However, even with baseline flow conditions, limiting factors for fishes exist under the environmental baseline. Under the modeled baseline flow conditions today, competition and predation from nonnative fishes would be a factor. Also, under the modeled baseline flow conditions today it is likely that many floodplain habitats would be diked off and bank stabilization would be in place. Impacts from dams such as changes in temperatures and sediment loads, and barriers to fish movement would alter habitat conditions for endangered fishes.

EFFECTS OF THE ACTION

The effects of the Federal action described on page 1 are presented in this section.

Factors to be Considered

The Service believes that water depletions are a major factor contributing to the reductions in the populations of the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. Other major factors include impacts of dams, competition from and predation by nonnative fishes, changes in flow and temperature regimes, and changes in river channel (which are also related to water depletions). These reductions in population and loss of habitat have caused the Service to list these species as endangered and to implement programs to conserve the species. Implementation of the Recovery Actions outlined in the proposed action are designed to offset depletion impacts to the 15-Mile Reach and the Colorado River downstream to Lake Powell.

Water depletions reduce the ability of the river to create and maintain important habitats and reduce the frequency and duration of availability of these habitats, as described below. Food supply, predation, and competition are important elements of the biological environment. Food supply is a function of nutrient supply and productivity; because high spring flows flood bottomland habitats increasing the nutrient supply and productivity of the river environment, reduction of high spring flows from water storage reservoirs that store water during spring peak flows may reduce food supply. Predation and competition from nonnative fish species have been identified as factors in the decline of the endangered fishes. Water depletions contribute to alterations in flow regimes that favor nonnative fishes, as described below. The Service concludes that water depletions impact all four species of endangered fishes and the primary constituent elements of their critical habitat.

There are a number of benefits associated with implementation of the Recovery Action Plan elements that positively affect the Colorado River from Rifle to Lake Powell, including the 15-Mile Reach. These benefits include: augmentation of late summer/fall base flows; spring peak enhancement; habitat restoration; fish passage; nonnative fish management; and propagation and stocking of endangered fishes.

Analyses for Effects of the Action

Water Quantity

Water depletions have/will cause discrete, identifiable, additive, adverse impacts to the Colorado River endangered fishes. As shown in the following flow analysis, the action subject to consultation has/will cause flow depletions that alter baseline flow regimes. The proposed action is intended to result in the continued existing depletion of water as well as new depletions up to 120,000 acre-feet/year beyond existing levels. Existing depletions are defined under the description of the proposed action.

Quantification of depletion impacts have focused on the 15-Mile Reach for four reasons. First, the Service considers the 15-Mile Reach to be especially important habitat for the Colorado pikeminnow and razorback sucker. Second, the Service has developed flow recommendations for the 15-Mile Reach against which current flows can be compared. Numerous studies of habitat and habitat needs have been conducted in the 15-Mile Reach. Third, the 15-Mile Reach is the most depleted reach on the Colorado River because it is located upstream of the Gunnison River confluence and immediately downstream of the large diversions at and above Palisade; consequently, a reduction in flow will impact the 15-Mile Reach to a greater degree than the other reaches. Fourth, almost any action which offsets depletion impacts to the 15-Mile Reach will necessarily offset depletion impacts to the reaches downstream to the confluence with the Green River because there are no major diversions below the 15-Mile Reach.

To determine the effects of the existing and future levels of depletions on water quantity and alteration of the hydrologic regime, an analysis of flow changes was conducted. This analysis compares existing conditions, future conditions (60,000 acre-feet/year and 120,000 acre-feet/year of additional depletion), the environmental baseline conditions (baseline flow conditions), and 15-Mile Reach flow recommendations.

The State Model was used to model existing conditions and future depletions. Two levels of future demands were added to the model immediately downstream of Cameo: 60,000 and 120,000 acre-feet per year. These demands were imposed in the following distribution:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total[3]
1200	1200	1200	1200	1200	1200	1200	19200	24000	6000	1200	1200	60,000
2400	2400	2400	2400	2400	2400	2400	38400	48000	12000	2400	2400	120,000

These distributions were based primarily on when the water would physically be available. The resulting depletions in the modeling were very close to these demands. The average depletions over the study period were 59,082 and 118,165 acre-feet per year, respectively.

[3]Distribution was developed by Leonard Rice Consulting Water Engineers.

To determine conditions with water depletions and implementation of the recovery actions, the following items were modeled.

Grand Valley Water Management components, which include a reduction in irrigation demand of the Grand Valley Project, and an operational bypass of 9,000 acre-feet/year at the Grand Valley Project headgate.

Grand Valley Project Power demand with a junior priority during summer months.

Orchard Mesa Check operated only to benefit the Grand Valley systems, with surplus Historic Users Pool water delivered to the Grand Valley to benefit endangered fish up to the capacity of the Grand Valley Power Plant canal.

Surplus Historic User Pool water in excess of the Grand Valley Power Plant canal capacity, delivered by agreement for non-consumptive municipal/recreational uses and to indirectly benefit endangered fish.

Wolford Mountain Reservoir releases from the 6,000 acre-feet fish pool to the 15-Mile Reach.

Ruedi Reservoir releases from storage accounts of 21,650 acre-feet[4] (as described above) and 5,000 acre-feet (initial storage release commitment, available every year) and 5,000 acre-feet (available 4 out of 5 years via reservoir operation) to the 15-Mile Reach.

Priority of use of various reservoir storage accounts in deliveries to the 15-Mile Reach were modeled in the following order. This does not represent the priority for release during periods when flows will be augmented.

Ruedi 10,000 acre-feet pool
Ruedi 21,650 acre-feet pool
Wolford Mountain 6,000 acre-feet pool
Green Mountain Historic User Pool Surplus pool

It is important to note that the above priorities are for modeling purposes only. Actual operations will for the most part follow these priorities but do not represent the absolute order in which water will be released from the various facilities due to hydrologic, operational, emergency and other considerations.

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[4]Because the 21,650 could be released from a combination of Ruedi Reservoir and other Division 5 facilities and it is unknown at this time where the total volume would be released from, Ruedi Reservoir was selected for modeling purposes. The benefit to the species and their habitat will be the same regardless of the water source.

Figures 4 - 6 and Tables 4 - 6 compare a range of hydrological conditions in the 15-Mile Reach. In dry years baseline flows are typically lower than existing conditions through the winter months (November, December, January, February, and March). With future water depletions and implementation of the recovery action items, flows are reduced to levels closer to baseline conditions and flow recommendation conditions during those months. During the spring months in dry years (April, May, and June) baseline flow conditions far exceed flow recommendations and existing conditions. During the late summer and fall months baseline flows exceed all flow conditions. However, the implementation of recovery action items, with future depletions will provide flows that meet the flow recommendations during August September and October.

During average years, baseline flows are lower than existing flows during winter months and exceed existing flows the rest of the year. During late summer and fall, conditions with future depletions and implementation of the recovery actions will maintain flows close to the flow recommendation. During the spring months (April, May, and June) baseline flow conditions exceed flow recommendations and existing conditions. However, these figures and tables do not include the flows provided by Coordinated Reservoir Operations or Coordinated Facilities Studies, because the model uses average monthly flows which do not reflect flows provided by these two recovery items designed to augment spring peak flows. Coordinated Reservoir Operations augment the spring peak during below average, average, and above average years, but not during dry or wet years.

During wet years, baseline flows are lower than existing flows in most winter months and exceed existing flows the rest of the year. In wet years, conditions with future depletions and implementation of recovery actions are close to flow recommendations during the runoff months. In wet years, reservoirs fill quickly and the diversions are minor compared to the total volume of flow. During late summer and fall future conditions meet or exceed the flow recommendations.

Augmentation of Late Summer and Fall Base Flows

A number of actions will provide water to the 15-Mile Reach during July, August, and September. It is important to augment flows during these months in the 15-Mile Reach because this is when this reach can be extremely dewatered due to agricultural diversions. The CWCB administers an instream flow right of 581 cfs in the 15-Mile Reach which protects the water released from the Orchard Mesa Power Plant and the Orchard Mesa Irrigation District Pump Station. They also administer an instream flow right for 300 cfs of accretions to the 15-Mile Reach during July, August, and September. These flow rights would ensure protection of some existing flows in the 15-Mile Reach.

Release of 5,000 acre-feet annually plus an additional 5,000 acre-feet 4 out of 5 years from Ruedi Reservoir also would provide water to the 15-Mile Reach during July, August, and September. In addition, the leases for release of 10,825 acre-feet/year of water from Ruedi Reservoir and the permanent dedication of 10,825 acre-feet/year of water from Colorado Water Division Number 5 Facilities will be delivered and protected to the 15-Mile Reach during the late summer period.

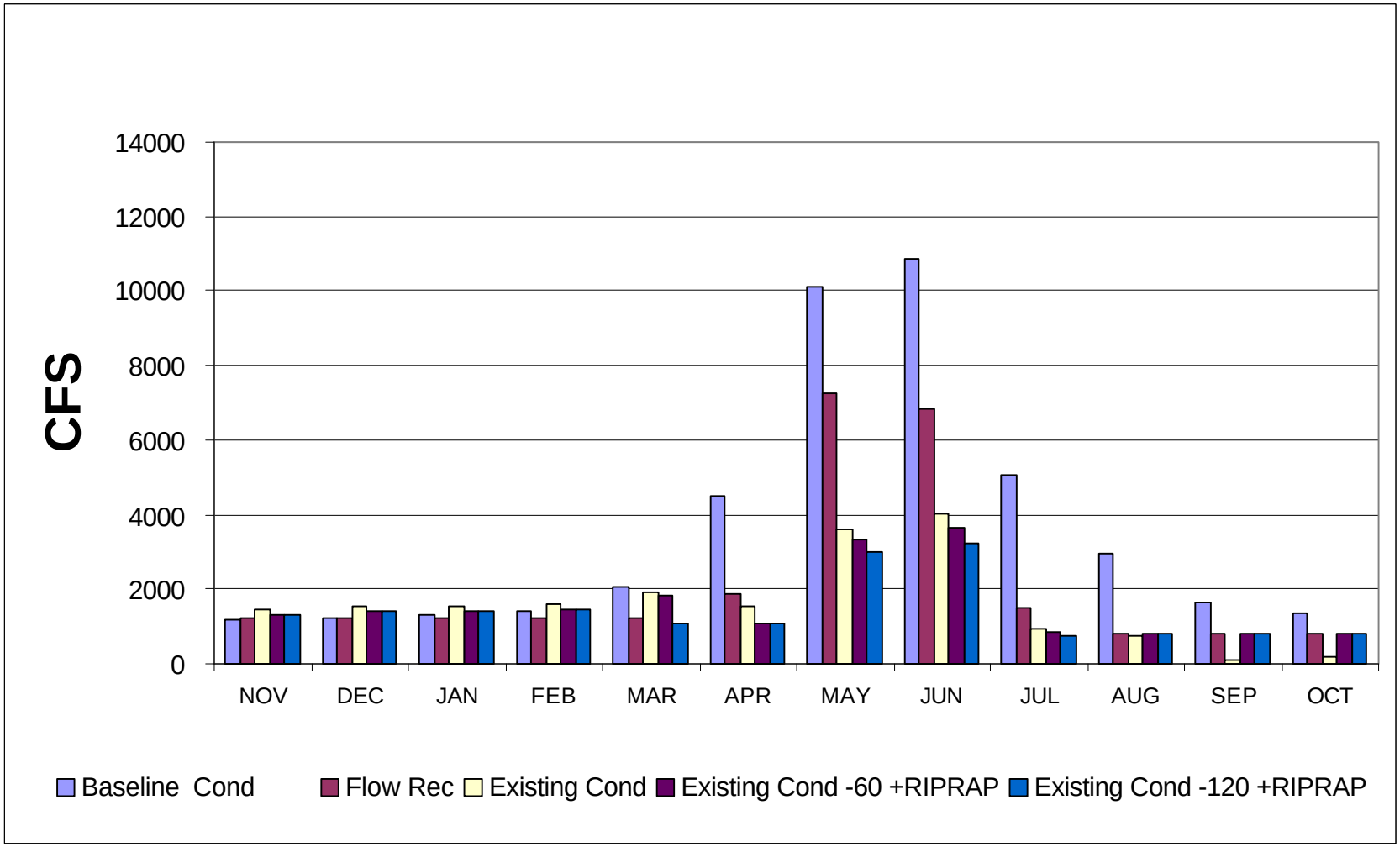


FIGURE 4. Colorado River near Palisade, flow below GVIC Diversion Dam illustrating changes resulting from future depletions and Recovery Actions Items. Dry year (1989) as modeled by CRDSS.

TABLE 4. Changes in Flow Near Palisade in a Dry Year with Future Depletions With and Without Recovery Action Items.

						ACRE-FEET								
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Existing	1989	87106	95870	93912	88060	118519	90979	222751	240928	58239	46833	6227	11164	1,160,588
	Change	-1154	-1155	-1157	-1158	-1160	-1602	-19198	-23996	-5999	-1200	-58	-57	-57,894
Existing - 60K	1989	85952	94715	92755	86902	117359	89377	203553	216932	52240	45633	6169	11107	1,102,694
														0
	Change	-6691	-7242	-6542	-5224	-5031	-24184	61	-55	8	4173	42030	38699	30,002
Existing - 60 + RIP	1989	79261	87473	86213	81678	112328	65193	203614	216877	52248	49806	48199	49806	1,132,696
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
	Change	-2269	-2274	-2278	-2281	-2287	-3544	-38396	-47665	-11998	-2400	-164	-163	-115,719
Existing - 120	1989	84837	93596	91634	85779	116232	87435	184355	193263	46241	44433	6063	11001	1,044,869
	Change	-6777	-7323	-6621	-5301	-5104	-23442	59	-219	7	5373	42136	38805	31,593
Existing - 120 + RIP	1989	78060	86273	85013	80478	111128	63993	184414	193044	46248	49806	48199	49806	1,076,462
						DRY YEAR (CFS)								
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Existing	1989	1464	1559	1527	1586	1927	1529	3623	4049	947	762	105	182	
	Change	-19	-19	-19	-21	-19	-27	-312	-403	-98	-20	-1	-1	
Existing - 60K	1989	1444	1540	1508	1565	1909	1502	3310	3646	850	742	104	181	
	Change	-112	-118	-106	-94	-82	-406	1	-1	0	68	706	629	
Existing - 60 + RIP	1989	1332	1423	1402	1471	1827	1096	3311	3645	850	810	810	810	
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
	Change	-38	-37	-37	-41	-37	-60	-624	-801	-195	-39	-3	-3	
Existing - 120	1989	1426	1522	1490	1545	1890	1469	2998	3248	752	723	102	179	
	Change	-114	-119	-108	-95	-83	-394	1	-4	0	87	708	631	
Existing - 120 + RIP	1989	1312	1403	1383	1449	1807	1075	2999	3244	752	810	810	810	

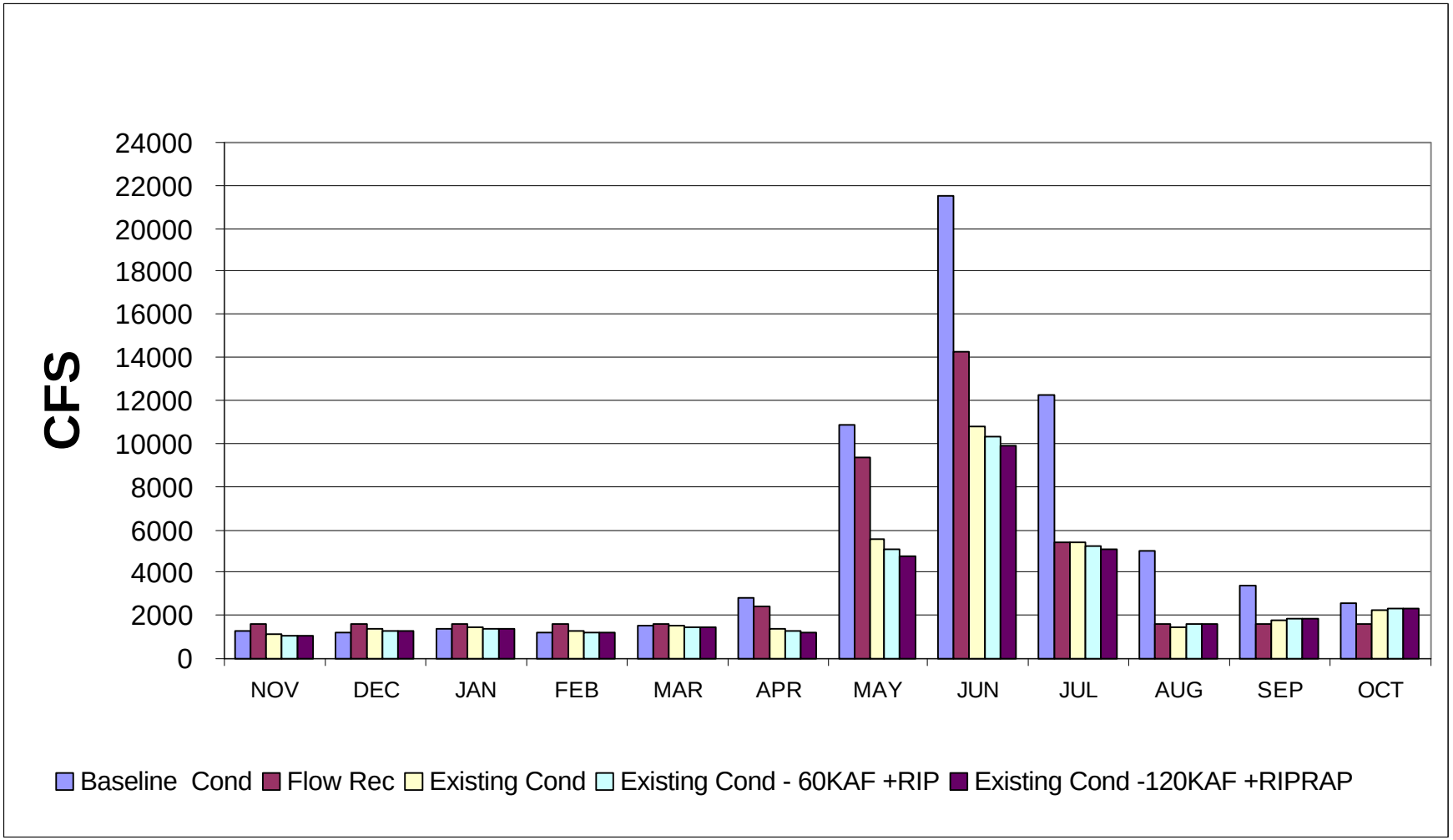


FIGURE 5. Colorado River near Palisade, flow below GVIC Diversion Dam illustrating changes resulting from future depletions and Recovery Actions Items. Average year (1982) as modeled by CRDSS.

TABLE 5. Changes in Flow Near Palisade in a Average Year with Future Depletions With and Without Recovery Action Items.

						ACRE-FEET								
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Existing	1982	64991	84846	88110	72642	93856	82800	342481	640511	334103	90844	105984	134065	2,135,233
	Change	-1203	-1202	-1201	-1201	-1261	-1203	-21116	-24006	-3910	-3342	-1204	-1200	-62049
Existing - 60K	1982	63788	83644	86909	71441	92595	81597	321365	616505	330193	87502	104780	132865	2,073,184
	Change	-2692	-3776	-3683	-3933	-2433	-6184	-9002	-4116	-10681	12724	7037	10622	-13,425
Existing - 60K + RIP	1982	61096	79868	83226	67508	90162	75413	312363	612389	319512	100226	111817	143487	2,057,067
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
	Change	-2404	-2402	-2401	-2422	-2461	-2403	-42110	-48006	-3910	-5592	-2566	-2484	-119,161
Existing - 120	1982	62587	82444	85709	70220	91395	80397	300371	592505	330193	85252	103418	131581	2,016,072
	Change	-2692	-3777	-3683	-3919	-2433	-6184	-7207	-4118	-16681	14974	7049	10556	-18,115
Existing - 120 + RIP	1982	59895	78667	82026	66301	88962	74213	293164	588387	313512	100226	110467	142137	1,997,957
						AVERAGE YEAR (CFS)								
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Existing	1982	1092	1380	1433	1308	1526	1391	5570	10764	5434	1477	1781	2180	
	Change	-20	-20	-20	-22	-21	-20	-343	-403	-64	-54	-20	-20	
Existing - 60K	1982	1072	1360	1413	1286	1506	1371	5226	10361	5370	1423	1761	2161	
	Change	-45	-61	-60	-71	-40	-104	-146	-69	-174	207	118	173	
Existing - 60 + RIP	1982	1027	1299	1354	1216	1466	1267	5080	10291	5196	1630	1879	2334	
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
	Change	-40	-39	-39	-44	-40	-40	-685	-807	-64	-91	-43	-40	
Existing - 120	1982	1052	1341	1394	1264	1486	1351	4885	9957	5370	1386	1738	2140	
	Change	-45	-61	-60	-71	-40	-104	-117	-69	-271	244	118	172	
Existing - 120 + RIP	1982	1007	1279	1334	1194	1447	1247	4768	9888	5099	1630	1856	2312	

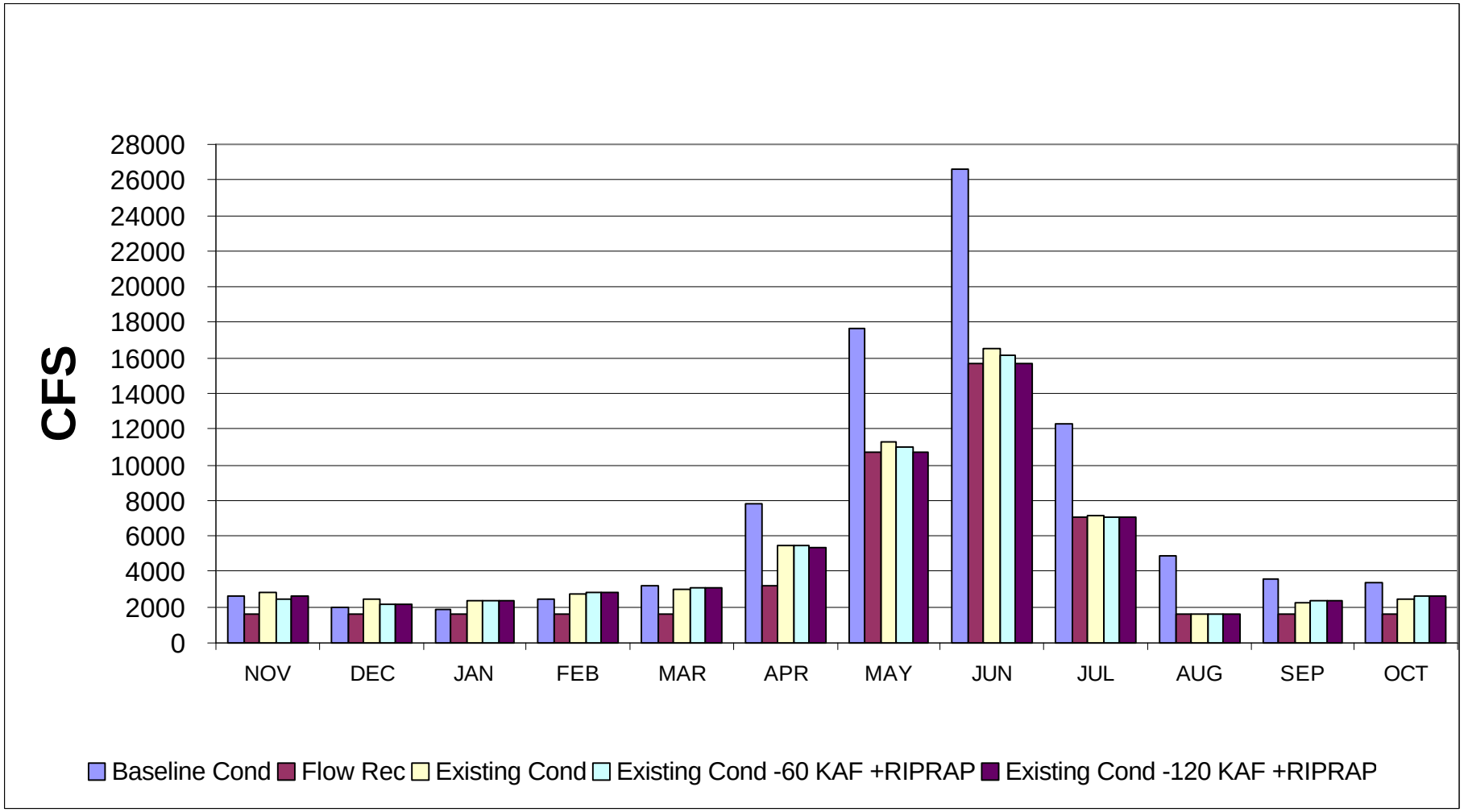


FIGURE 6. Colorado River near Palisade, flow below GVIC Diversion Dam illustrating changes resulting from future depletions and Recovery Actions Items. Wet year (1986) as modeled by CRDSS.

TABLE 6. Changes in Flow Near Palisade in a Wet Year with Future Depletions With and Without Recovery Action Items.

						ACRE-FEET								
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Existing	1986	166117	148812	143994	153057	187101	323775	694058	986555	436383	100226	132121	149286	3,621,485
	Change	-1200	-1200	-1200	-1200	-1200	-1200	-19200	-24000	-2274	0	-2302	-2180	-57,156
Existing - 60K	1986	164917	147612	142794	151857	185901	322575	674858	962555	434109	100226	129819	147106	3,564,329
	Change	-7775	-16104	3020	6015	5118	-534	-33	367	0	359	11967	17406	19,806
Existing - 60 + RIP	1986	157142	131508	145814	157872	191019	322041	674825	962922	434109	100585	141786	164512	3,584,135
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
	Change	-2400	-2400	-2400	-2400	-2400	-2400	-35722	-50416	-2274	0	-3995	-3930	-110,737
Existing - 120	1986	163717	146412	141594	150657	184701	321375	658336	936139	434109	100226	128126	145356	3,510,748
	Change	-8014	-16343	2781	5776	4879	-534	1	335	0	0	12327	17510	18,718
Existing - 120 + RIP	1986	155703	130069	144375	156433	189580	320841	658337	936474	434109	100226	140453	162866	3,529,466
						WET YEAR (CFS)								
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Existing	1986	2792	2420	2342	2756	3043	5441	11288	16579	7097	1630	2220	2428	
	Change	-20	-20	-20	-22	-20	-20	-312	-403	-37	0	-39	-35	
Existing - 60K	1986	2771	2401	2322	2734	3023	5421	10975	16176	7060	1630	2182	2392	
	Change	-131	-262	49	108	83	-9	-1	6	0	6	201	283	
Existing - 60 + RIP	1986	2641	2139	2371	2843	3107	5412	10975	16182	7060	1636	2383	2675	
	Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
	Change	-40	-39	-39	-43	-39	-40	-581	-847	-37	0	-67	-64	
Existing - 120	1986	2751	2381	2303	2713	3004	5401	10707	15732	7060	1630	2153	2364	
	Change	-135	-266	45	104	79	-9	0	6	0	0	207	285	
Existing - 120 + RIP	1986	2617	2115	2348	2817	3083	5392	10707	15738	7060	1630	2360	2649	

Release and protection of surplus HUP water and flows made available by the Grand Valley Management Project both would augment flows during late summer and early fall. Up to 6,000 acre-feet of water also will be delivered to the 15-Mile Reach from Wolford Mountain Reservoir. All these actions combined provide flows that meet or exceed the 15-Mile Reach flow recommendations under most conditions for August, September, and October (Figures 7,8,9). Because there are no major diversion below the 15-Mile Reach, augmentation of flows in the 15-Mile Reach also would likely benefit all reaches downstream to Lake Powell. The management objective of providing the recommended flows is to provide conditions that promote species recovery by maximizing preferred adult Colorado pikeminnow habitat (Osmundson et al. 1995). When populations are augmented, razorback sucker, and bonytail will benefit from increased base flows inside and outside of the 15-Mile Reach. Increased base flows also would benefit humpback chub populations in Black Rocks and Westwater Canyon.

Water Quality

This biological opinion is limited to addressing water depletions above the confluence of the Gunnison River (water quantity), however, changes in water quantity affect water quality, which is a primary constituent element of critical habitat. Most projects covered by this opinion remove "clean" mountain water before it enters the Colorado River, therefore, depletions could reduce the dilution effect provided by this clean mountain water. This results in an increase in heavy metal, selenium, salts, PAHs, pesticides, and other contaminant concentrations in the Colorado River. An increase in contaminant concentrations in the river would likely result in an increase in the bioaccumulation of these contaminants in the food chain which could adversely affect the endangered fishes, particularly the predatory Colorado pikeminnow. Selenium may be of particular concern due to its effects on fish reproduction and its tendency to concentrate in low velocity areas that are important habitats for Colorado pikeminnow and razorback suckers. The Recovery Program is intended to offset water quality impacts associated with flow reductions (USFWS 1987). These impacts include changes in temperature, salinity and turbidity, as well as the reduced dilution factor associated with depletions. However, the Recovery Program is not intended to offset any point or nonpoint discharges of pollutants, such discharges will have to be offset or avoided by other means. This would include discharges of irrigation water with elevated levels of selenium.

Physical Habitat

Water depletions during spring runoff affect physical habitat in several ways. High spring flows are very important for creating and maintaining complex channel geomorphology and suitable spawning substrates, and in creating and providing access to off-channel habitats. Adequate summer and winter flows are important for providing a sufficient quantity of preferred habitats for a duration and at a frequency necessary to support all life stages of viable populations of all four endangered fishes. However, the effect of water depletions are most prevalent in the 15-Mile Reach where Colorado pikeminnow and razorback sucker occur. Bonytail and humpback chub do not currently occur in the 15-Mile Reach.

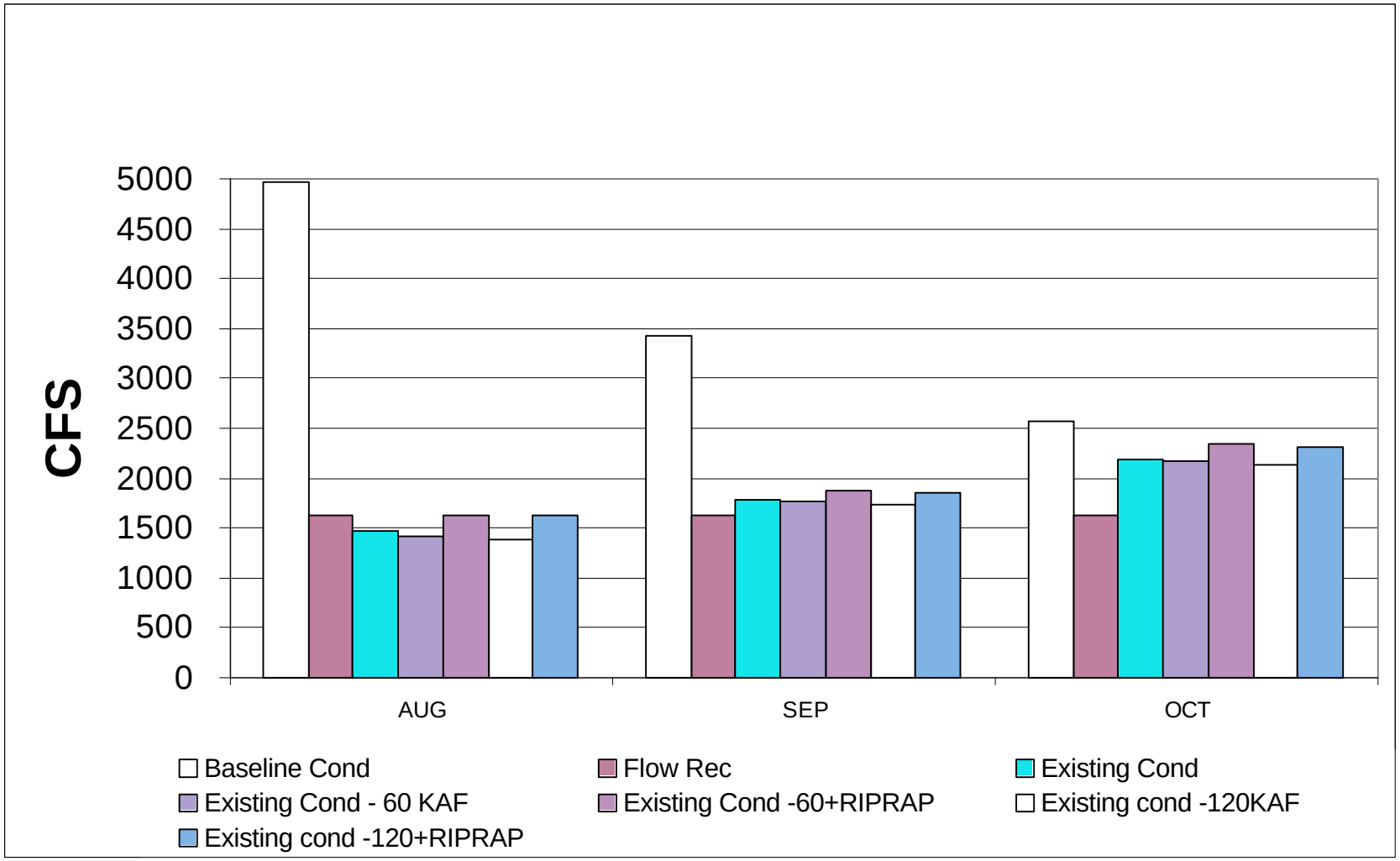


FIGURE 7. Colorado River Near Palisade, flow below GVIC Diversion, August to October for a average year (1982) as modeled by CRDSS.

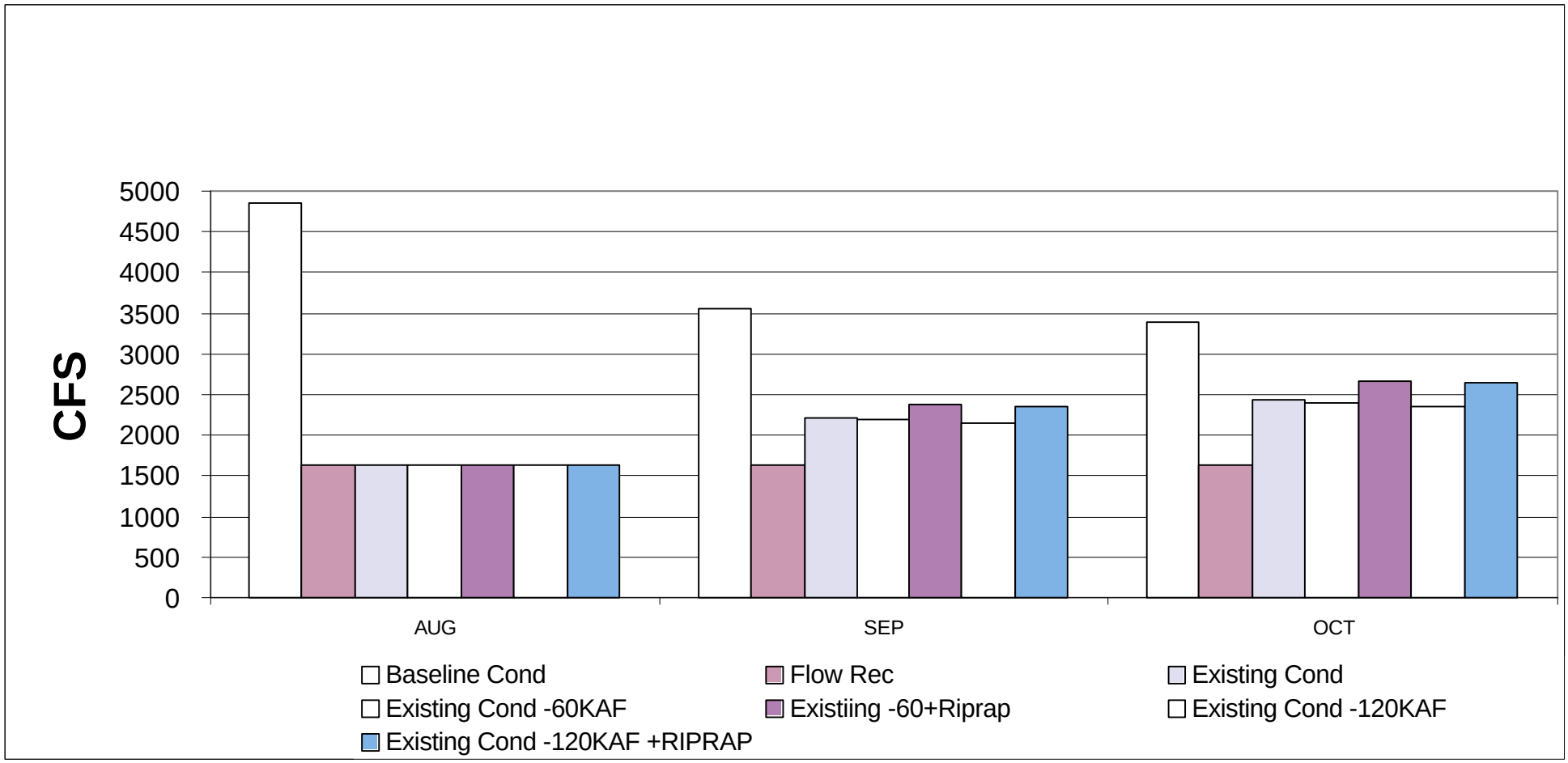


FIGURE 8. Colorado River near Palisade, flow below GVIC Diversion, from August to October for a wet year (1986) as modeled by STATEMOD.

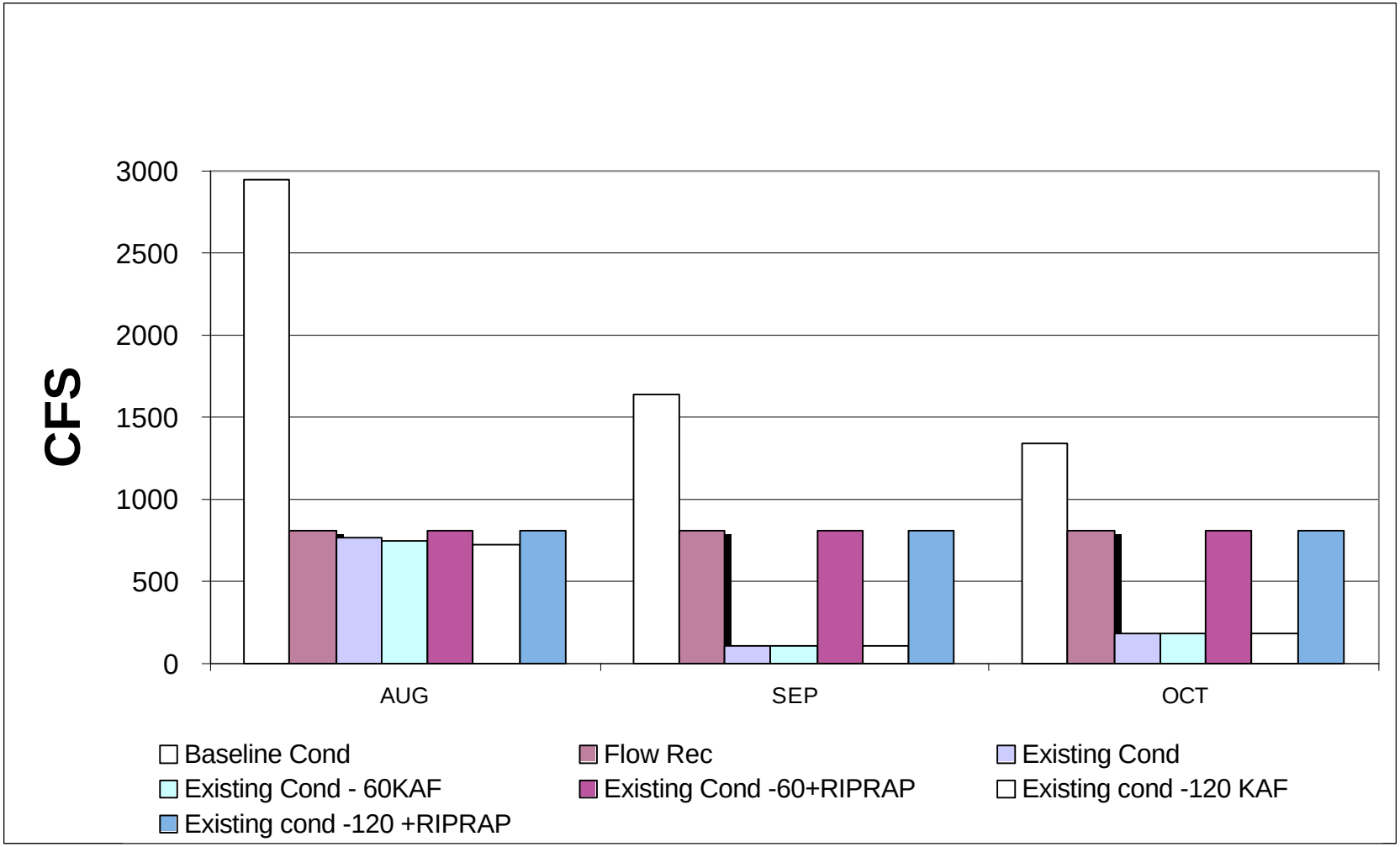


FIGURE 9. Colorado River near Palisade, flow below GVIC Diversion, from August to October for a dry year (1989) as modeled by STATEMOD

The formation of a variety of channel habitats is essential to ensure the availability of the range of habitats required by all endangered fish life stages to fulfill daily requirements (foraging, resting, spawning, avoiding predation, etc.) under various flow conditions. The number and distribution of these channel habitats can be described as channel habitat complexity, diversity, or heterogeneity. Osmundson and Kaeding (1991) found that adult Colorado pikeminnow in the Grand Valley select river segments with a complex morphometry over those that are simple. Floodplain depressions used by razorback sucker are typically formed by abandoned main channels, side-channels, backwaters, and meander cutoffs.

The creation of complex channel habitat and the formation and eventual abandonment of channel features from which floodplain depressions are formed occur primarily during spring runoff when flows are of sufficient magnitude and duration to cause major changes in channel morphology through significant erosion and deposition of bed and bank materials. The reduction in the magnitude, duration, and frequency of high spring flows has slowed the rate at which channel morphology changes (Osmundson and Kaeding 1991). Consequently, the creation of complex channel habitat and floodplain depressions has slowed. In a Geographic Information Systems analyses of aerial photographs, Van Steeter (1996) showed a measurable change in the morphology of the river during the period of water development. Results of the research indicate that there has been a decrease in complexity that appears to be caused by sediment filling in side channels and backwaters during low flow periods. Then vegetation colonizes in these sediments and islands become attached to the floodplain.

The placement of riprap and other bank stabilization measures and the construction of dikes and levees impede changes in channel morphology and contribute to the slowed creation of complex channel habitat. In addition, the construction of dikes and levees reduces existing channel habitat complexity by causing channelization of the river. Dikes and levees also isolate existing floodplain depressions from the channel during high flows. The slowed creation of complex channel habitats and new floodplain depressions, the reduction of existing channel habitat complexity, and the isolation of existing floodplain depressions have acted to reduce the quantity and quality of important habitat for endangered fishes.

Backwaters, identified as important nursery areas for endangered fishes, are altered by the deposition of fine sediments which reduces their depth and consequently their duration and frequency of inundation (Osmundson and Kaeding 1991, Osmundson et al. 1995, Van Steeter 1996). Fine sediments fill the interstitial spaces of gravel and cobble substrates where eggs are deposited by Colorado pikeminnows during spawning. The establishment of vegetation on backwater sediments and on bars further reduces the value of these habitats for endangered fishes because it reduces the ability of the cobble substrate to be flushed clean (Osmundson et al. 1995). Furthermore, higher flows are required to flush sediments from vegetated backwaters than from unvegetated ones. Osmundson and Kaeding (1991) reported observations that, in the 15-Mile Reach during the drought years of 1988 to 1990, backwaters were filling in with silt and spring flows were not sufficient to flush out the fine sediment. Also, they reported that tamarisk colonized sand and cobble bars. The lower frequency of high water years, therefore, decreases

the frequency at which silt and sand is flushed from backwaters, fine sediments are flushed from gravel/cobble substrates, and vegetation is scoured from backwaters and bars. As a result, the frequency at which these habitats are suitable for use by endangered fishes has decreased. Recent studies by Pitlick et al. (1996) indicate that flows in the range of 12,900 and 29,000 cfs mobilize the gravel/cobble substrate.

Also, the quantity and frequency of availability of inundated floodplain depressions used by razorback suckers for spawning is dependent on the magnitude and frequency of spring flows necessary to inundate these areas. The decrease in the magnitude and frequency of spring flows necessary to inundate floodplain depressions is believed to be largely responsible for poor razorback sucker recruitment (Osmundson and Kaeding 1991).

Spring Peak Enhancement to Benefit Physical Habitat

Spring peak flows have been identified as important for habitat formation and maintenance. The Recovery Program has two actions aimed at augmenting spring flows. The benefits of these actions are not reflected in the figures and tables presented in this document, because the hydrology is presented as average monthly flows. In order to show the benefits of the two programs described below, daily flows would need to be modeled. Modeling daily flows was not possible with the model selected, therefore, the benefits are explained below.

The Service and the Recovery Program have been working on a number of initiatives to secure water to augment spring flows to the 15-Mile Reach. The Coordinated Reservoir Operations were implemented to provide a coordinated inter-agency effort to coordinate discretionary bypasses of inflow at major reservoirs in the basin to coincide with the natural spring peak. Augmentation of the peak can occur during below average, average, and above average hydrologic conditions. The Coordinated Reservoir Program was successful in 1997 in providing approximately 2,000 cfs of peak augmentation and in 1998 approximately 2,500 cfs was added to the peak. The Service has identified target flows in the 15-Mile Reach in the range of 12,900 to 29,000 cfs, because flows of this magnitude have been shown to mobilize gravel/cobble substrate (Pitlick et al. 1996).

The second initiative is the Coordinated Management of Colorado Water Division Number 5 Facilities. This initiative is intended to assess water management facilities and operations that can be coordinated to benefit fish habitat in spring and late summer. This analysis will include, but not be limited to examining options similar to what is proposed for operation of Ruedi Reservoir where water is made available to the fish until needed by water interests. The intent of the initiative is for project sponsors to secure a firm water supply for project purposes, and to utilize flexibility that may currently exist to provide water for enhancement of the spring peak. Other options being evaluated include storing or withholding release of available flows in excess of the Service's winter flow recommendations for release during the spring peak, and examining the feasibility and benefits of an off channel storage facility somewhere below the Shoshone Power Plant. The amount of water available, benefits, physical and legal constraints, and recommended

options will be determined through the analysis and presented to the Recovery Program. The intent is to provide additional water up to approximately 20,000 acre-feet/year, without diminishing project yield or causing project sponsors to incur significant costs, for meeting fish flow needs either short-term or under certain hydrologic conditions (above what is currently targeted for coordinated reservoir operations). Following the analysis, agreements and/or operating protocols will be developed, as needed. The analysis should be completed by September 2000 and agreement on implementation reached by March 2001. An example of the benefits of this proposal is that if an additional 20,000 acre-feet is released in a given year, it would augment spring peak flows by approximately 1,000 cfs for 10 days in the 15-Mile Reach.

Reproductive success and natural recruitment are dependent on high spring flows to create and maintain habitat. Augmentation of the spring peak is an essential recovery action upon which the Recovery Program depends to avoid the likelihood of jeopardy and adverse modification of critical habitat. Increased spring peak flows in the 15-Mile Reach, would likely benefit all reaches downstream to Lake Powell.

Habitat Restoration

The habitat restoration element of the Recovery Program will enhance, restore, and protect natural floodplain habitat through easement/acquisition of floodplain property, dike removal, and physical manipulation of habitat. Floodplain habitats inundated and connected to the main channel by high spring flows are typically warmer and substantially more productive than the adjacent river and have abundant vegetative cover. Floodplain habitat has been identified as important for adult Colorado pikeminnow during the pre-spawning period and for all life stages of razorback sucker. Restoration of bottomland habitat is providing pre-spawning staging habitat for Colorado pikeminnow. It will also provide pre-spawning, post-spawning, and nursery habitat for razorback sucker. Bottomland habitats have not been identified as important to humpback chub. Not enough information is available to determine the benefits to bonytail.

The lack of availability of seasonally flooded habitats has been identified as a major factor in the decline of razorback sucker populations. Wydoski and Wick (1998) concluded that zooplankton densities in the main channel of the Green River never reached densities required for larval razorback sucker to survive. However, they consistently found zooplankton densities necessary for survival in floodplain habitats. Because razorback suckers spawn on the ascending limb of the spring runoff hydrograph, when main channel food organism densities are extremely low, Wydoski and Wick (1998) concluded that starvation may be a factor in larval razorback survival. Wydoski and Wick (1998) also concluded that floodplain habitat with vegetative cover provides protection from nonnative predators for larval and juvenile razorbacks. The Service believes that restoring floodplain habitats will increase densities of zooplankton and benthic invertebrates to provide adequate quantity and quality of food organisms for larval razorback sucker survival; and the vegetative cover provided in floodplain habitat will help reduce predation by nonnative fishes.

Fish Passage

Biologists believe dams and water diversion structures in the river are one of the primary reasons for the decline of the Colorado pikeminnow, razorback sucker, humpback chub and bonytail. These barriers have fragmented migration routes of endangered fish, reducing their historic range (to the Gulf of California) by 75 percent. The fish are no longer able to access spawning, feeding, and winter habitats. Upstream of such barriers on the Colorado and Gunnison Rivers, these fish are nearly extinct.

It is believed that Colorado pikeminnow and razorback sucker historically spawned in river reaches above the existing diversion dams within critical habitat. After the dams were built, populations above the dams declined over time. Spawning may have continued to occur, but the newly-hatched larvae would drift downstream over the dams. After rearing downstream, young adults would not have been able to move into upstream areas to replenish the declining spawning populations above the dams. After spawning, adults of these species move back to their home ranges, areas where they can feed, rest, and overwinter. Construction of diversion dams has denied access to some of these habitats. Construction of passage facilities at structures on the Colorado and Gunnison Rivers is expected to restore access to 112 miles of historically-occupied habitats, and assist in recovery of these endangered fishes.

The fish passageway constructed on the Gunnison River at the Redlands Diversion Dam is an example of a successful fish passage project. Since its completion, approximately 28,200 fish have used the fishway, including 42 Colorado pikeminnow. Native fish have comprised about 93 percent of this total. Native fish that had been marked and released above the dam dispersed upstream, some as far as 57 river miles to the base of the Hartland Diversion Dam. Colorado pikeminnow that passed through the fishway have been found upstream. Ongoing studies will determine if fish using the passageway are spawning in the Gunnison River above the Redlands Diversion Dam.

The following recovery actions will eliminate fish passage problems on the upper Colorado River.

> There are three barriers on the Colorado River near Grand Junction, Colorado: Grand Valley Irrigation Company (river mile 185), Price-Stubb (river mile 188), and Grand Valley Project (river mile 194). Restoration of passage at these diversion dams will allow access to 55 miles of habitat, from Palisade (river mile 185) upstream to Rifle (river mile 240), Colorado.
>
> The Grand Valley Irrigation Company diversion dam has been in place since 1883. The low dam (approximately 2-feet high) was a barrier to upstream fish passage at flows less than 1,200 cfs. Construction of a 30 foot wide notch and 5 pools and riffles provides fish passage at flows above 100 cfs, was completed in January 1998. Ten adult Colorado pikeminnow were captured above the dam during recent studies to evaluate the fish passage (Burdick 1999). However, it is unknown whether these fish used the newly constructed notch or passed over the dam during high flows.

Passage at the Price-Stubb Diversion Dam is currently scheduled to be completed in September 2000. However, one fish passage alternative is dam removal and if this option is chosen the schedule could be delayed until April 2002 to accommodate completion of the Plateau Creek Pipeline Project by Ute Water Conservancy District. Restoration of passage at the Government Highline Diversion Dam is tentatively scheduled for completion during 2001.

Biological Environment

Food supply, predation, and competition are important elements of the biological environment. Stocking of nonnative fishes and the modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has contributed to the establishment of nonnative fishes. Predation and competition from nonnative fishes have been clearly implicated in the population reductions or elimination of native fishes in the Colorado River Basin (Dill 1944, Osmundson and Kaeding 1989, Behnke 1980, Joseph et al. 1977, Lanigan and Berry 1979, Minckley and Deacon 1968, Meffe 1985, Propst and Bestgen 1991, Rinne 1991, and others). Data collected by Osmundson and Kaeding (1991) indicated that during low water years nonnative minnows capable of preying on or competing with larval endangered fishes greatly increased in numbers.

More than 50 nonnative fish species were intentionally introduced in the Colorado River Basin prior to 1980 for sportfishing, forage fish, biological control and ornamental purposes (Minckely 1982, Tyus et al. 1982, Carlson and Muth 1989). Nonnative fishes compete with native fishes in several ways. The capacity of a particular area to support aquatic life is limited by physical habitat conditions. Increasing the number of species in an area usually results in a smaller population of most species. The size of each species population is controlled by the ability of each life stage to compete for space and food resources and to avoid predation. Some nonnative fishes' life stages appear to have a greater ability to compete for space and food and to avoid predation in the existing altered habitat than do some native fishes' life stages. Tyus and Saunders (1996) site numerous examples of both indirect and direct evidence of predation on razorback sucker eggs and larvae by nonnative species.

Nonnative fishes often are stocked in and enter rivers from off-channel impoundments. The periodic introduction of these nonnative fishes into a river allows them to bypass limitations to reproduction, growth, or survival that they might encounter in the river. Consequently, populations of nonnative fishes in the river are enhanced. Endangered and other native species in the river experience greater competition and predation as a result. Tyus and Saunders (1996) concluded that the nonnative fish impacts play a significant role in the decline of the Colorado River endangered fishes.

Nonnative Fish Management

The implementation of the Nonnative Fish Stocking Procedures (USFWS 1996) will help in the effort to reduce competition and predation from nonnative fish. Further reduction of nonnative fishes should come with the State of Colorado's removal of bag limits on all nonnative warmwater sportfishes within critical habitat.

The Recovery Program is in the process of reclaiming floodplain ponds (removal of nonnative fishes from ponds) in critical habitat. Also, small nonnative cyprinids are being removed from backwaters and other low velocity nursery habitats in critical habitat. These efforts are designed to reduce nonnative fish from critical habitat. Centrarchid removal in the Colorado River began in 1997 and continues.

A Fisheries Management Plan is being developed for the reach from Rifle to the Colorado-Utah state line. This plan will incorporate nonnative fish control and management of sportfish. This effort should help reduce nonnative fishes in critical habitat.

Propagation

Recovery Program propagation activities will provide endangered fishes for augmentation of populations and provide refugia to insure various stocks of endangered fishes will not be lost. Propagation facilities are being expanded at the Ouray National Fish Hatchery, Wahweap, and in the Grand Valley.

The Recovery Program is currently managing Colorado River razorback sucker stocks. The Recovery Program has completed a 5 year stocking plan (Nesler 1998) that includes stocking razorback sucker and Colorado pikeminnow in the Colorado River above Palisade. Between 1996 and 1998 over 10,000 bonytail were stocked in the Colorado River in Utah. The 5 year stocking plan calls for stocking bonytail between Palisade and Loma, which includes the 15-Mile Reach. Stocking will proceed in accordance with dates established by the Recovery Program and/or included in the Recovery Action Plan.

Populations of razorback sucker and bonytail are so low in the Upper Colorado River that augmentation of populations is an essential tool for species recovery.

<u>Species and Critical Habitat Response to the Proposed Action</u>

The Service believes that the greatest impacts of water depletions addressed in this biological opinion are on endangered fishes and their habitats in the 15-Mile Reach of the Colorado River. Historic water depletions have greatly altered the natural flow regime, and new depletions totaling 120,000 acre-feet/year will have additional impacts. As a result of existing depletions and other factors affecting habitat availability and quality, critical habitat for the endangered fishes has been degraded to varying degrees and population responses to habitat modification varies among

species. Recent population estimates indicate that Colorado pikeminnow populations have increased in the Colorado River (Osmundson and Burnham 1998), but populations are still low compared to historic levels. Nonetheless, the 15-Mile Reach currently supports more adult Colorado pikeminnow per mile than the rest of the mainstem Colorado River except for the adjacent downstream 18-Mile Reach (USFWS, unpublished data). Populations of razorback sucker throughout the Colorado River basin have suffered severe declines, apparently due in part to loss of critical floodplain habitats, and wild fish are almost unknown in recent collections from the upper Colorado River sub-basin. Humpback chubs do not occur in the 15-Mile Reach, and population responses to present river modifications are difficult to determine because populations in the upper Colorado River subbasin were not discovered until the late 1970's. However, results from monitoring suggest that populations in Black Rocks and Westwater Canyon are stable (McAda et al. 1994). Wild populations of bonytail have been extirpated from the upper Colorado River subbasin.

Ongoing or planned Recovery Program actions for the endangered fishes in the Colorado River include augmentation of spring peak flows, providing adequate base flows, implementing control measures for nonnative fishes, restoring access to historically occupied river reaches and habitats, and augmentation of populations through stocking to assist in reestablishing viable populations (particularly bonytail and razorback sucker). The Service has concluded that although the flow-related recovery actions will not be sufficient to fully offset all the adverse effects of historic and new water depletions, it is expected that a combination of flow and nonflow management activities will provide suitable habitat for increasing numbers of the endangered fishes and likely restore critical habitat areas that have been substantially modified or completely lost, to adequately offset such depletions and to avoid take including harm. The life history of the endangered fishes suggests that populations are recruitment-limited (Wydoski and Wick 1998), therefore ensuring adequate levels of recruitment appears to be the key for their recovery. The expected long-term response of the endangered fishes to habitat restoration and population augmentation (where needed) will be a function of the enhancement of populations through increases in abundance, expansion of current distributions, and restoration of viable population structure (i.e., all life stages present and successful recruitment of young to adult stocks).

Management activities to enhance spring (March–July) peak flows include Coordinated Reservoir Operations and implementation of Phase II of Coordinated Facilities. Although the Service recognizes that spring flow recommendations for the endangered fishes will not be met under the proposed action, the expected result of enhancing the spring peak is increased frequency of years in which flows exceed 12,900 cfs, the threshold identified for moving fine sediments (Pitlick et al.1996). Adequate sediment transport is important because cobble and gravel deposits free of silt and sand are preferred spawning sites of the endangered fishes (Tyus 1990; Harvey et al. 1993; Harvey and Mussetter 1994; Wick 1997), and backwaters (the preferred nursery habitat of young Colorado pikeminnow) are maintained by periodic removal of accumulated sediments and rejuvenation of deposits that provide the structure for formation of the habitat after spring flows recede (Rakowski and Schmidt 1999, Osmundson et al. 1995). The Service believes that improving spawning and nursery habitats should result in increased reproductive success and

survival of young fish (i.e., enhanced recruitment) which, over time, should lead to increases in population abundance. While spring flow recommendations have not been achieved in recent years, data indicates that populations of Colorado pikeminnow are increasing (Osmundson and Burnham 1998, USFWS unpublished data). In 1999, the Service released razorback suckers into the Colorado River and anticipates that this and future augmentation efforts will result in self-sustaining populations.

Prior to implementation of recovery actions, recommended summer/fall base-flow targets for the 15-Mile Reach were seldom met. With full implementation of recovery actions, base-flow targets for August–October will be met in most years. The base-flow recommendations are intended to provide the maximum area of habitat preferred adult Colorado pikeminnow (Osmundson et al. 1995) and, therefore, the numbers of adult Colorado pikeminnow in the 15-Mile Reach should increase in response to the additional habitat. Further, the August–October base flows achieved through implementation of the recovery actions should provide adequate depth and stability in nursery backwater and other low-velocity channel-margin habitats, which are the habitat types most sensitive to changes in river stage (Hlohowskyj and Hayse 1995, Osmundson et al. 1995). The Service believes that increases in suitable backwaters should provide additional nursery habitat in the 15-Mile Reach, possibly resulting in increased recruitment of Colorado pikeminnow. The Service concludes that, although information on habitat use by razorback suckers in the 15-Mile Reach is limited, providing nursery backwaters with adequate depth and stability for young fish should increase the likelihood for reestablishment of the species in this reach. All of the 14 early juvenile razorback suckers caught in riverine habitats of the Upper Colorado River Basin since 1962 were from backwaters (Taba et al. 1965; Gutermuth et al. 1994; Muth et al. 1998). The winter base-flow targets will continue to be met with implementation of the proposed action. During winter, adult Colorado pikeminnow mostly use pools and backwaters (Osmundson et al. 1995). Winter flows with the proposed action should provide adequate depth in these habitats for overwinter survival.

Nonnative fishes dominate the ichthyofauna of Colorado River basin rivers and have been identified as contributing to reductions in distribution and abundance of native fishes (Carlson and Muth 1989). Because introduced species vary in body size, environmental tolerances, and habitat preferences and have wide distributions, high abundance, and diets ranging from herbivory to piscivory, they are potential competitors with or predators on nearly all life stages of native fishes, but particularly young fish in nursery habitats. Nonnatives of greatest concern in the Upper Basin are red shiner, common carp, fathead minnow, channel catfish, northern pike, and centrarchids because of known or suspected negative interactions with native fishes (Hawkins and Nesler 1991). Lentsch et al. (1996) and Tyus and Saunders (1996) emphasized the need for nonnative fish control to achieve recovery of the endangered fishes and presented options for controlling nonnative fishes in the upper basin that included more restrictive stocking protocols, more liberalized harvest regulations, mechanical removal, chemical eradication, and management of flows to benefit native fishes and suppress the abundance of nonnative fishes. The purpose of the September 1996 Procedures for Stocking Nonnative Fish Species in the Upper Colorado River Basin is to ensure that all future stocking of nonnative fishes will be consistent with recovery of

the endangered fishes. Ongoing Recovery Program projects to actively control nonnative fishes in the Colorado River include mechanical removal of cyprinids and centrarchids from backwaters, and screening of point-sources and chemical eradication of fishes in ponds adjacent to the river within critical habitat to prevent escapement into the river during high flows. Nonnative fish control activities implemented by the Recovery Program should improve the quality of habitat for all endangered fishes by reducing predation and competition for food and space, resulting in enhanced native fish population abundance. The Service believes that providing backwaters with adequate depth and reduced nonnative predators or competitors will likely increase survival of young Colorado pikeminnow, and, in particular, razorback sucker, thereby potentially resulting in stronger year classes and enhanced levels of recruitment.

Habitat restoration and augmentation of populations through stocking to provide sufficient numbers of fish to take full advantage of restored habitats are key elements for recovery of the endangered fishes. Completion of fish-passage structures on the Colorado River will restore access to 55 miles of habitat historically occupied by endangered fishes between Palisade and Rifle. Runs and pools comprise 49 to 70 percent of the available habitat within this reach; these habitats provide excellent feeding and wintering areas for Colorado pikeminnow and razorback sucker (Anderson 1997). Providing access up to an additional 3,500 acres of floodplain habitat will also improve habitat quality during spring runoff. Floodplain habitats inundated and connected to the main channel by high spring flows are typically warmer and substantially more productive than the adjacent river and have abundant vegetative cover. These habitats apparently are important growth and conditioning areas for all life stages of razorback sucker (also used by adult Colorado pikeminnow), but are critical for survival of early life stages (Wydoski and Wick 1998; Muth et al. 1998). The decline of razorback sucker in the Upper Colorado River Basin has been linked to recruitment failure, and recovery of the species seems unlikely without restoration of floodplain habitats. Enhanced growth of young razorback suckers in warm, food-rich floodplain habitats may increase overall survival by reducing the effects of size-dependent processes on survival, such as shortening the period of vulnerability to predation by nonnative fishes (Muth et al. 1998).

The Service concludes that the effect of implementation of the recovery actions will be an increase in the populations of all four species of endangered fish. The Service believes the above recovery actions must be accomplished on schedule to halt further habitat degradation and promote restoration of important habitats and enhancement of endangered fish populations. The Service recognizes that the 15-Mile Reach flow recommendations will not be met for the spring months, and infrequently not met during the late summer/fall period; however, the Service anticipates that the combination of flow and nonflow recovery actions will increase populations of endangered fishes to the levels described as a “positive response” in Appendix D and restore critical habitat. The Service will use fish population responses to determine if the recovery actions are producing the desired positive results, but, because the endangered fishes are long-lived, detection of responses to recovery actions may take several years. Ultimately, the anticipated long-term species response to the Recovery actions is attainment of recovery goals, which are being developed. If fish population responses do not indicate that the Recovery actions are improving

populations to levels described as a “positive response” in Appendix D, section 7 consultation will have to be reinitiated, according to the conditions for reinitiation listed in the reinitiation notice and Appendix D. It should be noted that Appendix D will be refined as new information becomes available.

The criteria to determine positive or negative fish population responses is presented in the reinitiation notice of this biological opinion and in Appendix D. As described in the reinitiation notice, the status of fish populations will be reviewed prior to new depletions reaching 60,000 acre-feet/year. This review will begin when actual new depletion levels reach 50,000 acre-feet/year or the year 2015, whichever comes first. The method for determining the level of new depletions is described in Appendix B. According to the criteria outlined in Appendix D, a positive response would require the adult Colorado pikeminnow population estimate to increase to and to be maintained at approximately 1,100 individuals in the Colorado River (confluence of the Green River to Rifle). When population estimates for wild adult humpback chub are finalized, they will also be used to determine population response. As outlined in Appendix D, Colorado pikeminnow and humpback chub will serve as surrogates for razorback sucker and bonytail for 10 years. Recovery goals for all four species are expected to be developed in the year 2000. If a population meets or exceeds the numeric recovery goal for that species, it will be considered to exhibit a positive response. However, short of reaching a specific recovery goal, trends in certain populations indices provide an interim assessment of a species’ progress toward recovery.

It is the Service’s best scientific judgment at this time that the combination of flow and nonflow recovery actions will increase population estimates to levels described as a positive response in Appendix D and restore critical habitat. However, if this judgment is determined to be inaccurate during the year 2015 or at the 50,000 acre-feet/year check point, and population estimates for Colorado pikeminnow in the Colorado River do not reach 1,100 adults, this would be considered new information and section 7 consultation will be reinitiated.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Endangered Species Act. The Service is not aware of any future non-Federal actions not included in this action under consultation involving water depletions that are reasonably certain to occur in the action area.

CONCLUSION

After reviewing the current status of the endangered fishes, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service’s biological opinion that the proposed action is not likely to jeopardize the continued existence of

the Colorado pikeminnow, razorback sucker, bonytail, or humpback chub and is not likely to destroy or adversely modify the designated critical habitat of these species.

INCIDENTAL TAKE

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken so that they become binding conditions of any Federal discretionary activity, for the exemption in section 7(o)(2) to apply. The participating Federal Agencies have a continuing duty to monitor the activity covered by this incidental take statement. If the Recovery Program (1) fails to assume and implement the terms and conditions or (2) fails to retain oversight to ensure compliance with the terms and conditions, the protective coverage of section 7(o)(2) may lapse for the projects covered by this incidental take statement.

Incidental take is considered with full implementation of recovery actions which are part of the Project (Federal Action) which is the subject of this consultation. The Service has determined that no take including harm is anticipated to occur as a result of the depletions contemplated in this opinion because of the implementation of recovery actions. Take that is incidental to activities addressed in this opinion are associated with endangered fish being diverted into irrigation, municipal, and industrial water delivery systems. This incidental take is expected to be in the form of killing because the fish will likely enter canals and be transported by water to agricultural areas or irrigation, municipal, and industrial facilities where they would not survive. Any incidental take associated with recovery actions has been or will be addressed during project specific environmental compliance. The Recovery Program will be responsible for providing any required reasonable and prudent measures to minimize incidental take.

AMOUNT OR EXTENT OF TAKE

The Service considers it likely that adult Colorado pikeminnow and razorback sucker will swim into irrigation canals or be removed from the river through municipal or industrial water delivery systems along the Colorado River above the 15-Mile Reach. There are no major diversions in or downstream of the 15-Mile Reach. In the future, if and when reproducing populations of Colorado pikeminnow and razorback sucker are established upstream of the 15-Mile Reach, the Service anticipates some degree of incidental take of larval and young Colorado pikeminnow and razorback sucker in this area. The take is expected because of lack of larval habitat in canals and killing of larvae in water which will be removed from the river though irrigation, municipal, and industrial water delivery systems. The Service does not anticipate incidental take of bonytail or humpback chub in irrigation, municipal, or industrial water delivery systems because bonytail do not presently occur above the 15-Mile Reach and humpback chub tend to stay in canyon reaches.

The Service finds that the anticipated amount of incidental take associated with irrigation, municipal, and industrial water delivery systems will be difficult to detect for the following reasons: finding a dead or impaired specimen is unlikely; larval fish are extremely small; the river is very turbid and fish of any size are not easily observed. However, the anticipated incidental take for Colorado pikeminnow and razorback suckers >300 mm was estimated as follows.

Adult and Subadult Fish

Existing diversions from Rifle to the 15-Mile Reach include those used for agricultural, municipal, and industrial purposes. Many of these diversions are very small and pose little threat to fish >300 mm, because fish of this size are not likely to enter small canals or pumps. However, two major diversions above the 15-Mile Reach likely take all life stages of fish. These diversions are the Grand Valley Project Diversion Dam (Government Highline Canal) and the Grand Valley Irrigation Company Canal. The reasonable and prudent measure was developed to minimize take above the 15-Mile Reach at these large diversion canals.

The Service anticipates an annual incidental take of 1 percent of the current adult Colorado pikeminnow population above Westwater Canyon. The current population of adult Colorado pikeminnow above Westwater Canyon is estimated to be 253 fish, with a survival rate of 86 percent per year (Osmundson and Burnham 1998). Therefore, the current level of anticipated incidental take is 3 adult Colorado pikeminnow per year. As population estimates change (either up or down), the level of anticipated incidental take would change. A recent management objective of the Recovery Program (Lentsch et al. 1998) is to establish a population of 5,477 adult Colorado pikeminnow in the Colorado River. Assuming this target is met in the future and there is a similar distribution of adult fish as presented by Osmundson and Burnham (1996), there would be approximately 1,683 Colorado pikeminnow above Westwater Canyon. Therefore, the anticipated level of incidental take will increase to 17 adult fish per year or 1 percent of the adult population which ever is greater.

There are no current population estimates for razorback sucker in the Colorado River due to the low numbers of remaining fish. Therefore, the Service estimates the anticipated incidental take to be 2 adult fish per year until augmentation efforts are successful above the diversion structures. The current management objective is to have 5,316 adult razorback suckers in the Colorado River, in Colorado. As the population of razorback suckers increases, the incidental take could increase. The Service estimates future incidental take to be 1 percent of the population. Therefore, the anticipated level of incidental take will increase to 53 adult fish per year or 1 percent of the adult population which ever is greater.

To reduce the level of incidental take of adult and subadult Colorado pikeminnow and razorback sucker, reasonable and prudent measures have been developed.

Young Fish

Currently, there is no anticipated incidental take of larval or young fish, because there is no known reproduction of Colorado pikeminnow or razorback sucker above the 15-Mile Reach. However, in the future when passage is established at Price-Stubb and the Grand Valley Diversions, and reproducing populations are established, and spawning occurs above the 15-Mile Reach, the Service expects young fish might be diverted into canals. When it is detected that endangered fishes are spawning above the 15-Mile Reach, state-of-the-art sampling techniques will be applied to help the Service anticipate incidental take of young razorback sucker and Colorado pikeminnow.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that this level of anticipated incidental take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat with full implementation of recovery actions.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of Colorado pikeminnow and razorback sucker. The two diversions listed below have the greatest potential for access by the endangered fish because of their location and the amount of the river that is diverted at these facilities. It is not anticipated that other existing water delivery systems above the 15-Mile Reach pose much threat to the endangered fish, therefore, individual reasonable and prudent measures above the major diversions are not required at this time .

1. The Recovery Program will design, construct, and maintain fish preclusion devices to prevent or reduce adult and subadult fish (>300 mm total length) from entering the existing major irrigation diversion systems (Grand Valley Irrigation Company Canal and

Grand Valley Project Diversion Dam [Government Highline Canal]). These are Recovery Plan actions II.B.1.b.(3) and II.B.3.b.(3).

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the following terms and conditions must be complied with, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

1. The Recovery Program will develop an appropriate design for fish preclusion devices that are compatible with the operation of the subject facilities.

2. Fish preclusion devices to prevent or reduce adult and subadult fish (>300 mm total length) from entering the canals within the time frame outlined in the Recovery Action Plan will be constructed by the Recovery Program.

3. If another existing water delivery system between Rifle and the 15-Mile Reach is found to result in take that may cause the incidental take limit to be exceeded, then the Recovery Program will design and construct fish preclusion devices to prevent or reduce adult and subadult fish (>300 mm total length) from entering that facility.

4. A plan to monitor the amount of take will be developed by September 30, 2001, by the Recovery Program and added to the Recovery Action Plan.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize incidental take at existing facilities in the action area (Rifle to Lake Powell) from depletions above the confluence with the Gunnison River that might otherwise result from the proposed action. Incidental take statements exempt those actions covered by the incidental take statement from the Act's section 9 prohibitions if the reasonable and prudent measures and the implementing terms and conditions of incidental take statements are complied with. In summary, the anticipated incidental take of Colorado pikeminnow when adults are taken in irrigation canals and municipal intakes is 3 adult fish per year or 1 percent of the latest adult population estimate above Westwater Canyon, whichever is greater. The anticipated level of incidental take of razorback suckers when adults are taken in irrigation canals and municipal intakes is 2 adult fish per year or 1 percent of the adult population, whichever is greater. If, during the course of the action, this minimized level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation to review of the reasonable and prudent measures provided. The Service will consider the causes of the taking and review the need for possible modification of the reasonable and prudent measures.

If consultation is reinitiated because the incidental take limit has been exceeded for existing intakes between Rifle and the 15-Mile Reach, additional reasonable and prudent measures would be developed. The Recovery Program would be responsible for the implementation of any

additional reasonable and prudent measures for such intake structures. As stated in 50 CFR 402.14(I)(2) these "Reasonable and prudent measures along with the terms and conditions that implement them, cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes."

INDIVIDUAL CONSULTATIONS UNDER THE UMBRELLA OF THIS PROGRAMMATIC BIOLOGICAL OPINION

This programmatic consultation is on the Federal action as described on page 1. The Service believes that the Recovery Action Plan items are sufficient to avoid the likelihood of jeopardy and/or adverse modification of critical habitat for depletion impacts for individual existing depletions (estimated average annual 1 million acre-feet/year) as defined in the description of the proposed action, and future depletions (up to 120,000 acre-feet/year). Individual consultation is not required on future specific Federal actions within the scope of this opinion as they relate to Reclamation's existing operations and depletions as defined in the description of the proposed action, or to Reclamation's portion of the 120,000 acre-feet of new depletions from existing projects. Operation of Reclamation facilities to carry out recovery actions as described in this biological opinion will not require further section 7 consultation. However, individual section 7 consultation will still be required on all other future specific Federal actions pursuant to the Endangered Species Act, to determine if they fit under the umbrella of this programmatic biological opinion. Non-Federal projects with existing depletions are not required to consult under section 7 until there is a Federal nexus, at which time it will be determined if the project fits under the umbrella of this programmatic biological opinion. The following criteria must be met at the time of individual project consultation to rely on the Recovery Program and be considered under the umbrella of this programmatic consultation:

1. A Recovery Agreement must be offered and signed prior to conclusion of section 7 consultation.

2. A fee to fund recovery actions will be submitted as described in the proposed action for new depletion projects greater than 100 acre-feet/year. The 2000 fee is $14.36 per acre-foot and is adjusted each year for inflation.

3. Reinitiation stipulations, described below, will be included in all individual consultations under the umbrella of this programmatic.

4. The Service and project proponents will request that discretionary Federal control be retained for all consultations under this programmatic.

Under this opinion, future consultations that meet the criteria would avoid the likelihood of jeopardy and/or adverse modification of critical habitat from depletion impacts. Projects that don't meet the criteria are not part of the proposed action, and therefore will require consultation outside of the Recovery Program.

REINITIATION NOTICE

This concludes formal consultation on the subject action. As provided in 50 CFR sec. 402.16, reinitiation of formal consultation is required for Reclamation projects and where discretionary Federal Agency involvement or control over the action has been retained (or is authorized by law) and under the following conditions:

a. The amount or extent of take specified in the incidental take statement for this opinion is exceeded. The Service has determined that no incidental take, including harm, is anticipated to occur as a result of the depletions contemplated in this opinion because of the implementation of recovery actions. The implementation of the Recovery actions contained in this opinion will further decrease the likelihood of any take caused by depletion impacts.

b. New information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion. In preparing this opinion, the Service describes the positive and negative effects of the action it anticipates and considered in the section of the opinion entitled "Effects of the Action." New information would include, but is not limited to, not achieving a "positive response" or a significant decline in population, as described in Appendix D. Significant decline shall mean a decline in excess of normal variations in population (Appendix D). The current population estimate of adult Colorado pikeminnow in the Colorado River is 600 individuals, with a confidence interval of ± 250. Therefore, with the criteria established in Appendix D, a negative population response would trigger reinitiation if the population declined to 350 adults. The Recovery Program is currently developing recovery goals for the four endangered fishes. If a population meets or exceeds the numeric goal for that species, it will be considered to exhibit a positive response. The Service retains the authority to determine whether a significant decline in population has occurred, but will consult with the Recovery Program's Biology Committee prior to making its determination. In the event of a significant population decline, the Service is to first rely on the Recovery Program to take actions to correct the decline. If nonflow recovery actions have not been implemented, the Service will assess the impacts of not completing these actions prior to reexamining any flow related issues.

New information would also include the lack of a positive population response by the year 2015 or when new depletions reach 50,000 acre-feet/year. According to the criteria outlined in Appendix D, a positive response would require the adult Colorado pikeminnow population estimate to be 1,100 individuals (±250) in the Colorado River (Rifle to the confluence with the Green River). When the population estimate increases above 1,100, a new population baseline is established at the higher population level.

c. The Recovery Action Plan actions listed as part of the Proposed action in this opinion are not implemented within the required time frames. This would be considered a change in the action subject to consultation and the section 7 regulations (50 CFR 402.16 (c)) state that reinitiation of consultation is required if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion.

The Recovery Action Plan is an adaptive management plan because additional information, changing priorities, and the development of the States' entitlement may require modification of the Recovery Action Plan. Therefore, the Recovery Action Plan is reviewed annually and updated and changed when necessary and the required time frames include changes in timing approved by means of the normal procedures of the Recovery Program, as explained in the description of the proposed action. In 2003 and every 2 years thereafter, for the life of the Recovery Program, the Service and Recovery Program will review implementation of the Recovery Action Plan actions to determine timely compliance with applicable schedules.

d. The Service lists new species or designates new or additional critical habitat, where the level or pattern of depletions covered under this opinion may have an adverse impact on the newly listed species or habitat. If the species or habitat may be adversely affected by depletions, the Service will reinitiate consultation on the programmatic biological opinion as required by its section 7 regulations. The Service will first determine whether the Recovery Program can avoid such impact or can be amended to avoid the likelihood of jeopardy and/or adverse modification of critical habitat for such depletion impacts. If the Recovery Program can avoid the likelihood of jeopardy and/or adverse modification of critical habitat no additional recovery actions for individual projects would be required, if the avoidance actions are included in the Recovery Action Plan. If the Recovery Program is not likely to avoid the likelihood of jeopardy and/or adverse modification of critical habitat then the Service will reinitiate consultation and develop reasonable and prudent alternatives.

For purposes of any future reinitiation of consultation, depletions have been divided into two categories.

Category 1:

a) existing depletions, both Federal and non-Federal as described in the project description, from the Upper Colorado River Basin above the confluence with the Gunnison River that had actually occurred on or before September 30, 1995 (average annual of approximately 1 million acre-feet/year);

b) depletions associated with the total 154,645 acre-feet/year volume of Green Mountain Reservoir, including power pool (which includes but is not limited to the all of the 20,000 acre-feet contract pool and historic user's pool), the Colorado Big-Thompson replacement pool, and

c) depletions associated with Ruedi Reservoir including Round I sales of 7,850 acre-feet, Round II sales of 6,135 acre-feet/year as discussed in the Service's biological opinion to Reclamation dated May 26, 1995, and as amended on January 6, 1999, and the Fryingpan Arkansas Project replacement pool as governed by the operating principles for Ruedi Reservoir, but excluding 21,650 acre-feet of the marketable yield.

Category 1 depletions shall remain as Category 1 depletions regardless of any subsequent change, exchange, or abandonment of the water rights resulting in such depletions. Category 1 depletions associated with existing facilities may be transferred to other facilities and remain in Category 1 so long as there is no increase in the amount of total depletions attributable to existing depletions. However, section 7 consultation is still required for Category 1 depletion projects when a new Federal action occurs which may affect endangered species except as provided above under "Individual Consultation Under the Umbrella of this Programmatic Biological Opinion." Reinitiation of this consultation will be required if the water users fail to provide 10,825 acre-feet/year on a permanent basis.

Category 2:

Category 2 is defined as all new depletions up to 120,000 acre-feet/year; this includes all depletions not included in Category 1 that occur after 1995 regardless of whether section 7 consultation has been completed. This category is further divided into two 60,000 acre-feet/year blocks of depletions.

The recovery actions are intended to avoid the likelihood of jeopardy and/or adverse modification of critical habitat and to result in a positive response as described in Appendix D for both 60,000 acre-feet blocks of depletions in Category 2. However, prior to depletions occurring in the second block, the Service will review the Recovery Program's progress and adequacy of the species response to the Recovery Action Plan actions. According to the criteria outlined in Appendix D, a positive response would require the adult Colorado pikeminnow population estimate to be maintained at approximately 1,100 individuals in the Colorado River (Rifle to the confluence with the Green River), unless the criteria in Appendix D is changed because of new information. If the adult Colorado pikeminnow population is maintained at approximately 1,100 adults or whatever is determined to be the recovery goal in the Colorado River, a new population baseline would be established to determine a positive or negative population response.

When population estimates for wild adult humpback chub are finalized, it would also be used to determine population response. As outlined in Appendix D, Colorado pikeminnow and humpback chub population estimates will serve as surrogates for razorback sucker and bonytail to assess the status of their populations for 10 years. Recovery goals for all four species are expected to be developed in the year 2000. If a population meets or exceeds the numeric goal for that species, it will be considered to exhibit a positive response. However, short of reaching a specific recovery goal, trends in certain populations indices provide an interim assessment of a species' progress toward recovery. This review will begin when actual depletion levels from the first depletion block reach 50,000 acre-feet/year or the year 2015, whichever comes first.

Calculation of actual depletions is to be accomplished using Cameo gage records and State Division of Water Resources data (Appendix B). The review will include a determination if all the Recovery actions have been satisfactorily completed, that all ongoing Recovery actions are continuing, and the status of the endangered fish species. If it is determined that the Recovery

actions have all been completed and the status of all four endangered fish species has improved (based on criteria in Appendix D), then the Service intends that this opinion would remain in effect for new depletions up to 120,000 acre-feet/year (total of both 60,000 acre-feet blocks of Category 2 depletions).

Monitoring, as explained in Appendix D, will be ongoing to determine if a population estimate of 1,100 (± one confidence interval) adult Colorado pikeminnow is maintained. If it is not maintained, this would be considered new information and section 7 would have to be reinitiated. Population baselines will be adjusted as population estimates change. If the adult Colorado pikeminnow population estimates increase during the next 15 years, a new population baseline would be established to determine a positive or negative population response. If the population estimate for Colorado pikeminnow in the year 2015 is greater than 1,100 adults, then the higher number would be used to establish a new population baseline. These numeric values may be revised as new information becomes available. Revisions will be made to Appendix D as needed.

If the 50,000 acre-foot or 2015 review indicates that either the recovery actions specified in this opinion have not been completed or that the status of all four fish species has not sufficiently improved, the Service intends to reinitiate consultation on the Recovery Program to specify additional measures to be taken by the Recovery Program to avoid the likelihood of jeopardy and/or adverse modification of critical habitat for depletions associated with the second 60,000 acre-feet/year block. Any additional measures will be evaluated every 5 years. If other measures are determined by the Service or the Recovery Program to be needed for recovery prior to the review, they can be added to the Recovery Action Plan according to standard procedures, outlined in that plan. If the Recovery Program is unable to complete those actions which the Service has determined to be required for the second 60,000 acre-feet/year, consultation on projects with a Federal nexus may be reinitiated in accordance with Endangered Species Act regulations and this opinion's reinitiation requirements. The Service may also reinitiate consultation on the Recovery Program if fish populations do not improve according to the criteria in Appendix D or if any positive response achieved prior to the 50,000 acre-foot or the year 2015 review is not maintained. Failure to maintain a positive response, whenever achieved, will be considered a negative response.

If the Service reinitiates consultation, it will first provide information on the status of the species and recommendations for improving population numbers to the Recovery Program. Only if the Recovery Program does not implement recovery actions to improve the status of the species, will the Service reinitiate consultation with individual projects. The Service will reinitiate consultation first on Category 2 projects and second on Category 1 projects. The Service will only reinitiate consultations on Category 1 depletions if Category 2 depletion impacts are offset to the full extent of the capability of the covered projects as determined by the Service, and the likelihood of jeopardy and/or adverse modification of critical habitat still cannot be avoided. The Service intends to reinitiate consultations simultaneously on all depletions within the applicable category.

All individual consultations conducted under this programmatic opinion will contain language requesting the applicable Federal agency to retain sufficient authority to reinitiate consultation should reinitiation become necessary. The recovery agreements to be signed by non-Federal entities who rely on the Recovery Program to avoid the likelihood of jeopardy and/or adverse modification of critical habitat for depletion impacts related to their projects will provide that such non-Federal entities also must request the Federal agency to retain such authority. Non-Federal entities will agree by means of recovery agreements to participate during reinitiated consultations in finding solutions to the problem which triggered the reinitiation of consultation.

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A Review of the Upper Colorado River Endangered Fish Recovery Program's Recovery Actions and Endangered Species Response in the Colorado River

as called for in the U.S. Fish and Wildlife Service's

FINAL PROGRAMMATIC BIOLOGICAL OPINION FOR BUREAU OF RECLAMATION'S OPERATIONS AND DEPLETIONS, OTHER DEPLETIONS, AND FUNDING AND IMPLEMENTATION OF RECOVERY PROGRAM ACTIONS IN THE UPPER COLORADO RIVER ABOVE THE CONFLUENCE WITH THE GUNNISON RIVER
DECEMBER 1999

ES/GJ-6-CO-99-F-033



Prepared by the
The Upper Colorado River Endangered Fish Recovery Program Director's Office

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Executive Summary: Program Progress and Relevant Trends Pertaining to

15-Mile Reach Species Recovery Efforts to Date

Recovery Action Plan Action	Program Progress: Successes (+), Shortcomings (~), and Remaining Uncertainties (?)	Notable Trends: Encouraging (+) and Concerning (~)
Habitat Protection (Flows) (Section 3.1)	**+** Progress reducing shortages to base flow targets; since 1998, the Program has augmented 15-Mile Reach (15MR) base flows during the Aug-Oct period on average by more than 400 cubic feet per second (cfs) **+** Progress enhancing peak flows in nearly 50% of years with an average of more than 33,000 acre-feet of deliveries through voluntary coordinated reservoir operations **~** In spite of substantial Program flow augmentation and collaboration by water users to augment flows, 15MR flows frequently fall short of PBO recommendations, particularly in dry years	**+** Successful acquisition of additional water for 15MR augmentation in recent years **+** 10-year running average depletion analyses indicate no net new depletions to flows since 2000 (Section 2) **~** Natural runoff in this basin in the July-through-October base flow months is likely to decrease with climate change
Habitat Development and Maintenance (Section 3.2)	**+** Fish passages have been installed at all four target locations in Grand Valley; fish now have unrestricted access to the entire 240 miles of designated Critical Habitat (CH) in the Colorado River from the Green River confluences to near Rifle, Colorado, including the previously inaccessible upper 55 miles of CH in the Colorado River **+** Fish screens have been installed at all major Grand Valley diversions (at all three target locations) **+** Diversion canal fish salvage operations conducted annually since 2002 have salvaged approximately 300,000 native fish, including (19) RBS and (15) bonytail through 2018 **?** 592 acres of floodplain habitat have been acquired and enhanced along Colorado and Gunnison Rivers, which is less than the Program originally thought possible, but reflects the participation by willing landowners	**+** Increased endangered fish use of passages in the Grand Valley since 2007 **+** Improved reliability of fish screen operations over time **+** Improved Program understanding of effective floodplain operation and management ~Irrigation fish screens and passages are not operated continuously, as low flow periods preclude the ability to maintain screens and passages
Native fish stocking (Section 3.3)	**+** More than 220,000 razorback sucker have been stocked in the upper Colorado River basin (UCRB) system since 1995, generally meeting annual targets for numbers and size **+** More than 145,000 bonytail have been stocked in the UCRB system since 2000, generally meeting annual targets for number and size	**+** Growing numbers of juvenile and adult razorback sucker are being found in upper basin primarily because of stocking efforts; evidence of recruitment still very rare but increasing **~** Very low recapture rates and low survival of stocked bonytail

Nonnative fish control (Section 3.4)	**+** Since 2004, ~$2.5 million has been expended on nonnative predator control in the Colorado River between Rifle, Colorado and Westwater Canyon **+** Through electrofishing, backwater seining, and selective removal at fish passages, thousands of nonnative fish are removed annually from the UCRB system. ~Abundances of smallmouth bass and walleye remain problematic throughout the Grand Valley and downstream + States are more effectively controlling off-channel sources of nonnative fish through various activities, including installation of measures to prevent reservoir escapement, removal of bag limits associated with certain problematic species, shifting sportfishing management to species that are compatible with recovery, and fishing tournaments targeting non-natives	**~** Since PBO was written, the threat of non-native fish predation and competition has increased greatly ~ Despite monumental control efforts, smallmouth bass (the most problematic predator) still demonstrate capacity to spawn successfully and in large numbers during most years ~The emergence of walleye as a predator of juvenile Colorado pikeminnow is troubling + Northern pike are now very rare in the Colorado River and smallmouth bass have been reduced upstream of the GVWUA diversion ~ Continued illegal introductions of nonnative fish require expensive reservoir treatment and screening
Research, Monitoring, and Data Management (Section 3.5)	**+** SSA and 5-Yr Review for Colorado pikeminnow (CPM) completed in 2020 **+** SSA and 5 Yr Review for Humpback chub (HBC completed in 2018; a proposed rule + 4(d) to downlist was published in January 2020 **+** SSA and 5-Yr Review for Razorback sucker (RBS completed in 2018; a proposed rule + 4(d) to downlist was published in January 2021	**+** The population of Colorado pikeminnow in the Colorado River has demonstrated long-term stability since 1992 **~** However, the CPM population basinwide has been in decline since 2005 and is currently at historically low levels largely because of impacts from nonnative species + HBC populations in Black Rocks and Westwater canyons declined through 2007 but have increased or stabilized since that time. The combined population estimate of these two populations (~3,600 to 3,800) exceed the 2002 adult demographic criterion of 2,100 + RBS larval, young-of-year, juvenile, and adult numbers continue to increase as the result of continued stocking and spawning successes

Table of Contents

1 Background 5

1.1 History 5

1.2 Purpose and Need for this Review 5

1.3 Review Process as Described in PBO 6

2 New Depletions Accounting (Colorado Water Conservation Board Lead) 7

3 Recovery Actions and Endangered Species Response 10

3.1 Flow Protection 10

3.1.1 Peak Flows 11

3.1.2 Base Flows 16

3.1.3 SUMMARY 29

3.2 Habitat Development and Maintenance 32

3.2.1 Floodplain Acquisition and Management 32

3.2.2 Fish Passage Structures 33

3.2.3 Fish Screens 35

3.2.4 Irrigation Efficiency 37

3.2.5 Summary 37

3.3 Native Fish Stocking 38

3.4 Nonnative Fish Control 39

3.4.1 Background 39

3.4.2 Removal Efforts 40

3.4.3 Reservoirs as Sources 41

3.4.4 Regulations and agreements 42

3.4.5 Summary 43

3.5 Research, Monitoring, and Data Management 43

3.5.1 The State of Endangered Fish Monitoring in 1999 44

4 Long Term Funding 57

5 Conclusions 58

6 Recommendations 58

1 Background

1.1 History

On December 20, 1999, the U.S. Fish and Wildlife Service (Service or USFWS) finalized the first of three programmatic biological opinions for water depletions in the upper Colorado River basin. Known as the "15-Mile Reach Programmatic Biological Opinion (PBO)", the proposed action evaluated in the consultation included existing water depletions[1] and 120,000 acre-feet (AF) per year of potential new depletions, including the Bureau of Reclamation's (Reclamation's) reservoir operations and water depletions, other non-federal water depletions, and funding and implementation of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program or Program). The consultation considered a 15 mile action area within the Colorado River upstream from the Gunnison River confluence (located at Colorado River Mile 171 – miles upstream of the confluence with the Green River) to the Grand Valley Irrigation Company diversion structure (RM 185.5), also known as the 15-Mile Reach. This 15-Mile Reach is situated in the upper portion of Designated Critical (Service 1994) on the Colorado River, which extends from the Green River confluence in Utah upstream to near Rifle, CO (RM 240.4). The proposed action impacts the endangered fishes by reducing the quantity of water in the occupied habitat, thus altering the ecological conditions for the fishes. However, the PBO considered that funding and implementation of the Recovery Program would constitute a sufficient conservation measure because the Recovery Program would implement recovery actions, such as flow augmentation and protection, habitat restoration, endangered fish stocking, and nonnative fish control. The PBO cites specific action items needed to enhance the populations of the endangered fishes and charges the Recovery Program with the responsibility to ensure that these action items are completed and/or implemented. Therefore, the PBO concluded that implementation of the Recovery Program would sufficiently offset impacts of water development and the proposed action would not jeopardize the continued existence or recovery of the endangered fishes. In order to ensure adequate advancement of the recovery actions, Page 74 of the PBO says: "In 2003 and every 2 years thereafter, for the life of the Recovery Program, the Service and Recovery Program will review implementation of the Recovery Action Plan actions to determine timely compliance with applicable schedules." Those biennial reviews have been completed on schedule since 2003.[2]

1.2 Purpose and Need for this Review

In the PBO, the Service identified checkpoints to determine if its original conclusion remained valid or if re-initiation of Section 7 consultation was necessary:

The recovery actions [both flow and non-flow] *are intended to avoid the likelihood of jeopardy and/or adverse modification of critical habitat and to result in a positive response as described in Appendix D for both 60,000 acre-feet blocks of depletions. However, prior to depletions occurring in the second block,*

[1] Depletions prior to 1995; estimated in the amount of ~1 million acre-feet (af) per year.

[2] Biennial reviews of recovery actions related specifically to the 15-Mile Reach PBO have been coupled with the Service's annual Sufficient Progress reviews of the Recovery Program and can be found at: http://www.coloradoriverrecovery.org/documents-publications/section-7-consultation/sufficient-progress-letters.html

the Service will review the Recovery Program's progress and adequacy of the species response to the Recovery Action Plan actions…. Recovery goals for all four species are expected to be developed in the year 2000. If a population meets or exceeds the numeric goal for that species, it will be considered to exhibit a positive response. However, short of reaching a specific recovery goal, trends in certain population indices provide an interim assessment of a species' progress toward recovery. This review will begin when actual depletion levels from the first depletion block reach 50,000 acre-feet/year or the year 2015, whichever comes first.

[excerpt from PBO – Reinitiation Criteria; pg 75]

This review is based on the time requirement, as the 50,000 acre-feet/year depletion level has not been reached.

1.3 Review Process as Described in PBO

Prior to reaching the water depletion checkpoint of 60,000 acre-feet referenced in the biological opinion, but no later than 2015, the Recovery Program Director's office or the Fish and Wildlife Service will prepare a report describing fish population status and trends based on the population indices and other factors. The report will be reviewed by the Biology and Management Committees prior to finalization. Based on this report, the Service will determine whether continuing water depletions up to the 120,000 acre-feet/year limit established in the biological opinion is biologically justified. The Service's rationale and conclusions will be documented in a report to the Biology, Management, and Implementation Committees. If necessary, the Service would amend the biological opinion, as appropriate.

[excerpt from PBO – Appendix D]

This review follows the structure of the Proposed Action in the PBO. We provide an update on water depletion accounting, a status report of recovery actions {'other factors' from above}, and an assessment of status and trends of the endangered fish. Throughout this review (section by section) we offer to the Service the rationale for the Recovery Program's conclusions and recommendations that re-initiation or amendment of the PBO is not needed at this time. We expect that the Service will respond to the adequacy and conclusions of this assessment with a formal concurrence following the Service's review of this document.

2 New Depletions Accounting

2.1 Colorado Water Conservation Board Depletion Estimates

The 15-Mile Reach PBO provides Endangered Species Act (ESA) compliance for water uses in the Colorado River basin upstream of the Gunnison River confluence existing as of 1999, plus up to 120,000 acre-feet/year (AFY) of new depletions. It separates the 120,000 AFY into two 60,000 AFY 'blocks', and specifies (page 75) that "prior to depletions occurring in the second block, the Service will review the Recovery Program's progress and adequacy of the species response to the Recovery Action Plan actions."

To determine the magnitude of depletions affecting flows in the 15-Mile Reach, Appendix B of the PBO describes a process of periodic data collection, modeling, and reporting to account for water depletions. In compliance with those requirements, and using the State Consumptive Use (CU) model, the Colorado Water Conservation Board (CWCB) in 2008 completed depletion accounting and reporting for the 2001 to 2005 period (CWCB 2008). In 2020, using the same model, CWCB completed depletion accounting and reporting for the 2006-2010 and 2011-2015 periods (CWCB 2020). [3]

Table 1 summarizes CWCB's conclusions. Results are presented for both the average depletions calculated for each 5-year period, and for the 10-year average of annual depletions at the end of the last two periods (the PBO, recognizing the extreme year-to-year variability in hydrology and water use demand patterns, recommended that depletions be calculated as a 10-year moving average). Differences between the modeled post-1999 periods and the PBO comparison baseline are presented in the shaded columns. Those differences correspond to estimated net changes in depletions since the PBO took effect.

As indicated in Table 1, all of the CWCB analyses for the three periods indicate that net new depletions have not approached or are not approaching the 60,000 AFY "first block" magnitude. CWCB's analyses, depending on the time periods compared, suggest that total depletions have ranged from a *decrease* of 139,902 AFY during the baseline period in 2011-2015 (i.e., no net new depletions) to an increase of 19,472 AFY in 2006-2010 (representing net new depletions). The wide range in these estimates reflect

[3] Colorado used the StateCU model for these analyses, and incorporated an elevation adjustment for the Modified Blaney-Criddle crop evapotranspiration (ET) estimates for all three modeled periods. This adjustment increases estimated ET and is believed to result in more accurate consumptive use estimates. For the 2006-2015 analyses, Colorado also used a variable efficiency method to model irrigation efficiency. Colorado re-quantified the baseline (pre-1995) depletion estimates using the same methodology, to ensure consistency in comparing all time periods. While this methodology does not strictly adhere to what was contemplated in Appendix B of the 1999 PBO, the technical reviewers convened by the Recovery Program were satisfied with Colorado's depletion analyses, and recommended to the Service that it be accepted as satisfying the requirements of the PBO.

the substantial year-to-year variations in depletions, due primarily to variations in trans-mountain diversions (basin exports) and in agricultural consumptive use. Figure 1 illustrates this interannual variability, and identifies estimated Colorado River depletions above the Gunnison River confluence attributable to each of several water use categories from 1971 to 2015.

Table 1. Summary of depletions estimates from Colorado River Conservation Board's two depletion reports (CWCB 2008 and CWCB 2020).

Period	A	B	C	D	E	F
	Estimated average consumptive use during 5-year period (AFY)	**Estimated average consumptive use during comparison period (AFY)**	**Net difference between Column A and Column B averages (AFY)**	**Estimated 10-year average total depletions at end of period (AFY)**	**Estimated 10-year average total depletions at end of 1971-1995 baseline period (AFY)**	**Net difference between 10-year averages in Column D and E (AFY)**
2001-2005	987,200	1,029,000 (1971-2005)	-41,800	Not reported	Not reported	
2006-2010	1,100,528	1,081,056 (1971-1995)	+19,472	1,074,811	1,094,105	-19,294
2011-2015	941,154	1,081,056 (1971-1995)	-139,902	1,020,841	1,094,105	-73,264

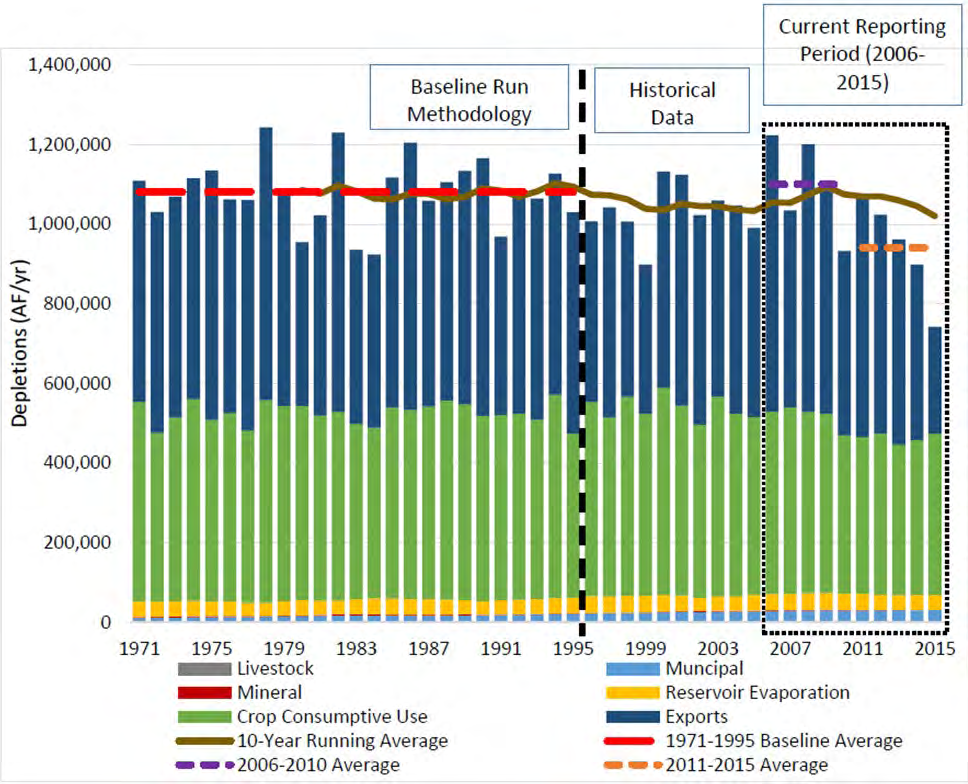


Figure 1. Estimated Colorado River basin depletions above the Gunnison River confluence by water use category, 1971-2015 (from CWCB 2020).

2.2 U.S. Fish and Wildlife Service Consultations Tracking

The Recovery Program maintains a list of all projects that have been consulted on since the Program was initiated in January 1988. Consultations eligible for coverage under the 15-Mile Reach PBO are summarized and publicly available online[4]. Since establishment of the 15-Mile Reach PBO in 1999 through the end of 2019, 348 post-PBO projects in the basin have consulted with the USFWS and received ESA coverage under the PBO. Collectively these represent 52,190 AFY of estimated new depletions at full build-out. Note that many of these water uses are not yet fully developed, and thus depletions from those uses are not yet fully occurring in the Colorado River. This list is not an accounting of new depletions to Colorado River flows occurring as of the date of this report; CWCB's depletions accounting described above is the sole assessment of actual depletions relative to the PBO baseline and incorporates depletions through 2015.

2.3 Summary

CWCB's analyses of depletions in the Colorado River above the Gunnison River confluence indicate that net new depletions to flows since 1999, if any, have on average remained well below the 50,000 AFY net new depletion threshold that would trigger an evaluation of the Program's sufficiency for a 'second block' of new depletions. Exports from the basin, which vary tremendously from year to year, were significantly lower than the long-term average over the most recent 2011-2015 reporting period, especially during the last two years of this period, and this contributed to the net decrease in estimated total depletions.

Future trends in basin depletions remain to be determined through future depletions analyses. The depletions analyses through 2015 suggest that the 2005 PBO can provide ESA compliance for considerable additional water development before triggering the need to evaluate PBO sufficiency for a second block of new depletions.

[4] https://www.coloradoriverrecovery.org/documents-publications/section-7-consultation/sec7/4-15MR%20PBO%20Table%20through%2031Dec18x.pdf

3 Recovery Actions and Endangered Species Response

3.1 Flow Protection

The Colorado River's 15-Mile Reach is a particularly important reach of river for Colorado pikeminnow and razorback sucker, and is considered critical to the recovery of these species' Colorado River populations (Osmundson 1996). Providing and protecting adequate instream flows is of high importance due to the quality and extent of habitat available for endangered fish in this reach, as well as in the river reaches above and below (Osmundson 2000). The PBO (p. 37) notes that the 15-Mile Reach is important to endangered fish for several reasons:

- The 15-Mile Reach provides valuable spawning habitat for Colorado pikeminnow and razorback sucker;
- The 15-Mile Reach provides an optimum balance between temperature and food availability for adult Colorado pikeminnow in the Colorado River; and
- The 15-Mile Reach provides an important refuge for endangered fishes should a catastrophic event cause a loss of populations in the Gunnison River or in the Colorado River below the Gunnison River confluence.

Osmundson (2000) further elaborated on this reach's important role in the overall life history of the Colorado pikeminnow. The Colorado River reach downstream of Moab, Utah, provides the most important rearing habitat for young pikeminnow, while the reach upstream of Westwater, Utah, evidently provides the most important adult habitat in the Colorado River.

> "Upstream of Westwater, the 33-mile long Grand Valley [18 river miles in Colorado downstream of the Gunnison River confluence, plus the 15-Mile Reach above the confluence] consistently supports the greatest concentrations of adult Colorado pikeminnow. The relatively high gradient, clear water, broad floodplain and a diversity of habitat types make these upstream sections of river more productive than more downstream sections. Higher standing stocks of periphyton and invertebrates support relatively high numbers of forage fish, in turn providing greater food availability for the rivers top [native] piscivore, the Colorado pikeminnow." (p. i)

Efforts to maintain adequate instream flows in the 15-Mile Reach are complicated by its location immediately downstream of several large senior-priority water diversions, and upstream of Gunnison River inflows. Thus, many of the Recovery Program's recovery actions are targeted at protecting and augmenting flows in this reach.

Flow recommendations for the Colorado River 15-Mile Reach generally fall into two categories: elevated spring peak flows that are intended to mobilize streambed sediment, maintain channel complexity, and provide spawning cues; and lower base flows that provide over-summer foraging and sheltering habitat, support the food base, and allow for fish movement.

3.1.1 Peak Flows

3.1.1.1 Spring Peak Flow Recommendations for the 15-Mile Reach

The clean cobble bars found in the 15-Mile Reach provide some of the most suitable spawning conditions for the Colorado pikeminnow and razorback sucker. Coarse bed materials that build those bars are mobilized, cleansed of fine sediment, and redistributed during very high spring runoff, which contributes to channel habitat complexity supporting these species' reproduction and survival.

Spring peak flow recommendations for the 15-Mile Reach by Osmundson et al. (1995) are incorporated into the PBO. They describe recommended magnitudes and frequencies of peak flows (Table 1), as well as mean monthly flows considered capable of producing these peaks while maintaining the natural shape of the spring hydrograph (Table 3).

Table 2. Target peak spring flows in the 15-Mile Reach in cubic feet/second (cfs)

> 23,500 cfs (5 in 20 years) – "Wet" years **21,750 cfs** (10 in 20 years) – "Wet/Average" years **16,700 cfs** (16 in 20 years) – "Dry/Average" years **12,900 cfs** (20 in 20 years) – "Dry" years

Table 3. Mean Monthly Flow Recommendations for the April-July Peak Runoff Months in the 15-Mile Reach, in cfs

	Percent Exceedance			
	25	**50**	**80**	**100**
APR	3,210	2,440	2,260	1,860
MAY	10,720	9,380	7,710	7,260
JUN	15,660	14,250	11,350	6,850
JUL	7,060	5,370	3,150	1,480

These recommendations represent refinements to the earlier flow recommendations of Osmundson and Kaeding (1991) by incorporating the results of subsequent streambed monitoring studies. Field work by Osmundson et al. (1995) indicated that the spring runoff in 1993, which peaked at 25,900 cubic feet per second (cfs), was capable of moving coarse bed materials and winnowing accumulated fine sediments from the channel substrate. Based on preliminary results from hydrologic modeling (Pitlick and Van Steeter 1994), Osmundson et al. (1995) determined that a peak of 23,500 cfs (the wet year target) would be capable of moving bed materials.

Peak flows in excess of 12,900 cfs (the dry year target) were recognized by Pitlick et al. (1996) as being important because these appear to be capable of flushing accumulated fine sediments from the bottoms of backwaters, thereby restoring backwater depths.

3.1.1.2 Recovery Program Actions / Reservoir Operations for Spring Peak Flows

Coordinated Reservoir Operations (CROS) to augment spring peak flows in the 15-Mile Reach were first implemented in 1997. Under CROS, upper basin reservoir operators voluntarily coordinate and bypass inflows to enhance the Colorado River's natural spring peak. Augmentation of the peak occurs when (1) peak flows are forecast to be between 12,900 cfs and 26,000 cfs in the 15-Mile Reach, and (2) when

participating reservoir operators voluntarily agree to coordinate their bypass of flow to significantly boost the peak flow. The goal of CROS is to increase both the magnitude and duration of the spring peak without impairing the water rights and yields of participating reservoirs.

The 26,000 cfs upper limit respects potential flooding concerns. The flood stage elevation on the Colorado River at the U.S. Geological Survey (USGS) Cameo gage (#09095500) has been established as 12.5 feet by the National Weather Service[5]. According to provisional February 2020 USGS rating curve data, this stage elevation corresponds to a discharge of nearly 26,000 cfs. During unusually wet years, peak flow at this location exceeds 30,000 cfs without augmentation.

Conditions have been conducive in 11 of the 23 years from 1997 through 2019 for coordinating an enhanced peak flow through CROS implementation. These 11 years of CROS operations, and the corresponding bypasses/releases from participating reservoirs to augment peak flows, are summarized in Table 4. As noted therein, collective reservoir releases for peak flow augmentation during CROS years have ranged from 6,949 to 73,971 AF.[6]

Table 4. Voluntary CROS contributions from upstream reservoirs, 1997 through 2019, for coordinated peak flow augmentation in the 15-Mile reach (in AF).

Coordinated Reservoir Operations (CROS)					Augmentation of Peak Flows (AF released/bypassed)					
Reservoir	**Homestake**	**Lake Granby**	**Green Mtn**	**Ruedi**	**Williams Fork**	**Willow Creek**	**Windy Gap**	**Wolford Mtn**	**Moffat Tunnel**	**Total AF**
1997			3,568	693	946			10,635		**15,842**
1998			12,482	5,106	1,672			4,431		**23,691**
1999		8,515	11,010	3,602	1,543	6,631		8,555		**39,856**
2006			6,788	6,297	6,625			9,007		**28,717**
2008			2,101	4,848						**6,949**
2009			14,113	5,858	5,044	2,638	2,061	13,069		**42,783**
2010			34,666	10,050	19,982			9,273		**73,971**
2015		18,002	11,292	4,599	2,733	8,000	906	4,587		**32,117**
2016	1,430		8,632	4,007	4,893			8,452	1,960	**29,374**
2017			14,410	4,502	3,293	7,206		4,245	2,079	**35,735**
2019	655		21,223	5,998	9,273		2,007			**39,156**
Sum	**2,085**	**26,517**	**140,285**	**55,560**	**56,004**	**24,475**	**4,974**	**72,254**	**4,039**	**368,193**

3.1.1.3 Recovery Program Historic Performance in Meeting PBO Spring Peak Flow Recommendations

Although CROS operations were first implemented in 1997, reservoir releases intended to improve habitat conditions for the endangered fish in the 15-Mile Reach began in 1991. Figure 2 illustrates ranked spring peak flows at the top of the 15-Mile Reach as measured at the USGS's Palisade, Colorado

[5] This flood elevation was resurveyed by NWS in 2010, at the request of the Recovery Program.

[6] For reference, a release of 10,000 AF is equivalent to a release of about 720 cfs for a period of seven days. Flow losses and attenuation en route to the 15-Mile Reach typically would result in some reduction of the flow magnitude.

stream gage (#09106150) from 1991 through 2017. During this period, peak flows ranged from 4,520 cfs in 2002 to 32,700 cfs in 2011. The red line in Figure 2 illustrates the recommended frequency of peak flows of various magnitudes over this period as established by the Program (Table 2), while the blue bars demonstrate the observed distribution of hydrologic conditions over this series of years. Asterisks in the figure denote years in which CROS releases augmented peak flow in the 15-Mile Reach. While the delivery pattern differed in each of the 11 CROS years, the average amount of bypassed water during CROS operations (33,469 acre-feet) is equivalent to 2,410 cfs for seven days; it is reasonable to conclude the 15-Mile Reach peak flow in CROS years was typically increased by a similar magnitude.

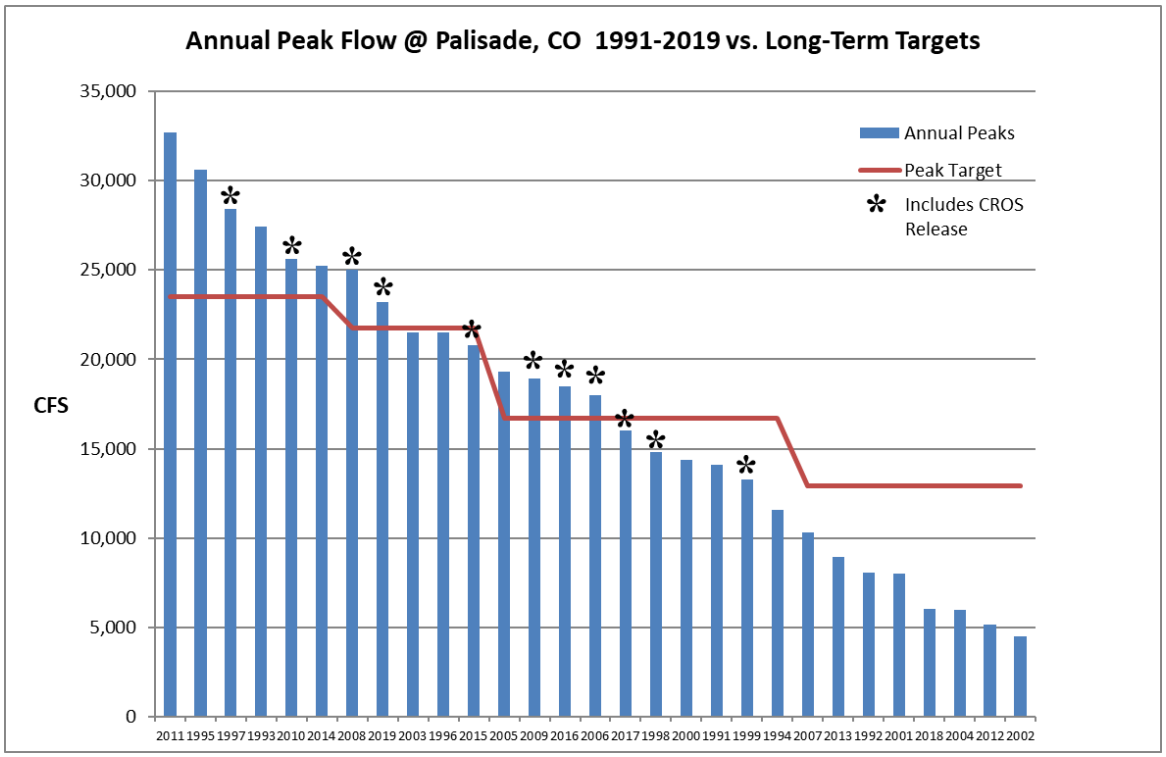


Figure 2. Annual peak flows at the top of the 15-Mile Reach, including augmented flow from CROS releases. The red line illustrates the recommended frequency of peak flows of particular magnitudes based on the actual distribution of runoff season hydrologic year types observed over this period.

Over these 29 years, flows have exceeded the 'wet' year target of 23,500 cfs seven times, surpassing the Program's target of six years. CROS contributed to peak flow in three of these years. Eleven years during this period exceeded or came within 5% of the 'average-wet' year peak flow target of 21,700 cfs, compared to 11 years in which this target was applicable, with CROS operations augmenting five of these events. Conversely, peak flows have generally fallen short of the target magnitudes over the drier half of this 29-year distribution.

As already mentioned, peak flows in excess of 12,900 cfs are recognized in the PBO as being important because they sweep fine sediments from backwater habitats in the 15-Mile Reach (Pitlick et al. 1996). Since 1991, peak flows in excess of this magnitude have occurred in 69% of years (20 of 29). CROS augmented the peak in 11 of those 20 years.

In summary, the 15-Mile Reach is experiencing high peak flows (>23,500 cfs) at greater than recommended frequencies, aided substantially by CROS releases. However, the lower peak targets corresponding to drier-than-average years are not met at the recommended frequency. The recommended minimum peak to be met in all years (>12,900 cfs) has been met in only 69% of years since 1991. As discussed below, a review of pre-Program peak flows in the 15-Mile Reach suggests that the 12,900 cfs dry-year target may not be realistic.

3.1.1.4 Reconsidering Minimum Peak Flow Targets

The Program's recommendation to achieve a minimum peak flow of 12,900 cfs in all years, based on the Pitlick et al. (1996) recommendation, does not appear to align well with the recent historic flow regime at this Colorado River location. An evaluation of historic flows since 1943 suggests that annual peaks exceeding 12,900 cfs in the 15-Mile Reach have occurred with a frequency of only around 53% to 76%, depending on the time period considered (Figure 3). Three periods are illustrated in Figure 3: The red line plots peak flow exceedance frequencies for the 1943-1968 period, which was a very active period of dam construction upstream of the 15-Mile Reach (Green Mountain Reservoir, Lake Granby, Williams Fork Reservoir, Dillon Reservoir, and Ruedi Reservoir all became operational during this period). The blue line plots peak flow exceedance frequencies for the 1969-1990 period following the most active dam construction phase, but before the Recovery Program began managing flows. The green line plots peak flow exceedances for 1991-2019, during which time the Recovery Program has been active. In light of the peak flow distributions observed over these 77 years, the Service needs to be aware how difficult it has been and will be to achieve a spring peak of 12,900 cfs in the 25% driest years. We recommend the addition of a task and timeline to the Recovery Implementation Plan (RIPRAP) to evaluate the need to revise or qualify the 12,900 cfs minimum peak flow target based on these historical analyses and the Recovery Program's past efforts to achieve it.

The Recovery Program recently completed a strategy to evaluate peak flow recommendations throughout the upper Colorado River basin overall (LaGory et al. 2016). As part of that strategy, a recommendation was made to monitor fine sediment mass balance at a variety of locations including in the mainstem of the Colorado River above and below the confluence with the Gunnison River. The intent being that monitoring fine sediment mass balance may help inform the Program's understanding of flows necessary to maintain satisfactory channel conditions under the current sediment budget. The Program chose to initiate fine sediment transport studies in 2017 on the middle reach of the Green River, its highest priority monitoring location. Based on lessons learned on the Green River (under Project 85f; Topping 2020), similar fine sediment mass balance work could be implemented on the Colorado River as future priorities are identified, and annual work plans developed.

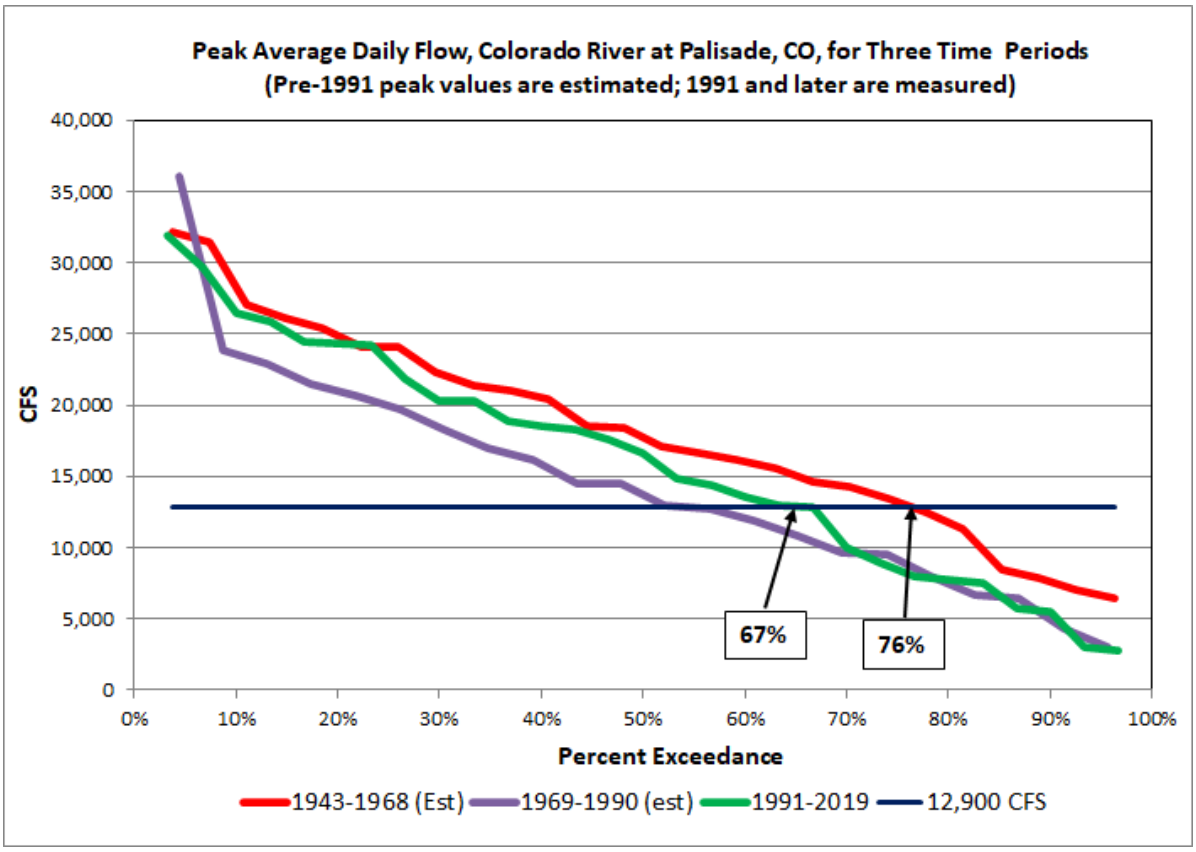


Figure 3. Historic peak mean daily flow at the Palisade, CO gage location for three consecutive periods of record.

Coordinated Facilities Water Operations

Additional options for providing and protecting supplemental peak flows to the 15-Mile Reach are being evaluated under an effort called the Coordinated Facilities Water Operations Study (CFOPS). Phase I was completed in 2001, Phase II in 2003 (Brown and Caldwell 2003). These studies evaluated the flexibility that may exist in water management facilities and operations to further enhance spring flows for endangered fish. The enhancement water would come from pools in reservoirs designated for base flow enhancement. The intent is to provide up to approximately 20,000 AF/year of additional water to enhance the spring peak flow without diminishing project yield nor causing water users to incur significant costs. (This volume of water, when made available, could provide an additional ~1,000 cfs of flow for a period of up to ten days.)

As of 2019 no additional water has been provided under CFOPS. Water users participating in the Program voluntarily assumed responsibility for developing the Phase III CFOPS report to assess the physical and legal feasibility of using Recovery Program fish pools in various reservoirs that are normally used to augment summer low flows to enhance spring peak flows. With assistance from the State Engineer's Office, the CWCB, and reservoir owners, the Service identified reservoirs that could participate in CFOPS. The amount of additional water that could be released would be designated by the Service around May 5 of each year from existing reservoir environmental pools used to augment base flows. In years when augmentation would be needed through use of CFOPS, the Service would

review hydrologic conditions, determine if additional augmentation is needed, and assess the level of augmentation justified based on conditions in the 15-Mile Reach. As of this writing, Water Consult Engineering and Planning Consultants (Loveland, Colorado) continues work on a final draft of the Phase III CFOPS report.

3.1.2 Base Flows

Diversions and depletions affect base flows within the 15-Mile Reach more than in any other critical habitat of the Colorado River because, in addition to the diversions and depletions occurring throughout the contributing drainage basin, several large diversions occur immediately upstream of this reach.[7] Extremely low water conditions can occur during the late summer and early fall months that dramatically reduce available habitat for Colorado pikeminnow and razorback sucker, and compromise the available food base. As a result, many Program recovery actions are focused on improving base flow conditions in the 15-Mile Reach.

3.1.2.1 Base Flow Recommendations for the 15-Mile Reach

Mean monthly flow (MMF) recommendations, summarized in Table 5, are intended to provide sufficient habitat preferred by adult Colorado pikeminnow (Osmundson et al. 1995). The MMF recommendations shown for August through March (ranging from 810 cfs to 1,630 cfs, depending on month and hydrologic condition) represent the minimum monthly average base flows recommended in the PBO during this lower-flow period.

Table 5. Recommended mean monthly flows (cfs) for the top of the 15-Mile Reach. August through March are considered the 'base flow' months. 'Percent Exceedance' identifies the percent of years for which it is recommended flows meet or exceed the identified targets. For example, in the wettest 80 percent of years, flows in October should average at least 1,240 cfs; stated another way, this recommendation should be met in 16 of every 20 years. (Osmundson et al 1995).

	Percent Exceedance			
	25	50	80	100
AUG	1,630	1,630	1,240	810
SEP	1,630	1,630	1,240	810
OCT	1,630	1,630	1,240	810
NOV	1,630	1,630	1,630	1,240
DEC	1,630	1,630	1,630	1,240
JAN	1,630	1,630	1,630	1,240
FEB	1,630	1,630	1,630	1,240
MAR	1,630	1,630	1,630	1,240

The August–October base flows identified should provide adequate depth and stability in backwater and other low-velocity channel-margin habitats most sensitive to changes in river stage (Osmundson et al. 1995). An increase in the availability of these habitats should increase the success of pikeminnow recruitment. Base flows during winter months also are important for meeting habitat needs of the endangered fish. During the winter, adult Colorado pikeminnow mostly use pools and backwaters

[7] These diversions serving irrigation, municipal, and industrial uses in the Grand Valley occur through the Government Highline Canal, the Grand Valley Canal, and the Orchard Mesa Canal systems.

(Osmundson et al. 1995). The flows recommended for winter months in Table 5 should provide adequate depth in these habitats for over-winter survival. Because diversions and depletions are minimal during this time of the year, obstacles to meeting flow targets are reduced.

15-Mile Reach base flow targets are established by the Service during each irrigation season based on hydrologic conditions in the basin, including consideration of antecedent flows, developing water demands, weather outlooks, and projected runoff. While the 15-Mile Reach irrigation-season target flow typically is set in late June, natural flow in the 15-Mile Reach normally remains above the base flow target through at least the middle of July, usually making flow augmentation measures unnecessary until late July or August.

A question remains as to whether 810 cfs is a reasonable and appropriate base flow target for all dry years, as an analysis of historic flows suggests this target was rarely met in dry years prior to Program implementation, both before and after storage project construction (Appendix II). Nevertheless, conditions for the endangered fish are clearly enhanced when summer flows can be maintained at this level or greater. The lowest flow evaluated by Osmundson et al. (1995) was 557 cfs, which corresponded to a reduction in the weighted useable area of preferred summer Colorado pikeminnow habitat by approximately 17% relative to conditions at 810 cfs. In personal communication (Dec. 8, 2015), Osmundson recalled that at a flow of 557 cfs, the fish could "make it", but there were locations where the entire channel was a riffle. Fish traversing those riffles would be highly vulnerable to avian predation unless fish movements occurred after dark. In April 2018, Service biologist Dale Ryden (personal communication) added that below 400 cfs, a considerable portion of river channel goes dry, and because portions of the 15-Mile Reach are braided, there may be in these areas only a few inches of water remaining in each of the multiple wetted channels. Terrestrial predators then become more of a concern, in addition to avian predation. In addition, the exposed riverbed loses its productivity as an invertebrate food base for fish, and endangered fish are forced to either leave the 15-Mile Reach, or become increasingly crowded into semi-isolated pools with deteriorating habitat conditions, including increased vulnerability to predators.

3.1.2.2 Base Flow Recovery Program Actions / Reservoir Operations for 15-Mile Reach

Multiple sources of water are annually available, or potentially available, to augment base flows in the 15-Mile Reach for purposes of promoting species recovery and complying with the PBO. These sources are discussed below. They include dedicated environmental storage in reservoirs, water obtained through temporary leasing arrangements, water determined to be surplus to other needs at Green Mountain Reservoir, and improved water management practices in the Grand Valley.

Each year approximately 20 meetings and/or conference calls between interested parties are held between June and October to manage releases from Green Mountain, Ruedi, Granby, and Wolford Mountain reservoirs, to coordinate irrigation and power diversions in the Grand Valley, and to attempt to meet the target flows in the 15-Mile Reach during the critical late summer and early fall months. These meetings are coordinated by Reclamation, which presides over the discussions and provides notes and summary documentation annually.

Dedicated Storage

Specified quantities of storage water in several different reservoirs are made available annually to the Recovery Program pursuant to permanent or long-term multi-party agreements to provide this water to the 15-Mile Reach for the benefit of endangered fish (Table 6).[8] This includes 15,825 AF of water considered a firm supply available every year, plus up to 11,000 AF of additional water available in most years, depending on the extent of reservoir filling.[9]

Table 6. Contracts and agreements that provide a firm supply of water for late summer base flow augmentation in the 15-Mile Reach for ESA compliance. [Modified Wolford amount to read "Up to 6,000 (depending on reservoir filling); long-term average estimated at 5,650 AF"]

Contractor/Contract No.	Amount (AF)	Notes	Period of Use	Expires
Ruedi Reservoir				
CWCB #0-07-60-W0540	5,000 + 5,000 (4 out of 5 years)	Signed 2/21/1990 for 40 years w/ renewability	January 1 – December 31	2030
River District #139D6C0024	5,412.5	West Slope contribution to 10,825 water.	January 1 – December 31	Perpetuity
Granby Reservoir				
Northern Water # 4310J	5,412.5	East Slope contribution to 10,825 water.	August – October	Perpetuity
Wolford Mountain Reservoir				
1998 Wolford Biological Opinion	Up to 6,000 (depending on reservoir filling); long-term average est. 5,650	Can carry-over 1 year to protect this junior fill right	March 1- December 1	Until fish are delisted

Green Mountain Reservoir Historic User Pool Surplus

In 1996, an agreement known as the Orchard Mesa Check Case[10] was reached among multiple parties, including the United States of America (with Reclamation taking the lead) and water users in the Grand Valley. This complex agreement provides up to 66,000 AF annually from the federal Green Mountain Reservoir power pool to augment base flows in the 15-Mile Reach.

This 66,000 acre-foot pool, also known as the 'Historic Users Pool' or 'HUP', represents the largest single pool of water potentially available annually to augment base flows in the 15-Mile Reach. However, in

[8] On occasion, collaborative exchanges of water between these and other reservoirs add flexibility to operations. For example, when an inspection takes place that requires a reduction in Wolford Reservoir releases, Williams Fork Reservoir may supply water that Wolford otherwise would have provided for the 15-Mile Reach, even though no dedicated Program fish pool exists in Williams Fork Reservoir. Under this scenario, Wolford Reservoir would later release water to meet a downstream demand that otherwise would have been serviced by a Williams Fork Reservoir release.

[9] This 11,000 acre-foot figure consists of 5,000 AF from Ruedi Reservoir available only in years when Ruedi Reservoir fills (statistically, about 4 out of 5 years), plus up to 6,000 AF from Wolford Mountain Reservoir (not all of which may be available in a given year, depending on reservoir inflow).

[10] Colorado District Court, Water Division Number 5, Case No. 91CW247 Stipulation and Agreement.

order for some or all of this water to be released for 15-Mile Reach instream flow purposes, an 'HUP surplus' must be declared by the Grand Valley irrigators and Reclamation in the subject year. [11] As per the terms of the Orchard Mesa Check Case, certain operational conditions must be met, and it must be determined there is additional water in the power pool surplus greater than the needs of the HUP beneficiaries (surplus).[12] Declarations of surplus are based on runoff forecasts, current and projected Grand Valley irrigation demand, current and projected Green Mountain reservoir contents, past experience, and reference to reservoir drawdown curves incorporated into the Agreement. Once a surplus is declared, this HUP water can be released from Green Mountain Reservoir and legally protected to the 15-Mile Reach (minus transit losses) to enhance instream flows. This surplus, if declared, typically becomes available in August and September, and can greatly improve flow and temperature conditions in the 15-Mile Reach. From 1998 through 2019 HUP surplus releases from Green Mountain Reservoir averaged 40,230 AF/yr in the years releases were made (no surplus was declared nor releases made in 2002, 2012, or 2018), with a maximum of 61,433 AF released in 2008.

The legal mechanism for protecting these HUP surplus releases to and through the 15-Mile Reach is a municipal-recreational contract between Reclamation and the municipalities of Palisade, Grand Junction, and Fruita. Reclamation initially contracted with these entities in 2002; in 2007 the contract was renewed through the end of 2012. The most recent municipal-recreational contract for this purpose (#14XX650133) was signed in April 2015 and expires December 31, 2054.

Leased Water

Water also has been made available to augment 15-Mile Reach flows through temporary lease agreements. From 2015 through 2019, CWCB supplemented available water by establishing a short term lease with the Ute Water Conservancy District (Ute WCD) for use of their storage in Ruedi Reservoir (Ute Lease CMS #83182; Ute Contract #139D6C0111) to supplement existing instream flow water rights to preserve and improve the natural environment of the 15-Mile Reach. By agreement between Ute WCD and CWCB, these leases are now authorized through 2025, and exercised through the optional establishment of a delivery contract between CWCB and Ute WCD on a year-by-year basis. From 2015 through 2019, a total of 37,687 AF was leased and released to augment 15-Mile Reach base flows from August through October. Ute WCD made this leased water available to CWCB at a cost of $7.20 per acre-foot.

An additional 626 AF of augmentation water was provided to the 15-Mile Reach in 2019 by means of temporary Ruedi Reservoir water leases arranged by the Colorado Water Trust (327 AF) and the Roaring Fork Conservancy District (299 AF). The former was a lease of Colorado River Water Conservation District (Colorado River District) water for delivery to the Grand Valley Power Plant in Palisade, Colorado, and then to the 15-Mile Reach, under a contract with Reclamation that authorizes use of Grand Valley

[11] "Surplus HUP water" is water in excess of the needs of the HUP beneficiaries as defined in paragraph 8 of the Green Mountain Reservoir Operating Policy (Federal Register, Volume 48, Number 247, December 22, 1983, as amended in Federal Register, Volume 52, Number 176, September 11, 1987) and the Stipulation and Agreement of the Orchard Mesa Check Case (Colorado Water Division 5, 91CW247).

[12] Among the HUP beneficiaries are various water users in the Grand Valley who receive "direct deliveries" of Green Mountain Reservoir HUP water to meet their diversion needs; this water is normally diverted before reaching the 15-Mile Reach.

Project conveyance facilities for this purpose when unused capacity is available. The latter water also was leased from the Colorado River District, representing the remaining portion of 3,500 AF leased by the Roaring Fork Conservancy District not released to the Fryingpan River over the preceding winter to avoid 'anchor ice'. Additional leases of this kind are likely to occur in the future.

Additionally, in 2020, CWCB entered into a five-year lease agreement with Garfield County for 350 AF of storage water in Ruedi Reservoir for release to supplement existing instream flow water rights to preserve and improve the natural environment of the 15-Mile Reach during the base flow season.

Other Stakeholder Contributions

Additional, "opportunistic" sources of water are occasionally provided by Program partners and stakeholders to benefit flows in the 15-Mile Reach. A notable example is Colorado River District efforts to strategically time their releases from Wolford Mountain Reservoir for reservoir maintenance to also provide benefits to the 15-Mile Reach. The Recovery Program greatly benefited from 18,812 AF of such propitiously timed Colorado River District deliveries during the unusually low flows of summer 2018, and an additional 2,676 AF was provided by the District in late summer 2019. Another example occurred in 2018 when Exxon Mobil Corporations (and their subsidiary XTO Energy, Inc.) freed up 5,000 AF from their pool in Ruedi Reservoir (Reclamation Contract No. 2-07-70-W0544) for delivery downstream for multiple uses including support of flows in the 15-Mile Reach. Exxon Mobil generously made that same volume of water available again in 2020.

Grand Valley Water Management

In addition to the various sources of augmentation water described above, the Program has assisted water users in the Grand Valley of Colorado with improvements to their water diversion and delivery systems to benefit 15-Mile Reach flows by reducing diversions.

Grand Valley Water Users Association (GVWUA): A 1997 assessment of GVWUA canal operations showed that August-October spills at the downstream terminus of the Government Highline Canal averaged 31,400 AF from 1992-1994 (ITRC, 1997). To improve the efficiency of the canal system, the Recovery Program provided approximately $7.2 million in funding for GVWUA to install additional check structures and modify existing check structures, install a pump station at Highline Lake, build a new Palisade Pipeline turnout, implement Supervisory Control and Data Acquisition (SCADA) systems, install 21 radio-linked Remote Terminal Units, and modify the Orchard Mesa Power turnout.

The resultant savings to the 15-Mile Reach have averaged 45,159 AF/yr.[13] Some of these savings are redirected immediately to the Colorado River, through the Palisade Pipeline or Bypass (see Table 7), immediately above the 15-Mile Reach. The majority of these reduced canal spills contribute to increased storage in Green Mountain Reservoir's HUP, much of which may later become available to the Program as HUP surplus.

[13] 2002-2016 estimates from the Western Colorado Area Office of Reclamation, using 1998 operations as the baseline for comparison.

Orchard Mesa Irrigation District (OMID): OMID also has worked with the Recovery Program to improve efficiency in its canal system, with funding of approximately $16.5 million provided by the Program to date. This includes constructing a canal automation system comprised of 33 check structures, an 87 AF regulating reservoir, pumping plants, upper/lower canal interconnect pipeline, replacement of open channel laterals with pressurized pipelines, and an integrated SCADA system. The objective of the canal automation system is to reduce the volume of water diverted from the Colorado River for irrigation use, redirect it to generate more hydroelectric energy, and increase return flows to the head of the 15-Mile Reach. Construction of the 33 canal check structures was completed prior to the 2014 irrigation season, and the structures have been operational since that time. In addition, the 87-AF regulating reservoir was completed and put into operation in 2017. Conservative estimates indicate that approximately 17,000 AF/yr can be redirected to improve instream flows in the 15-Mile Reach of the Colorado River at full build-out of the OMID improvements (Uilenberg 2017). However estimated savings associated with the improvements implemented to date is closer to 6,600 AF/yr. OMID anticipates that substantial additional water savings eventually will be realized after piping the Mutual Mesa Lateral and the final piping of approximately 15,000 feet of Canal #2, however the timing of those improvements is unknown. The Recovery Program annually reimburses OMID for operation and maintenance costs associated with these canal system improvements, but does not make any per-acre-foot payments based on the corresponding water savings.

3.1.2.3 Base Flow Deliveries for Endangered Fish

Table 7 summarizes the irrigation-season releases since 1998 from the sources identified above (and others) to augment base flows in the 15-Mile Reach. The average of annual deliveries from all sources for base flows over this period has been 78,037 AF, ranging from a low of 17,093 AF in 2002 to a high of 114,666 AF in 2010. For reference, 78,037 AF delivered at a constant rate for 100 days equates to about 393 cfs.

Table 7. Summary of water volumes (in AF) released from upstream 'fish pools' (1998 – 2019) to augment base flows in the 15-mile Reach. Releases from Ruedi and Wolford Reservoirs began earlier, in the early 1990's, but are not included here. 'Palisade Bypass' does not represent a reservoir release, but rather water diverted from the Colorado River into the Governmental Highline Canal above Palisade that was returned to the top of the 15-Mile Reach unconsumed.

Releases (AF) to augment baseflows in the 15-Mile Reach for endangered fish, July through October

Reservoir	Lake Granby	Green Mtn	Ruedi	Williams Fork	Willow Ck	Windy Gap	Wolford Mtn	Palisade Bybass*	Total AF	Total AF Reservoirs Only (not incl. Palisade Bypass)
1998		31,736	20,803				11,516		64,055	64,055
1999	26,914	29,277	20,418	1,825	649		4,939		84,022	84,022
2000		47,187	19,064	3,858			11,072		81,181	81,181
2001		34,656	21,345	5,369			8,577		69,947	69,947
2002		-	10,975	3,757			308	2,053	17,093	15,040
2003		47,526	20,434	3,757			286	10,161	82,164	72,003
2004		119	15,981	2,678			-	13,654	32,432	18,778
2005		31,200	17,163	3,814			1,000	19,143	72,320	53,177
2006		25,358	20,045	5,712			10,842	10,812	72,769	61,957
2007		32,745	14,650	2,624			7,037	10,625	67,681	57,056
2008	849	61,433	20,423	9,389		764		15,997	108,855	92,858
2009	3,144	56,290	20,822	5,411			8,747	18,302	112,716	94,414
2010	992	57,813	20,825	5,113		893	8,413	20,617	114,666	94,049
2011		37,132	15,251	5,412			8,413	20,466	86,674	66,208
2012		-	20,596	5,412			5,320	14,616	45,944	31,328
2013	5,412	2,514	10,412				1,501	15,937	35,776	19,839
2014	5,413	59,342	15,413				3,000	19,317	102,485	83,168
2015	5,415	54,610	24,412	1,289			4,712	8,162	98,600	90,438
2016	5,413	55,390	27,413				5,766	12,210	106,192	93,982
2017	5,409	46,216	21,413				6,000	20,272	99,310	79,038
2018	4,805	2,356**	19,496		607		24,812	10,198	59,918	49,720
2019	5,413	53,833	20,726				8,676	13,359	102,007	88,648
Average (in years of release)	6,289	40,230	19,004	4,361	628	829	7,047	14,217	78,037	78,388
Sum	69,179	764,377	418,080	65,420	1,256	1,657	140,937	255,901	1,716,807	1,460,906

*Unlike other columns, these are totals are for the entire April-October period

** This release was made in April 2018 to alleviate an 'April Hole', and is not included in these totals

Since that time, CWCB has obtained two instream-flow water rights that can protect water provided to support base flows in the 15-Mile Reach from July through September:

- In 1996, the Colorado Water Court (Case 5-92CW286) granted CWCB a 581 cfs instream flow right (3/5/1992 priority) for water in the 15-Mile Reach from July 1 through September 30 (from the tailrace of the Grand Valley Pumping Plant to the confluence with the Gunnison River). This rate of flow equates to the combined discharge of the Grand Valley Power Plant and the OMID hydraulic pumps when those are operating at full capacity;

- On the same date (Case 5-94CF330), CWCB was granted an additional 300 cfs instream flow right (11/4/1994 priority) for water accretions occurring in the 15- Mile Reach from July 1 through September 30. This right applies to only the downstream two miles of the 15-Mile

Reach (27.5 Road gage to the confluence with the Gunnison River), and is based on the amount of irrigation return flows that typically accrue to the river in the 15-Mile Reach.

Because these instream flow rights have very junior priorities, they provide limited protection of natural flow in this reach of the Colorado River in light of the many senior diversion rights upstream. However, these rights allow the State Engineer to legally protect water acquired and delivered to the 15-Mile Reach for purposes of augmenting endangered fish flows.

These rights do not protect such water from appropriators downstream of the location of the water right. However, the substantial Gunnison River inflow at the downstream terminus of the 15-Mile Reach, and the modest volume of water withdrawn along the "18-Mile Reach" downstream of the 15-Mile Reach from the Gunnison River confluence to the western end of the Grand Valley near Loma, Colorado, maintains better flow conditions for the endangered fish in this important stretch of critical habitat. Most of the water delivered to the 15-Mile Reach also benefits flows in this 18-Mile Reach.

Water rights associated with the Grand Valley diversions that produce many of the return flows to and downstream of the 15-Mile Reach are among the most senior rights in the basin, and therefore can call out the majority of upstream water rights. This helps ensure that water is delivered to the headgates of the Grand Valley project in De Beque Canyon, even in dry years, which in turn helps support flows in the 15-Mile Reach via returns from the Grand Valley Hydropower Plant and other water uses.

3.1.2.4 Recovery Program Performance in Meeting Base Flow Recommendations

In the 15-Mile Reach PBO, the Service recognized that prior to the specific flow augmentation efforts that began in 1991, summer/fall base flow targets in the 15-Mile Reach (Table 2) were seldom met. When historical exceedance curves are examined (dating back to 1902) it is apparent that flow targets were not met even in the early 1900's when upstream storage was not fully developed (Appendix II). The Service anticipated that with full implementation of flow-related recovery actions identified in the PBO, "base-flow targets for August–October will be met in most years" (PBO page 65), although the basis for making this assumption is not entirely clear.

Table 8 summarizes the Recovery Program's performance in meeting recommended mean monthly flows in the 15-Mile Reach during each month of the year, 1991 – 2019. In this table, the 'hydrologic year type' for the period reviewed (wet, wet/avg, dry/avg, and dry) is based on a ranking of the estimated calendar year 'naturalized flow' for the Colorado River at Cameo dating back to 1906[14]. Using this metric, the 1991 – 2019 flow years are skewed slightly toward more drier years, but these years reflect a reasonably representative range of flow conditions, and include the second wettest year in this 116-yr period of record (2011).

[14] 'Naturalized flow' means streamflow that would have occurred in the absence of human diversion, storage, or use of this water. Naturalized flow estimates for the Colorado River system are developed by the U.S. Bureau of Reclamation Upper Colorado Basin Region. They are updated periodically, and made available at www.usbr.gov /lc/region/g4000/NaturalFlow/current.html

As indicated in the table, average monthly recommended flows were achieved most often during wet years and during the winter months of dry years. During the irrigation season of drier years (April through October), recommended flows were achieved with low frequency. If Osmundson et al.'s (1995) lowest recommended minimum monthly flows (MMF) of 810 cfs is used as the metric for establishing the minimum desirable base flow, it is evident that:

- Flows in the 15-Mile Reach dropped below this MMF in three months of the eight years classified as 'Dry / Average', i.e. in 5% of the irrigation season months (3 out of 56); and

- Flows fell below the MMF in 22 months of the eight years classified as 'Dry', i.e., 39% of the time (22 out of 56 irrigation season months in dry years).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
'Wet' Year (<25% Exceedance) - Avg Monthly Flow Targets	**1,630**	**1,630**	**1,630**	**3,210**	**10,720**	**15,660**	**7,060**	**1,630**	**1,630**	**1,630**	**1,630**	**1,630**
2011	1,627	1,642	2,041	3,230	10,320	26,430	16,130	2,879	1,762	1,777	2,221	1,840
1997	2,179	2,122	2,798	3,402	12,870	20,860	5,213	3,574	2,461	2,560	2,484	2,370
1995	1,429	1,449	1,749	962	5,415	20,040	16,010	3,897	1,339	1,477	2,373	2,198
1993	1,449	1,544	2,015	2,540	14,160	15,830	6,702	1,788	1,287	1,279	1,837	1,873
2008	1,566	1,813	1,933	2,192	10,300	17,290	6,816	1,877	1,703	1,510	2,127	1,839
2014	1,703	1,816	2,200	3,892	10,120	13,740	4,435	1,837	1,786	1,945	2,094	1,928
'Wet / Avg' Year (26 - 50% Exceedance) - Avg Monthly Flow Targets	**1,630**	**1,630**	**1,630**	**2,440**	**9,380**	**14,250**	**5,370**	**1,630**	**1,630**	**1,630**	**1,630**	**1,630**
2019	1,274	1,364	1,845	2,421	5,658	15,820	11,550	2,330	1,285	1,248	1,980	1,612
1996	2,093	2,416	2,787	4,837	11,820	12,360	4,105	876	1,085	1,423	2,248	2,200
2009	1,831	1,770	1,874	2,337	11,720	11,870	4,841	1,461	1,127	1,413	1,870	1,453
1998	2,375	2,292	2,913	3,361	10,400	7,931	4,184	1,849	1,284	1,550	2,332	1,910
2005	1,677	1,429	1,512	2,140	7,808	10,030	4,154	1,353	1,305	1,528	2,272	2,015
2006	1,849	1,782	2,229	4,364	9,305	6,140	2,044	1,152	1,271	1,996	2,166	1,880
2015	1,747	1,755	1,990	1,441	6,096	14,980	4,921	1,045	1,241	2,379	1,827	1,520
'Dry / Avg' Year (51-80% Exceedance) - Avg Monthly Flow Targets	**1,630**	**1,630**	**1,630**	**2,260**	**7,710**	**11,350**	**3,150**	**1,240**	**1,240**	**1,240**	**1,630**	**1,630**
1999	1,939	1,854	1,789	996	4,794	11,000	4,556	2,183	1,771	1,837	2,054	1,780
2017	1,581	1,686	2,089	1,902	4,870	10,690	3,269	1,296	1,130	1,664	1,865	1,420
2016	1,585	1,698	1,776	1,642	6,932	12,530	2,706	957	955	1,114	1,636	1,532
2010	1,526	1,508	1,568	2,243	4,561	12,780	2,012	1,362	891	1,106	1,893	1,855
2003	1,145	1,156	1,336	710	5,906	7,244	1,052	611	1,088	1,078	1,419	1,403
1991	1,280	1,297	1,302	1,148	5,059	8,488	2,168	797	979.8	853.9	1,918	1,502
2007	1,565	1,705	2,368	1,795	6,132	5,951	1,616	893	1,353	1,553	1,870	1,825
2000	1,931	2,002	1,930	1,927	7,040	6,017	1,272	912	986	902	1,701	1,496
'Dry' Year (81 - 100% Exceedance) - Avg Monthly Flow Targets	**1,240**	**1,240**	**1,240**	**1,860**	**7,260**	**6,850**	**1,480**	**810**	**810**	**810**	**1,240**	**1,240**
1994	1,794	1,903	2,109	1,802	4,874	4,585	745	558	650	843	1,220	1,460
2001	1,322	1,352	1,476	973	5,149	3,764	995	1,133	1,014	807	1,573	1,345
1992	1,378	1,475	1,684	1,773	4,603	3,164	1,196	822	801	628	1,628	1,423
2013	1,137	1,147	1,204	308	4,043	4,306	743	727	1,272	1,288	2,031	1,707
2004	1,322	1,300	1,597	1,086	3,297	2,976	974	498	830	1,078	1,801	1,487
2018	1,400	1,418	1,490	911	4,123	2,369	424	642	265	755	1,395	1,260
2012	1,765	1,600	2,026	1,131	1,840	1,052	615	454	372	529	1,404	1,188
2002	1,405	1,286	1,396	1,010	1,016	935	161	115	241	526	1,618	1,217

observed average monthly flow target met

observed average monthly flow target not met, but > minimum monthly (810 cfs)

observed average monthly flow < 810 cfs

Summer flow conditions in the 15-Mile Reach were at their lowest in 2002, the most severe drought year in the basin since the beginning of the Recovery Program. In August 2002, the average monthly flow at the Palisade, Colorado stream gage (#09106150) was 115 cfs, and the average daily flow dropped below 60 cfs on August 19th (see 2002 hydrograph in Appendix I).

Appendix II provides an overview / update of Osmundson et al.'s (1995) analysis of historical August, September, and October monthly flows at Palisade, Colorado for three periods of time: 1902 – 1942, which represents the least amount of water development[15]; 1954 – 1984, which represents a period after considerable development had occurred; and 1991 – 2019, during which the Recovery Program has been managing summer base flows. As is apparent from these graphs, in all three of these months flows in the driest years (>80% exceedance) have been highest since the Recovery Program started augmenting flows. Summer flow conditions in the 15-Mile Reach would have been worse had it not been for the various sources of augmentation water discussed above, and the associated deliveries of water from those pools summarized in Table 7. Figure 4 illustrates the substantial difference that Recovery Program flow augmentation made to mean monthly flows in the 15-Mile Reach in August, September, and October of the six 'Dry' years since establishment of the PBO. Nevertheless, it is also apparent that historical flows frequently fell short of the MMF target of 810 cfs in dry years, and that even with Recovery Program augmentation this dry-year target is likely to remain difficult to routinely achieve.

Base flow hydrographs for the 15-Mile Reach for all years since 1998 are provided in Appendix I, where observed conditions are compared to 'what flows would have been' without the Recovery Program's flow augmentation efforts. In some years this reach of the river would have nearly or completely dried-up without this augmentation[16]. Even in the record drought year of 2002, approximately 17,000 AF of water was delivered to sustain flows in the 15-Mile Reach.

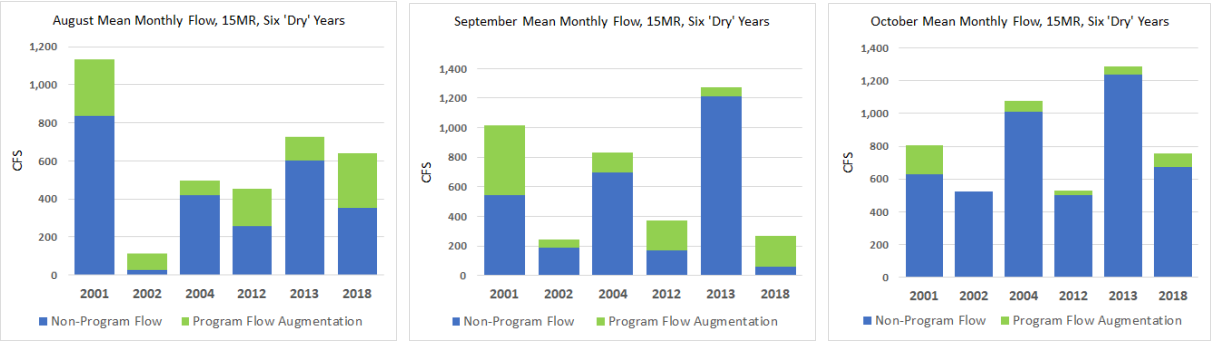


Figure 4. Proportions of the total mean monthly flow in the 15-Mile Reach in August, September, and October of the six 'Dry' hydrologic years occurring since 1999 provided by 'natural' and other non-Program sources (blue) versus Program flow augmentation (green).

[15] The Grand Valley Irrigation Company (GVIC diversion), constructed in 1894, was operational through this entire period of time; the Grand Valley Project diversion was completed in 1904.

[16] Data from 2018 indicate that flow in the 15-Mile Reach would have effectively dropped to zero for multiple days in late September, were it not for the supplemental flow provided by the Recovery Program.

'April Hole'

Of note in Table 8 are two occasions when the mean monthly flow in April dropped below 810 cfs: in 2003 (710 cfs) and in 2013 (308 cfs). Unprecedented conditions surrounding spring 2013 hydrology, not anticipated in the 15-Mile Reach PBO, combined to create extremely low April flows in the 15-Mile Reach, i.e. an 'April Hole.' Those conditions included: 1) cooling air temperatures that temporarily slowed mid- and high-elevation snowmelt runoff; 2) initiation of routine irrigation diversions; 3) "relaxation" of the Shoshone Hydropower Plant call, which allowed drought-impacted reservoirs with junior rights upstream to divert out of priority; and 4) the occurrence of all these events over a weekend, reducing the ability to coordinate a response to rapidly-changing conditions.

The Shoshone Hydropower Plant is owned by Xcel Energy and located on the mainstem of the Colorado River in Glenwood Canyon. Its senior 1902 non-consumptive water right of 1,250 cfs is often relied on to keep water in the Colorado River and sometimes prevents storage under junior water rights upstream (e.g., Denver Water's Dillon and Williams Fork Reservoirs, the Colorado River District's Wolford Mountain Reservoir, and Reclamation's Green Mountain Reservoir). Beginning in 2006, an agreement with Denver Water (valid through 2032) allows for a "relaxation" of the Shoshone call under certain defined water shortage conditions,[17] allowing Denver Water and other junior upstream reservoir operators to store more water than they otherwise would if they could not store out of priority. In exchange, Denver Water compensates Xcel Energy for the lost power revenues and guarantees Xcel additional water for its east-slope power operations. In April 2013 the Shoshone call was relaxed in accordance with this agreement, which permitted reservoirs impacted by the previous year's drought to operate in the absence of a senior call by the Shoshone hydro plant. Upstream junior reservoirs were permitted to divert and store water for a possible dry summer season, following a drought year in which reservoir storage was substantially depleted. This greatly impacted Colorado River flows downstream of the Shoshone hydropower plant, including flows in the 15-Mile Reach.[18]

During April 2013, flows measured at the Palisade gage dropped below 400 cfs for 24 days, and instantaneous flow dropped below 60 cfs on April 12 and April 27. Participants in the weekly CROS and HUP conference calls realized that the best strategy to reduce a repeat of an 'April Hole' would be to remain vigilant (primarily with respect to forecasted stream flows and weather conditions) and make necessary real-time adjustments (e.g., consider preemptive releases from Ruedi Reservoir, coordinate with the irrigators and their diversions, coordinate with the operators at Shoshone Power Plant). Since

[17] Specifically, a "water shortage" is triggered by Denver Water's projection that reservoir storage in their system on July 1 will be at or below 80% full, and the most probable forecast of April-July streamflow at the Colorado River at the Kremmling stream gage is less than or equal to 85% of average.

[18] Another flow protection element is the Shoshone Outage Protocol (SHOP). This is an agreement signed by several major water users upstream of the Shoshone Power Plant (including Denver Water, Aurora, and the Colorado-Big Thompson Project) to manage their diversions during a shutdown at the Shoshone Power Plant as if the Plant were still operational and calling its senior water right. The SHOP signatories are not bound to this protocol under certain specified conditions, such as when unusually dry hydrologic conditions meet the criteria of a 'Water Shortage' in the river basin.

2013, the CROS / HUP participants have conducted periodic 'State of the River' conference calls to closely monitor 'April Hole' conditions, which have recurred, but not with the same severity.

Climate Change Concerns

The Recovery Program's future ability to maintain and improve flow conditions in the 15-Mile Reach for endangered fish may be affected by changes in the hydrology and demand for water in the upper Colorado River basin. Recent studies suggest that runoff in the upper Colorado River basin is likely to decrease in the 21st century. For example, a report developed by the Western Water Assessment at the University of Colorado in collaboration with the Bureau of Reclamation notes that "warming temperatures observed across the [Colorado River] basin in the last few decades have discernibly impacted snowpacks, melt and runoff timing, runoff efficiency, and total basin runoff. It is unclear whether the period of below-normal precipitation since 2000 is indicative of future precipitation, but unless average basin precipitation increases substantially, system runoff and water supply are expected to decline over the next several decades due to warming alone." (Lukas and Payton 2020).

Further complicating the impact of a warming climate is uncertainty surrounding the social and economic changes that may affect water management, consumptive use, and water rights administration under a warming scenario, as individual water users, local communities, and the upper basin states implement new strategies to respond to actual or anticipated changes in runoff quantities and timing. The Recovery Program will continue to monitor changes in Colorado River flows and water management that may be attributable to climate change, and, as appropriate, propose adjustments in recovery actions to respond to observed or proposed changes.

Water Quality Considerations

The 15-Mile Reach PBO is "limited to addressing water depletions above the confluence of the Gunnison River (water quantity), however changes in water quantity affect water quality, which is a primary constituent element of critical habitat" (p. 54, PBO). The PBO notes that Colorado River depletions could reduce the diluting effect that relatively clean headwater inflow has on heavy metals, selenium, salts, polycyclic aromatic hydrocarbons, pesticides, and other contaminants, and that "selenium may be of particular concern due to its effects on fish reproduction and its tendency to concentrate in low velocity areas that are important habitats for Colorado pikeminnow and razorback suckers."[19]

As described earlier, since 1998 the Recovery Program has delivered more than 1.4 million acre-feet of water from reservoir storage originating high in the river basin to supplement low flows in the Colorado River during the August-through-October period. To the extent these deliveries have diluted the contaminants identified in the PBO, they have undoubtedly improved water quality conditions for the endangered fish.

[19] An additional water quality concern is the potential impacts post-wildfire runoff on river water quality, including delivery of ash, sediment, fire retardant, debris, or constituents that affect aquatic pH. This is a growing concern in light of a warming climate and increased landscape vulnerability to wildfire.

Separate from the Recovery Program (which, as noted in the PBO, is "not intended to offset any point or nonpoint discharges of pollution"), various upper Colorado River basin activities have been addressing high-priority water quality concerns. This includes, since 2009, a major selenium remediation effort in the Gunnison and Uncompaghre river drainages funded by Reclamation and the CWCB (Bureau of Reclamation 2020) in accordance with the Gunnison River PBO (USFWS 2009a). While the Gunnison River discharges to the Colorado River below the subject 15-Mile Reach, historically it has exhibited some of the highest selenium loads in the Colorado River system, and this selenium may adversely affect endangered fish using the mainstem Colorado River. In addition, the Service participates in the Colorado River Basin Salinity Control Program that works to reduce salinity concentrations across the Colorado River basin. One effect of the Salinity Control Program is to not only reduce salinity, but also reduce selenium loading (Colorado River Basin Salinity Control Forum Technical Work Group, 2016).

For more information on water quality, a report from the U.S. Geological Survey (Spahr et al. 2000) summarizes major findings regarding water quality in the upper Colorado River basin based on an assessment conducted between 1996 and 1998 through its National Water Quality Assessment (NAWQA) Program. Additionally, the Colorado Department of Public Health and the Environment (CDPHE) annually publishes an *Integrated Water Quality Monitoring and Assessment Report* that summarizes water quality conditions in the State of Colorado by major river basin (e.g., CDPHE 2020).

3.1.3 SUMMARY

Multiple partners and stakeholders in the Recovery Program have demonstrated a strong, ongoing commitment to improving both spring peak and year-round base flows in the 15-Mile Reach. Through Recovery Program actions, including flow augmentation, funding of improvements in irrigation project efficiencies, and other collaborative efforts among stakeholder interests in the Colorado River basin, the Program has substantially augmented flows in the 15-Mile Reach at those times of the year that provide the greatest benefits for the endangered fish. Program actions have also established other substantial habitat improvements (floodplain acquisition, fish passages, fish screens) described in the following section of this report.

Based on this history and these substantial accomplishments, and on the demonstrated enhancement to flow conditions, the Recovery Program does not at this time deem it necessary to reinitiate or amend this PBO for purposes of providing habitat improvement and flow management actions in compliance with the 15-Mile Reach PBO.

Our principal observations with respect to Program efforts to protect habitat in the 15-Mile Reach are summarized below:

<u>Peak Flows</u>

Over the 29 years (through 2019) that the Recovery Program has managed flows affecting the 15-Mile Reach:

- Annual peaks have exceeded the 'wet' year target at the Palisade gage location (23,500 cfs) with about the same frequency (24%) as proposed by the PBO (25%), in spite of relatively few wet years since 2000;

- Peak flows in 38% of years have exceeded or come within 5% of the target the PBO established for the wettest 50% of years.

- Voluntary Coordinated Reservoir Operations (CROS) have proven to be an important contributor to enhancing peak flows in the 15-Mile Reach and in helping to achieve peak flow targets with increased frequency. In 11 of 29 years (38%), peak flows were supplemented with CROS releases, which averaged more than 40,000 AF in years these releases were made. These operations should be continued, or further expanded, to help sustain and enhance Program success.

- Peak flows have generally fallen short of the PBO targets over the bottom (dry) half of the peak flow distribution, and the current peak flow recommendation to be met in all years (>12,900 cfs) has been met in only 69% of years since 1991. However, analysis indicates that prior to the Program, this target was met with a similar frequency (71%), which suggests that it may be an unrealistic dry-year target that should be re-evaluated.

Base Flows:

- The Recovery Program's base flow management has improved flow and habitat conditions, especially during periods of unusually dry hydrology, and especially when considering the long-term (100+ year) record, as shown in the data presented in Appendices I and II. Since 1998, dedicated reservoir fish pools and other sources have provided a total of more than 1.7 million AF of water to supplement flows in the 15-Mile Reach, for an average of more than 77,000 AF annually.

- Water leased for flow augmentation in the 15-Mile Reach has increased in recent years, most notably due to an annual leasing arrangement established between CWCB and the Ute Water Conservancy District beginning in 2015, but also through efforts of other entities including the Colorado River District, the Colorado Water Trust, and the Roaring Fork Conservancy and via donations from Exxon Mobil.

- Stakeholders working in cooperation with the Recovery Program have further enhanced base flow conditions in the 15-Mile Reach through voluntary actions including propitious timing of reservoir maintenance releases (Colorado River District) and making facilities available for temporary water exchanges to support water delivery to the 15-Mile Reach at the times of greatest benefit (Reclamation, Denver Water, and Colorado River District).

- In 'dry' years (>80% exceedance), the mean monthly flow target of 810 cfs frequently is not achieved during the months of August through October. Nevertheless, Program actions have generally improved low-flow conditions in these dry years when compared to conditions that existed prior to 1991, or would have otherwise occurred.

- The Osmundson et al. (1995) recommendation for a mean monthly flow of 810 cfs in dry years is not a flow level that historically (since 1902) was met on a regular basis, and thus may be an unrealistic dry-year target. The Program should re-evaluate this recommendation.

- Changes in hydrology and demands for water associated with a warming climate will be monitored by the Recovery Program. As appropriate, the Program Director's Office will propose adjustments in the Program's recovery actions to help the Program maintain recommended flows in the 15-Mile Reach.

- The Recovery Program should continue to diligently manage the available sources of augmentation water to reduce shortages to target flows, and should seek additional sources of augmentation water to achieve the recommended mean monthly flows with a greater frequency.

3.2 Habitat Development and Maintenance

Key habitat-related recovery actions for endangered fishes include improving the quality and quantity of floodplain habitats, providing access to disconnected river reaches by installing fish passage structures, and reducing entrainment by screening irrigation canal intakes. These actions are meant to improve recruitment, individual survival, and increase carrying capacity.

3.2.1 Floodplain Acquisition and Management

In the PBO, the Service referenced the Recovery Program's preliminary estimate that up to 3,500 acres in the Grand Valley and along the Gunnison River could be protected to provide habitat for a variety of life stages of the endangered fish. The Recovery Program investigated and evaluated 32 properties in five priority reaches: four reaches on the Colorado River; one reach on the Gunnison River (refer to Table 5.1 in Valdez and Nelson 2006). Thirteen properties were in various stages of pre-acquisition when the PBO was written. That Recovery Program preliminary estimate turned out to be high based on landowner response and because restorations were more expensive than anticipated. The Recovery Program eventually acquired 592 acres of floodplain/wetland habitat in the upper Colorado River (393.5 acres along the Colorado River and 198.2 acres along the Gunnison River). The Recovery Program's current strategy is to manage the habitats it has acquired to date as well as additional Federal, State, and other parcels to support a self-sustaining population of razorback sucker in the upper Colorado River.

Since the PBO was written the threat of nonnative fish competition and predation has increased basin wide. Now all recovery actions must be evaluated for their impacts to nonnative fish in addition to endangered fish. For example, flooded gravel pits provide deep and stable habitats for all fish species year round. The Recovery Program has learned that these habitats likely benefit nonnative species over native species and is working with the Service and mining companies to reconnect and reconfigure gravel pits in a manner that is beneficial to recovery.

Restoration of floodplain habitats along the Gunnison and Colorado rivers has occurred at a variety of sites. On the Gunnison River:

- The Butch Craig property was acquired in fee by the Recovery Program. Reclamation breached the levee at this site to provide reliable riverine connection to this floodplain site at a variety of spring flow magnitudes. Reclamation later returned to the Butch Craig property to repair a portion of the levee breach damaged during high spring flows.
- Escalante State Wildlife Area (owned by the State of Colorado) – Reclamation breached the levee at this site as well.

On the Colorado River:

- Audubon property – the Recovery Program established a perpetual easement. Reclamation breached the levee at this site.
- Soaring Eagle Gravel Pit - the Service and the Recovery Program coordinated with the landowner to determine the best method for reconfigure and reconnect this habitat to the river to benefit

native species over nonnatives. The Project Proponent funded this habitat restoration effort as per a separate Section 7 consultation.

- Grand Junction Pipe - acquired in fee title by the Recovery Program. This site was reclaimed with rotenone in March 2012 prior to levee breaching, which was completed by private industry (per project specific Section 7 consultation).
- Jarvis Pond – owned by the City of Grand Junction. The Recovery Program has cleared sediment deposited in the levee breech at this site on three occasions since 2003.
- Adobe Creek – multiple owners; Recovery Program has completed several restoration activities at this site. Initial site screening indicated there was a selenium issue at this location; remediation was put on-hold when National Irrigation Water Quality Program funding was cut.
- Walter Walker State Wildlife Area – owned by the State of Colorado has gone through two rounds of restoration activities and is currently managed for native fish and waterfowl hunting.
- Other sites - the Recovery Program used several Colorado River floodplain habitats (e.g. Beswick Pond and the 'Hot Spot' Complex) as razorback sucker grow-out ponds over the years until construction of 22 hatchery ponds at the Horsethief Canyon Native Fish Facility was completed in 2012.

The Recovery Program has learned that floodplain habitats along the Gunnison and Colorado rivers likely benefit juvenile and adult life stages of Colorado pikeminnow and razorback sucker more than larval razorback sucker.

3.2.2 Fish Passage Structures

The Recovery Program completed its first fish passage project in the Colorado River main channel at the Grand Valley Irrigation Company's (GVIC) diversion dam in 1998. This project consisted of side channel modification to provide adequate swimming lanes for adult sized Colorado pikeminnow during low flow conditions. The GVIC fish passage channel is non-selective (negotiable by native and nonnative species) and has not been fitted with Passive Integrated Transponder (PIT) antennas, however the effectiveness of this structure can be inferred from fish captures and detections reported at two other passage structures constructed upstream in later years (discussed below). The GVIC passage project was retrofitted with an automated Obermeyer gate at the upstream terminus of the passage channel in 2006 to improve irrigation operations at the diversion. When the Obermeyer gate is inflated (in operation) more water is diverted into the GVIC canal, and fish passage is closed off. The GVIC fish passage channel has required minimal maintenance during its 18 years in operation. The Bureau of Reclamation and GVIC are discussing retrofitting this structure by splitting the Obermeyer gate to provide more flow management options.

Construction of a selective[20] fish passage structure at the Grand Valley Water Users Association's diversion (GVWUA; also known as the Grand Valley Project (GVP); also known as the Government Highline Canal diversion; also known as the Roller Dam) was delayed due to regulatory and landowner

[20] All fish using the facility swim into a fish trap at the upstream terminus of the passage structure where they are sorted, measured, and released upstream. Nonnative species are removed.

issues and overall budget/construction priorities. This more classic 'Northwest –type' fish ladder was completed in 2004. Trial operations were conducted in 2005 and 2006. Full operation began in 2008 with completion of Price-Stubb passage located a few miles downstream. The GVWUA fish passage is operated by the Service's Grand Junction Fish and Wildlife Coordination Office (GJFWCO) personnel under Recovery Program Project No. C4b-GVP. In their annual reports, Francis and Ryden (2019; other authors in previous years) summarize fishes collected in the fish trap at the head of the passage structure. Every year fish collections are dominated by non-listed native species: flannelmouth sucker, bluehead sucker and roundtail chub – all considered important forage for Colorado pikeminnow. Over 170,000 native fish, comprising 82.7% of the total catch, have used this passage since operations began in 2005. In recent years, the number of endangered species collected at this facility and others in the area has increased (Figure 4). From 2005 through 2019, the Service reported that six Colorado pikeminnow, 280 razorback sucker, 118 bonytail, and 11 humpback chub have used this facility. In 2015 and again in 2019, prior to opening the ladder, Reclamation and GVWUA employees used a trackhoe to remove a sediment bar deposited in front of the upstream fish ladder opening and fish return tube. As per the recommendation of Francis and Ryden (2015), a portion of the heavily vegetated stream bank immediately upstream of the passage structure was removed in 2015 to reduce the sedimentation problem at this location. In 2016 and 2019, GVWUA adjusted their operations to release water through the roller gate bay on river-left which cleared sediment obstructing the fish passage. It is anticipated that this operation will continue in the future to remove sediment.

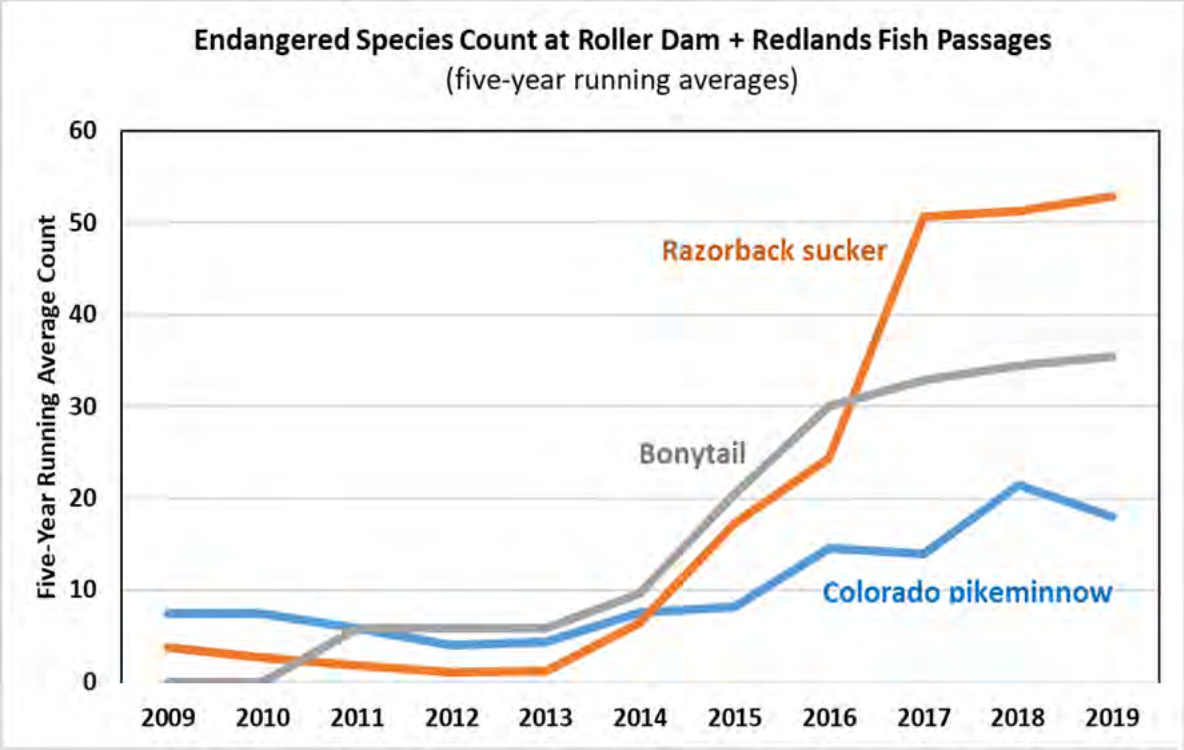


Figure 4. Five-year running averages of endangered fish use at two selective fish passage structures: a) the Grand Valley Water Users Association (Roller Dam; Project C-4b-GVP) constructed in 2005 and, b) the Redlands Water and Power Diversion dam (Project C-4b-Red) on the Gunnison River constructed in 1996. Greater detail on annual captures at each facility can be found here.

In the PBO the Service recommended that fish passage at the Price-Stubb diversion be completed by the year 2000 or by 2002 if the dam removal alternative was selected. The Recovery Program built a 900 foot-long passage, which consists of 190 strategically-placed concrete cylinders to provide current refuges for fish within the passage. The structure was completed in April 2008. With completion of this structure (and GVIC and GVWUA before it), Colorado River fish are now afforded unrestricted access from Lake Powell to the upper reaches of designated critical habitat near Rifle, Colorado. More specifically, these passages provide access to 55 miles of critical habitat on the Colorado River that had been cut off when the diversion structures were built in the early 1900's. Debris removal from the upstream entrance to the Price-Stubb fish passage channel is required in most years. The rock apron immediately downstream of the dam was damaged in the high flows of 2011 requiring extensive repair work prior to runoff in 2012. The fish passage structure was retrofitted with a PIT-tag monitoring station in 2010. Fish detections monitored by Service GJFWCO personnel demonstrate that endangered fish are using this passage successfully with detections of 70 Colorado pikeminnow, 1080 razorback sucker, 817 bonytail, and one humpback chub reported since 2010.

Also in close proximity to the 15-Mile reach, the first fish passage constructed by the Recovery Program was a U-shaped structure completed in 1996 on the lower Gunnison River at the Redlands Diversion Dam. This passage structure, like the one at the GVWUA diversion, is selective. The fish trap is monitored by Service GJFWCO personnel under Recovery Program Project No. C4b-RED. Since 1996, a total of 226 Colorado pikeminnow, 44 razorback sucker, 108 bonytail, three humpback chub, and more than 163,000 other non-listed native fishes (>80% of the total catch) have used this structure. The construction of fish passage at the Redlands Diversion structure opened up 57 miles of critical habitat on the Gunnison River.

3.2.3 Fish Screens

In the PBO, the Service recognized that unacceptable numbers of native and endangered fish were being entrained into the large irrigation canals in the Grand Valley. Fish screens have been installed in Grand Valley diversions. Fish salvage is conducted in Grand Valley canals as a further means of reducing entrainment in irrigation canals, as described below.

3.2.3.1 Grand Valley Irrigation Company Fish Screen:

In 2002, the Recovery Program constructed its first fish screen in the GVIC canal a short distance downstream of the head works. This screen was constructed in a single, diagonally oriented vertical wall comprising a series of panels made of 3/32" wedge wire and equipped with travelling brushes to sweep debris. This screen was designed to re-direct all life stages of fish larger than larvae back to the river. As per an Operation and Maintenance contract, GVIC has the option to lift the screen when debris loads clog the screens or at other times when operating the screen would preclude their ability to deliver water to its users. Since 2009, annual screen operations have varied, with the best performance in 2015 (16% unscreened days) to most problematic in the low-flow years of 2012 and 2018 when the screen was not operational for 68% and 75% of days during those respective irrigation seasons, respectively (Table 9). Reclamation continues to work with GVIC to troubleshoot problems and improve operations at the GVIC screen. In 2019, the Applegate Group (with funding from Reclamation)

completed hydraulic modeling of a proposed 12-inch raise to the crest of GVIC's diversion dam. The intent of the dam raise would be to improve the operation of GVIC's fish screens and fish passage by improving the effectiveness of diversions at low flows and increasing hydraulic head in the diversion canal. The Recovery Program has reserved $6.4M of its remaining capital funds for this project. The Program is evaluating the need to upgrade the entire screen to reduce maintenance problems and increase the time the screen is operational. The Recovery Program is working with Reclamation and GVIC to determine the best means of improving operations of this fish screen.

In response to concerns over potential injury to fish returning to the river through screen bypass pipes, the Recovery Program funded an evaluation using a surrogate species (nonnative white sucker). Although the data were sparse for this evaluation, results showed that the majority of fish recaptured after swimming through the return tube at the GVIC facility were unharmed (Francis and Ryden 2019).

3.2.3.2 Grand Valley Water Users Association:

The Recovery Program completed construction of a fish screen in the GVWUA canal in 2007. Although there were many design similarities to the GVIC screen, the diversion volume required considerably more screen surface area, which resulted in the W-shaped configuration. Operation and maintenance are contracted with the GVWUA. In the past 4 irrigation seasons, the screen has been in operation an average of 85% of the time (Table 9).

Table 9. Percent of time the fish screens in the Grand Valley have not been in` operation during the irrigation season.

Fish Screen Operations in Grand Valley		
	GVIC	**GVWUA**
	% Days off	% Days off
2009	19%	no reports
2010	32%	
2011	41%	
2012	68%	32%
2013	41%	13%
2014	36%	0.7%
2015	16%	0.3%
2016	22%	0.3%
2017	29%	0.0%
2018	75%	14%
2019	32%	3%
Average	**37%**	**8%**

3.2.3.3 Fish Salvage:

In 2002, the Recovery Program began conducting fish salvage operations in the both GVIC and GVWUA canals post-irrigation season to retrieve and return native and endangered fish back to the river (Crowley and Ryden 2019). This was in response to incomplete screening operations (see Table 9 above) due to flow and debris issues which allowed fish to become entrained. Since these canals have been

screened, in excess of 300,000 fish have been salvaged. The majority of those fish were native species. Through 2018, 28 razorback sucker and 25 bonytail have been salvaged; no Colorado pikeminnow or humpback chub have been collected during these post-irrigation season salvage efforts. In 2019, because of budget cuts, the Recovery Program discontinued funding this effort, but the State of Colorado and Program stakeholders continued a scaled down version of canal salvage on a mostly in-kind basis.

3.2.4 Irrigation Efficiency

The Grand Valley Water Management project (complete) and the Orchard Mesa Irrigation District project (under construction) were discussed above under the heading of Habitat Protection.

3.2.5 Summary

In summary, the Recovery Program secured 592 acres of floodplain habitat on the Colorado and Gunnison rivers. Despite a comprehensive floodplain acquisition effort, the Recovery Program experienced less than expected public interest and greater than expected costs than originally estimated (Valdez and Nelson 2006). These habitats are used by juvenile and adult Colorado pikeminnow and stocked razorback sucker and bonytail. Since the PBO was written, the Recovery Program has learned that effective floodplain management is more complicated. From the Green River, we have learned that floodplain habitats can be very inhospitable environments if the presence of nonnative species is high. The density of nonnative species is greatest in habitats that retain water from year to year. Gravel pits found on the Grand Valley floodplain (included in the 592 acres referenced above) are among the most persistent floodplain habitats in the upper Colorado River basin. In recent years, the Recovery Program has shifted management to focus on floodplains that are equipped with water control structures / large fish exclusion devices that allow managers to fine tune the timing of river connection and draining to maximize benefits to native species. The ability to drain wetlands also affords the option to 'reset' wetlands and thereby eliminate nonnative fish abundance if they become established during the spring and summer use periods. Effective floodplain management is intended to benefit all of the endangered species (with the exception of humpback chub), but most importantly to benefit early life stages of razorback sucker. The Recovery Program recently teamed with the Utah Division of Wildlife Resources and The Nature Conservancy to renovate a floodplain habitat on the Matheson Preserve, located near Moab, UT. This renovated wetland meets the criteria described above and became operational in 2020. **Despite acquiring less floodplain acreage than our preliminary target, the Recovery Program believes its performance toward razorback sucker recovery is on track and therefore should not be considered a reason to re-initiate or amend the PBO.**

The Recovery Program has constructed all of the passages and canal screens identified in the PBO, and they are operated to the greatest extent possible. The fish passages have provided an additional 55 miles of river access to the endangered and native fish populations on the Colorado River mainstem and 57 miles on the Gunnison River. Monitoring at the passage structures demonstrates usage by native and endangered fish. The screens have proven challenging to operate depending on the environmental conditions, but the irrigation companies that operate the screens have improved operations through the

years. Recent information indicates that the screen bypasses have negligible impacts on fish that are returned to the river. **We believe our performance on the prescribed list of capital projects (floodplain acquisition, fish passage, fish screens, and irrigation efficiency) demonstrate exceptional progress toward reducing threats of historical habitat fragmentation and entrainment of native and endangered fish into irrigation canals and precludes the need for re-initiation or amendment of the PBO.**

3.3 Native Fish Stocking

Hatchery-produced, stocked fish form the foundation for the reestablishment of naturally self-sustaining populations[21] of razorback sucker and bonytail in the upper Colorado and Green river systems. The Recovery Program has been implementing an Integrated Stocking Plan (Nesler et al. 2003) with the goal of establishing self-sustaining populations of razorback sucker and bonytail in the upper Colorado River basin by 2015. The stocking plan was revised to stock fewer and larger razorback sucker and more, larger bonytail (ISPRC 2015). The Program has been successful in meeting the plan's stocking targets.

Stocked razorback sucker are spawning, and wild juvenile razorback sucker are being captured in low numbers. From 1995 to 2012, more than 164,600 razorback sucker were stocked into the upper Colorado and Gunnison rivers under various stocking plans and at different sizes. Two reports on survival estimates of stocked razorback sucker recommended stocking larger fish during spring, fall and winter (Zelasko et al. 2004; 2008). Since 2013, under a revised stocking plan, 58,906 razorback sucker, averaging 12 inches in total length, have been being stocked as far upstream as Rifle, CO on the Colorado River and Delta, CO on the Gunnison River. Recaptures of stocked razorback sucker have been on a steady increase, and is discussed later in Section 3.5.

From 2000 to 2012, more than 145,000 tagged bonytail were stocked in the upper Colorado River. Very few of these stocked fish have been recaptured. As per a Revised Integrated Stocking Plan (ISPRC 2015), more and larger bonytail have been stocked since 2013. Under this new plan, approximately 74,400 bonytail averaging 8 inches have been stocked into the Colorado River between DeBeque, CO and Dewey Bridge in Utah, near the confluence of the Dolores River. The bonytail reintroduction effort in the upper Colorado River basin has not been nearly as successful as the razorback sucker reintroduction efforts in the Upper Colorado and San Juan rivers. Recaptures of stocked bonytail are rarer. However, since 2009, increasing numbers of bonytail have been detected by stationary PIT-tag reading antennas and by traditional sampling methods throughout the upper Colorado River basin. With the advent of the Recovery Program's new STReaMS[22] database, more consistent queries of all sampling methods are providing an improved and comprehensive assessment of bonytail survival (see Section 3.5).

The Recovery Program relies on two state facilities to rear bonytail to predetermined stocking size. The State of Colorado's J.W. Mumma Native Aquatic Species Restoration Facility produces about 5,000 bonytail averaging 250 millimeter (mm) total length (TL). The State of Utah's Wahweap State Fish

[21] To achieve naturally self-sustaining populations, adults must reproduce and recruitment of young fish into the adult population must occur at a rate to maintain the population at a minimum that meets the demographic criteria identified in the recovery goals.

[22] Species Tagging, Research and Monitoring System (STReaMS) – a web-based database developed via contract with Colorado Natural History Program.

Hatchery produces 10,000, 250-mm TL bonytail. The Recovery Program also relies on two units of the federal Ouray National Fish Hatchery (ONFH) complex located in the Grand Valley in Colorado and at Randlett, Utah to meet our stocking goals. Each unit of the ONFH stock fish in the Green River as well as Colorado River. In 2012, the Grand Valley Unit was expanded to include 22 grow out ponds at the Horsethief Canyon Native Fish Facility near Fruita, Colorado.

Hatchery managers and the Biology Committee continually incorporate feedback from field personnel to adjust hatchery practices to improve survival of stocked fish. **The Recovery Program and its partners have demonstrated a sustained commitment to re-establishing razorback sucker and bonytail throughout the upper Colorado River basin; therefore, we do not believe performance of our hatchery program warrants re-initiation or amendment of the PBO.**

3.4 Nonnative Fish Control

3.4.1 Background

The nature of the invasive species threat in the upper Colorado River basin has changed greatly since the PBO was written. The introduction, establishment, and proliferation of nonnative fishes is now considered the primary threat to the recovery of the endangered fishes. Since the PBO was finalized, the Recovery Program has shifted its nonnative fish management actions from species such as channel catfish and red shiner to large-bodied predators, such as smallmouth bass, northern pike, and walleye. The Recovery Program and its partners work to lessen the impact of nonnative fish by conducting in-river removal activities, preventing escapement from reservoir locations, chemical renovation of illegally stocked nonnative fish in selected reservoirs, and by updating state policies and harvest regulations to assist in nonnative fish management.

In 1999, the nonnative species of greatest concern were: 1) channel catfish, a top level main channel competitor / predator of native species, considered abundant throughout the lower 150 miles of the Colorado River; 2) localized populations of nonnative centrarchids (primarily green sunfish and largemouth bass) found in connected backwater habitats throughout the Grand Valley; and 3) nonnative cyprinids (red shiner, sand shiner, and fathead minnow) that are commonly found in backwater habitats throughout critical habitat where they compete with and prey on early life stages of the native species. The Recovery Program researched control strategies for each of these species or groups of species (Table 10).

Table 10. A summary of early Recovery Program research into strategies to control nonnative species or groups of species identified in the PBO.

Invasive Species or Group	Citation	Findings
Channel catfish	Jackson and Badame 2002	Experimental control efforts conducted in the middle and lower Green River. Authors identify most effective sample timing and techniques, but effect of removal efforts small and short lived. Program shifts emphasis away from this species when smallmouth bass invade the Upper Basin.
Centrarchids (Green sunfish and largemouth bass)	Martinez 2004	Author samples 190 riverside ponds (sources of riverine population). A variety of control methods employed at 71 ponds; 65% of ponds sampled post-treatment were quickly re-invaded.
Nonnative cyprinids (red shiner, sand shiner, and fathead minnow)	Trammell et al. 2004	Despite temporary reductions in abundance of nonnative adults at a reach level, no significant differences were observed between treatment and control reaches in the longer term. Program determines that future removal efforts to affect temporary control on a local scale may be worth pursuing but long-lasting reach wide reductions are not likely possible.

The invasive species or groups of species in Table 10 are no longer targeted by the Recovery Program's control strategy, because other, more predatory species have invaded the Colorado River. Warm water game fish, primarily stocked in reservoirs for recreational purposes or illegally stocked in reservoirs, are now thought to have the greatest adverse effect on endangered native fishes. Of those species, large bodied predators are considered the most problematic – specifically centrarchids (smallmouth bass), esocids (northern pike), and percids (walleye).

3.4.2 Removal Efforts

Since 2004, the Recovery Program has directed funds to specifically control a rapidly expanding population of nonnative smallmouth bass that had emerged in the Colorado River mainstem. Other nonnative species (green sunfish, largemouth bass, and northern pike), which tend to flare up from time to time are also removed opportunistically, but smallmouth bass is the primary target species. The majority of the Recovery Program's nonnative control efforts in the Colorado River are funded under Projects 126a and 126b (Francis 2019), but additional nonnative removal efforts occur during other Recovery Program projects (e.g. during Colorado pikeminnow population efforts). Over the past decade, the number of river miles and the number of removal passes has increased steadily since smallmouth bass were detected.

Since 2004, the Recovery Program has expended more than $2.5M on nonnative predator control in the Colorado River between Rifle, CO and the upper terminus of Westwater Canyon, approximately 120 river miles. The densities (catch per hour of electrofishing) of adult smallmouth bass (>200mm TL) in the

15-Mile and 18-mile reaches were greatest (4.39 fish/h) in 2005, gradually declined for many years, then rebounding up to 2.07 fish/h in 2013. Catch rates have remained below 2.0 fish / hr since 2013 (Francis 2019). The high densities reported in 2005 rivaled densities recorded in the Yampa and Green rivers (Breton et al. 2014). Despite intensive and focused removal efforts for years, smallmouth bass still demonstrate the capacity to spawn successfully and in large numbers during low flow years.

Northern pike captures in the Colorado River, from Rifle, CO to the upper terminus of Westwater Canyon were low (2 or 3 fish / year) from 2004 thru 2010. In 2011, the catch increased to 11 individuals. The annual catch increased again to 16 individuals in 2012 and 2014. In 2012, CPW researchers discovered a concentration of northern pike and other nonnative species at the Mamm Creek United (MCU) riverside pond near Rifle, CO. Specific nonnative fish removal efforts at that pond have occurred every year since that discovery. Sampling at the MCU pond was greatly increased in 2015 with the deployment of a Merwin trap, which yielded 326 northern pike . A total of 611 northern pike have been removed from this pond since sampling began. No northern pike were collected at this site in 2018 and 2019. Based on the elimination of MCU and other sources (see 4.4.3), northern pike are now rarely captured in the Colorado River.

Adult walleye numbers increased in the lower Colorado River in 2010, rose to their highest densities in 2013 and 2014 and have fluctuated at high levels since. The Recovery Program began directing specific removal effort targeting this species in 2013. In 2015, humpback chub population estimation in Black Rocks was postponed to divert more funds and effort to walleye removal. A total of 237 walleye, a relatively high catch, were removed from the Colorado River, primarily downstream of Westwater Canyon in 2019 (Michaud et al. 2019). The emergence of walleye as a predatory threat to native species, especially juvenile Colorado pikeminnow, since the PBO is of concern. The Recovery Program now invests heavily in source containment and removal of this species.

3.4.3 Reservoirs as Sources

Isotopic analysis (Johnson et al. 2014) of ten of the northern pike collected in the river in 2011 revealed that three likely came from Rifle Gap Reservoir (RGR). The same analysis showed that walleye collected in the river in 2006-2007 also likely originated in RGR. Colorado Parks and Wildlife (CPW) installed a Coanda-type screen[23] on the Rifle Gap Reservoir outlet in 2013. CPW's post-screen sampling indicates reservoir escapement of northern pike, walleye, and smallmouth bass has been greatly reduced and likely eliminated.

The Recovery Program, the State of Colorado, Reclamation, and Tri-County Water Conservancy District will install a screen on the Ridgway Reservoir spillway in the fall of 2021 to contain a population of illegally introduced smallmouth bass. Ridgway Reservoir is on the Uncompahgre River, a tributary to the Gunnison River. Tri-County WCD has been able to manage Ridgway Reservoir to avoid for spills since 2011 in an effort to assist the Recovery Program by containing smallmouth bass until the screen is installed. CPW has held fishing tournaments for smallmouth bass at Ridgway Reservoir since 2015. In

[23] CPW also installed a Coanda screen on the outlet of Juniata Reservoir to contain smallmouth bass and walleye; no post-screen evaluation data available at this time.

2019, anglers removed approximately 1,500 smallmouth bass in three weeks. Based on monitoring, it is estimated that five years of tournaments have reduced the population of smallmouth at Ridgway Reservoir by 79% from initial estimates. CPW and Colorado River Water Conservation District have implemented incentivized harvest of northern pike from Green Mountain and Wolford Mountain, paying anglers $20/ fish in recent years.

CPW, with financial support from the Recovery Program, has successfully applied rotenone (fish toxicant) at two reservoirs to control illegally introduced nonnative predators. In 2012, Paonia Reservoir was treated to remove northern pike. In 2013, Miramonte Reservoir was treated to remove smallmouth bass. In recent years, Utah and Colorado have increased messaging about the ecological impacts and detrimental effects to sport fisheries resulting from chronic illegal introductions.

3.4.4 Regulations and agreements

Procedures for stocking nonnative fish species in the entire upper Colorado River basin were approved by the Recovery Program (USFWS 1996). The purpose of the Procedures was to ensure that all future stocking of nonnative fish is consistent with the recovery of the endangered fishes. This agreement remains in effect through the life of the Recovery Program. On January 14, 1999, the Colorado Wildlife Commission adopted the Procedures and extended application to stocking of private ponds.

Martinez and Nibblelink (2004) evaluated Colorado's nonnative fish stocking regulations. They determined that because of data limitations and the short timeframe of their study, it was inconclusive whether Colorado's nonnative fish stocking regulations were effective in controlling or reducing nonnative fish proliferation. They recommended that their conclusion be viewed as an opportunity to clarify the existing regulation to facilitate compliance and to improve its potential to serve as a preventative control strategy rather than a basis to eliminate or relax the existing regulation. Since that time Colorado has continued to adhere to the stocking procedures and liberalized harvest regulations for the nonnative predators.

In 2009, the states and the Service completed revisions to the Procedures (USFWS 2009b). Through those revisions, the states and the Service expanded their areas of interest beyond a proposed stocking event to consideration of subsequent management as covered under specific water body management plans (referred to as 'lake management plans'). The revised Procedures retain the original intent, while making the document more user-friendly. If an illicit introduction occurs, the states and the Service will review how that introduction may affect management of the water body as well as potential effects on the recovery of the endangered Colorado River fish. The revised Procedures were implemented via a signed Cooperative Agreement (Upper Basin State Wildlife Agency Directors and the Service's Regional Director) in June 2009. CPW adopted regulation changes in January 2013 to implement the 2009 Stocking Procedures as they pertain to stocking of non-salmonid fishes in the UCRB in Colorado west of the Continental Divide, including the San Juan River basin.

In May 2015, the Recovery Program approved the *Upper Colorado River Basin Nonnative and Invasive Aquatic Species Prevention and Control Strategy* (Basinwide Strategy; Nonnative Fish Ad Hoc Committee 2015), which recommends focusing on prevention, eradication and swift control of problematic species.

Ongoing prevention and control actions (e.g., in-river mechanical removal, reservoir reclamations, reservoir screening, incentivized harvest, adjustments to existing bag and possession limits) mentioned above are in accordance with the Basinwide Strategy.

CPW convened a nonnative fish working group in 2015 to discuss regulations for nonnative species as they relate to endangered fish recovery. The outcome of the group focused on unlimited harvest of problematic species, preventing escapement from reservoirs, implementing harvest incentives, and improved messaging at specific waters. As result of these discussions, CPW is promoting a "catch and keep" unlimited harvest strategy as opposed to a must-kill regulation. CPW has removed all bag and possession limits for problematic nonnative fishes (northern pike and smallmouth bass) in the warm water reaches of the Green, Yampa, White, Colorado, and Gunnison rivers on the western slope in Colorado. CPW presented new harvest regulations to the CPW Commission in September 2015. The regulations were adopted in in November 2015, and took effect on April 1, 2016. In 2014 the State of Utah implemented a “must kill” regulation for smallmouth bass, northern pike, walleye and burbot caught in the Green and Colorado rivers.

3.4.5 Summary

In summary, the threat of nonnative predators in the Colorado River and throughout the upper Colorado River basin has increased substantially since the Service wrote the PBO. Smallmouth bass and walleye were not considered a widespread threat in the late 1990’s. Currently, the Recovery Program and our state partners recognize these nonnative predators as the greatest impediment to recovery. The Recovery Program is spending approximately $2M annually (basin wide) to control riverine populations of these invasive predators and is funding the installation of screens on specific reservoirs to contain them. The states are reclaiming off channel sources and shifting sport fish management to focus on species that are compatible with endangered fish recovery. The states have revised fishing regulations to assist with the removal of these invasive species and to convey the correct message to the public that the ‘worst-of-the-worst’ nonnative predators cannot be tolerated in the upper Colorado River basin. This suite of actions is consistent with the Recovery Program’s Basinwide Strategy. Although considerable funding and efforts are going to sufficiently manage the nonnative threat, the Recovery Program has demonstrated the strongest commitment to those efforts which will likely be needed indefinitely in the future. **The Recovery Program response to the considerable nonnative fish threat to recovery has been significant, adaptive, and sustained and therefore does not warrant re-initiation or amendment of the 15-Mile reach PBO.**

3.5 Research, Monitoring, and Data Management

The fifth recovery element, research, monitoring, and data management, assists the Recovery Program in evaluating the success of actions preformed under the previous four elements and in adaptively managing Recovery Program responses to changing conditions that affect recovery of the species. In the context of the PBO, this element comprises monitoring the status and trends in fish populations. Robust monitoring allows the Recovery Program to detect changes in endangered fish populations, new threats to the endangered fish, such as specific nonnative fish species, the effectiveness of Program

actions and modification of those actions as appropriate. Population estimates of endangered fishes are a fundamental data consideration when assessing the status of the species and were emphasized in the PBO. However, environmental, demographic, and sampling variability affect our ability to gather precise population estimates in this large desert river ecosystem. Because of high costs and potential impacts to endangered fish, the Recovery Program performs population estimates in two (humpback chub) or three (Colorado pikeminnow) consecutive year bundles and then takes a two-year hiatus. In recent years, the Recovery Program has been able to generate razorback sucker populations estimates using data collected as part of the Colorado pikeminnow population estimate.

3.5.1 The State of Endangered Fish Monitoring in 1999

In 1999, when the Service wrote the PBO and Appendix D – Endangered Fish Population Status Assessment, the Recovery Program had just completed the 2nd-yr of its second 3-yr rotation of Colorado pikeminnow adult / late juvenile population estimates in the Colorado River. Mark / recapture population estimates commenced on the Colorado River in 1992. From the five available population estimates' preliminary data points (1992 – 1994 (as summarized in Osmundson and Burnham 1998) and 1998 and 1999), the Service determined that the adult population in the Colorado River was relatively stable near 600 individuals. Additional and earlier monitoring information was also considered. Catch per unit effort (CPE) data collected from the Interagency Standardized Monitoring Program (ISMP) were available for adults (as # of fish / hr of electrofishing) and young of the year (Age-0 ; # of fish / area seined) life stages of Colorado pikeminnow dating back to 1986. In the late 1990's, the adult Colorado pikeminnow population was trending positively. The Service expected that the population would fluctuate naturally through time, but lacked empirical information to describe longer term population dynamics.

In 1999, the available information on humpback chub population abundance and trends was even more limited. ISMP catch rates (# of fish caught / hr in a standardized size trammel net) were available for juvenile and adult humpback chub in Black Rocks and Westwater canyons on the Colorado River, but mark / recapture population estimation for that species in those locations had just started the prior year in 1998.

Few wild razorback sucker adults (presumably very old individuals) were still being collected throughout the Colorado River drainage. The Recovery Program had determined that stocking to restore populations would be necessary for that species as well as for bonytail. In the PBO, the Service determined that population responses for Colorado pikeminnow and humpback chub would need to serve as surrogates for razorback sucker and bonytail responses.

The Service was developing quantifiable recovery goals (demographic and threat removal) for all four Colorado River fish, but those documents would not be finalized until 2002. In the PBO, the Service expected that the pending recovery goals would provide the best metrics for population response.

3.5.1.1 Colorado pikeminnow

From a population viability perspective it is important to note that Colorado pikeminnow populations in the Colorado and Green river subbasins are 'wild', i.e., they have not been maintained[24] by stocking hatchery produced fish. Colorado pikeminnow were stocked for a very short period of time (in 2003 and 2004) in the upper reaches of the Colorado and Gunnison rivers in an effort to repatriate areas long cut off from the lower rivers by main channel diversion dams. Osmundson and White (2014) estimated that survival of those stocked fish was 4% in their first year and had diminished to 0.03% by 2008. No stocked fish were recaptured after 2008. The existing populations are maintained by natural reproduction and the stocked fish have not measurably contributed to the current abundance.

Population estimation is a major undertaking requiring that crews conduct as many as 5 sampling passes across long river reaches in relatively narrow timeframes. The Recovery Program has estimated the size of the adult Colorado pikeminnow population in the Colorado River during 15 non-consecutive spring seasons from 1992 – 2015 including nine times since the PBO was signed in 1999.

In the PBO, the Service identified two possible adult Colorado pikeminnow population response outcomes that would trigger re-initiation: 1) if the population displayed a 'negative response'; or 2) the population did not display a 'positive response' by the year 2015. Furthermore, in the PBO - Appendix D, the Service defined possible population response(s) as follows:

- a *negative response* was defined as a population that had dropped to ≤ 350[25] adults (>450mm TL), and
- *a positive response* was defined as population that had increased to N≥ 1,100[26] adults. A population that fluctuated between N=350 – 1,100 adults was considered to have displayed a 'neutral response'.

The Service's 2002 Recovery Goals updated population response criteria. In the PBO, the Service expected that the pending recovery goals would provide better metrics for population response. The Recovery Goals for all four endangered fish (USFWS 2002 a-d[27]) were finalized in 2002. The Recovery Goals identify objective and measurable threat removal and demographic criteria. For Colorado pikeminnow in the Colorado River the Service determined the following downlisting demographic criteria:

Over a 5-year period:

- *A self-sustaining population of at least 700 adults is maintained such that:*
  - *the trend in adult point estimates does not decline significantly, and*
  - *mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality.*

[24] Over a 2-year period (2003-2004) a total of 4,214 Colorado pikeminnow (>150mm TL) were experimentally stocked in the Colorado River (upstream of the Grand Valley Project Diversion) and upstream of the Redlands Diversion on the Gunnison River. When it was determined that stocked fish were moving downstream into habitat occupied by wild fish, the Biology Committee immediately decided to cease stocking.

[25] Based on the 1999 estimate of N=600 adults and the associated 95% Confidence Interval of ±250.

[26] Based on the 1999 estimate of N=600 adults + 2(Cis); 600 + 2(250) = 1,100 adults.

[27] Available at: http://www.coloradoriverrecovery.org/documents-publications/foundational-documents/recovery-goals.html

The Recovery Goals were developed based on estimates of carrying capacity for the Colorado River, which ranged between 700 and 1,200 adults. The upper range of values depended on Colorado pikeminnow successfully expanding their range above fish passages on the Colorado and Gunnison rivers, as well as increasing water temperatures in the Gunnison River by installing a temperature control device at the Aspinall Unit. The PBO indicates the Recovery Goals can be used to assess a positive population response, which would be achieved if the Colorado River adult abundance exceeded 700 fish. There are no minimum abundance thresholds listed in the Recovery Goals, so the Recovery Program will use the original PBO guidelines (<350 adults) in assessing whether a negative response has been observed.

The adult Colorado pikeminnow population in the Colorado River has demonstrated considerable fluctuation since monitoring began. Although the Colorado River population appears to satisfy the 'self-sustainability' criterion in the 2002 Recovery Goals, it has not met the abundance criteria of 'at least 700 adults' in any five year period. The Service will be reevaluating the demographic and threat removal criteria for Colorado pikeminnow through revision of the species' recovery plan, which is appropriate as the Recovery Program has gathered considerably more information about Colorado pikeminnow population dynamics since the 2002 Recovery Goals were completed. The Service and the Recovery Programs (including the San Juan River Basin Recovery Implementation Program) completed a Population Viability Analysis (PVA) for this species in 2018 to better understand the species' risk of extinction over varying timeframes. Information from the PVA can be used to develop objective and measurable demographic criteria for use in a revised species recovery plan. In accordance with the Recovery Planning Implementation process, the Service completed a Species Status Assessment (SSA; USFWS 2020), which reviewed the species' needs, current condition, and viability using models from the PVA. As a result of this review of the most recent scientific information, the Service recommended (in their 5-Year Review) the Colorado pikeminnow remain listed as endangered and the recovery goals for the species should be revised.

Throughout the 23-yr period of study the precision associated with each annual population estimate (Figure 5) has varied considerably, but has yielded an average population size of 596 adults. Therefore, strictly according to the Service's definition of population response outlined in the 1999 PBO, we have documented a negative response in 1 of 15 annual estimates, and a positive response in three estimates. As depicted in Figure 5, three of 15 annual population estimates (1993, 2000, and 2005) exceeded the Service's 2002 Recovery Goal demographic criteria of N≥ 700 adults. However, the most recent population estimates are low; near 400 individuals. When considering the full breadth of population estimates the population has displayed what the Service considered a 'neutral response'.

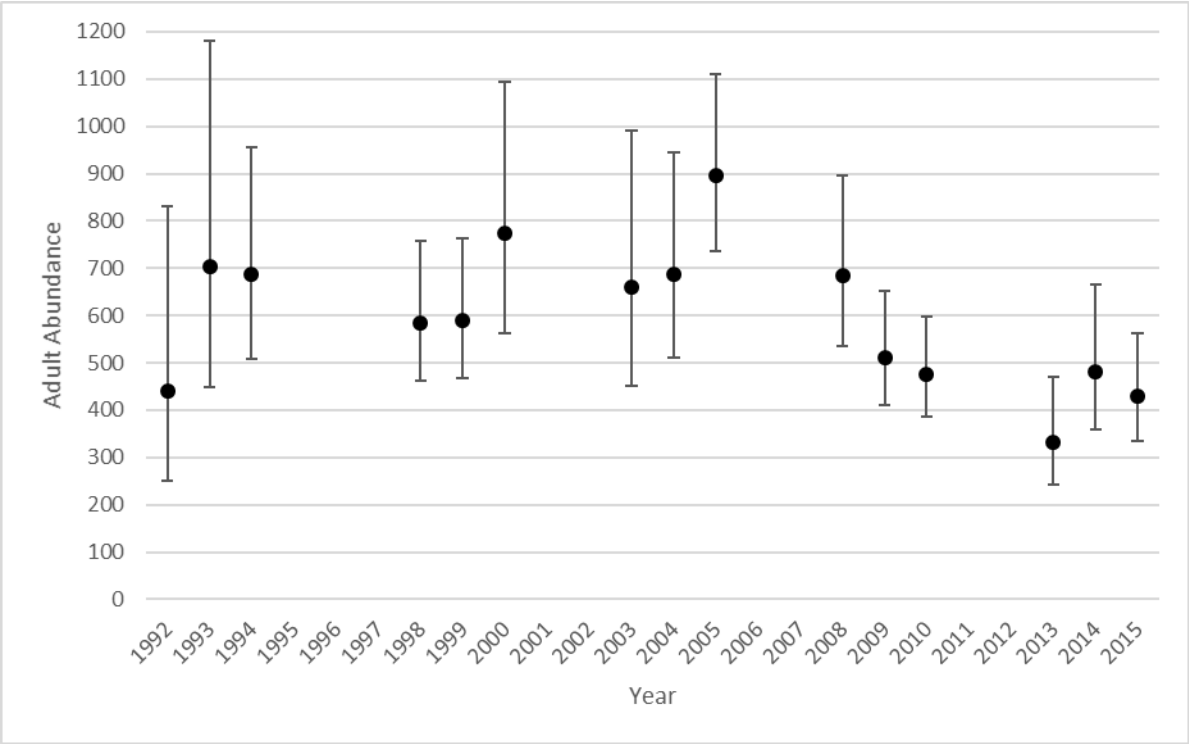


Figure 5. Adult (>450mm TL) Colorado pikeminnow population abundance estimates for the Colorado River (Osmundson and White 2014). Error bars represent the 95% confidence intervals. The 2013 - 2015 estimates are still considered preliminary (Elverud and Ryden 2016).

In a summary of the data collected from 1992 - 2010, Osmundson and White (2014) concluded:

During the 19-year study period [1992-2010], *the population remained self-sustaining. This was evidenced by: 1) annual abundance estimates of sub-adults (400–449 mm TL) about to recruit that indicated recruitment roughly balanced estimated adult mortality in years for which data were available, and 2) results of a weighted regression analysis of river-wide adult abundance estimates that indicated the intercept-only model as having the greatest weight, suggesting population stability. However, weighted regression of just the upper-reach adult population gave greatest weight to the quadratic model, suggesting the population increased and then later declined.*

A more recent analysis of this data set, which included estimates from 2013—2015, has been completed (Elverud et al. 2020). This report did not conduct a weighted regression analysis to assess long term population trends. The authors did estimate the net gain of adults based on recruit abundances and adult mortality, but these could only be estimated for years when sampling occurred. Elverud et al. (2020) also pointed out that while there appeared to be a net gain in adults, the population had declined dramatically from 2005 to 2013. This decline could be explained by estimated adult mortality in the absence of recruitment. The population decline since 2005 was also supported by the PVA models (Miller 2018), which found more statistical

support for models indicating an early increase followed by a recent decline compared to a model based on a single long-term trend.

Adult Colorado pikeminnow (≥450mm TL) are at least 7 years old. To understand trends, or more importantly to predict trends, in the adult population the Recovery Program gathers information on the abundance of earlier life stages: juveniles and age-0. The size structure of the Colorado pikeminnow population, particularly as it relates to recruitment, was an important consideration in the Service's PBO Appendix D as well as the Service's 2002 Recovery Goals. Colorado pikeminnow population size structure has been consistently tracked through time (Osmundson and White 2014; Elverud et al. 2020). Elverud and Ryden (2015) report that of the 203 individual Colorado pikeminnow collected in 2015, 81 (40%) were juvenile fish (<399 mm TL), i.e. there is a relatively strong pulse of fish recruiting into the adult portion of the population. All of the 81 individual juvenile Colorado pikeminnow were between 300-399 mm TL. Twenty (10%) of the 203 individual Colorado pikeminnow were sub-adults (400-449 mm TL). The remaining 102 individual Colorado pikeminnow captured in 2015 were adult size (>450 mm TL). The adult Colorado pikeminnow ranged from 451 mm TL to 928 mm TL. No Colorado pikeminnow were collected in 2015 that were below the minimum size (150 mm TL) to be PIT tagged.

Elverud and Ryden (2015) cautioned that the absence of Colorado pikeminnow < 300 mm TL in the collections from 2015 suggests spawning success and/or recruitment has been poor the previous three years. Observed declines in adult abundance appear to confirm this conclusion, since the more recent analysis found that without recruitment, estimated mortality rates of adults could account for the trend. Osmundson and White (2014) also expressed concern that in recent times pulses of recruitment may be too weak and infrequent to support long term stability.

The Recovery Program's first signal of possible future pulses of recruitment comes through monitoring densities of young of the year Colorado pikeminnow (age-0), which has been conducted every autumn since 1986. Breen et al. (2016) reported unprecedented catches of age-0 Colorado pikeminnow in the Colorado River in fall of 2015. Catch per unit effort in 2015 was 106.4 fish/100 m^2, well above the five-, 15- and 29-year averages (1.8, 1.9 and 4 fish/100 m^2, respectively). In fact, this was the highest CPE documented since ISMP began in 1986 in both the Green and Colorado rivers. Eighty-six percent of the 36 seine hauls completed in the fall of 2015 contained at least one age-0 Colorado pikeminnow. In 2016, UDWR reported that their catch of age-0 Colorado pikeminnow in the lower Colorado River was again above the long term average (5^{th} highest annual catch rate since 1986). It is encouraging that even with the number of adult Colorado pikeminnow at apparently historically low levels, they have the capacity to produce strong cohorts of age-0 fish.

Recent electrofishing data point to a large year class of Colorado pikeminnow sub-adults ready to enter the adult cohort. This pulse of fish corresponds to the high densities of age-0 fish collected in 2015. These recruit-sized Colorado pikeminnow present in the system today have largely made it through the gauntlet of troublesome densities of smallmouth bass and the relatively recent influx of nonnative walleye in the lower Colorado River (discussed in Section 3.4). However, researchers can only speculate how much stronger the current pulse of

recruitment could have been for the unprecedented 2015 year class in the absence of these nonnative predators.

The PVA incorporated the 2015 age-0 monitoring data, and described the phenomenon as a "spawning spike." Models projecting the future abundance of the Colorado River population included varying levels of survival of this spawning spike, assuming they continued at the observed frequency (once in 23 years). Given a continuation of existing conditions and population dynamics, the Colorado River population of Colorado pikeminnow was only projected to remain at current levels with the ongoing, occasional occurrence of these spawning spikes similar to 2015, and these spikes would need to result in recruitment to the adult stage.

The major threats to the Colorado pikeminnow throughout the upper Colorado River basin have been generally characterized as changes in hydrology / habitat and predation and competition from nonnative species. Both the PVA and SSA considered these factors in a variety of scenarios to assess viability of the species. In summarizing the available information for Colorado pikeminnow to build projection models, the PVA team modeled reproduction and recruitment as a function of base flows. Research by Bestgen and Hill (2016) found that above average densities of age-0 Colorado pikeminnow were more likely in an intermediate range of base flows on the Green River. A similar analysis for the PVA indicated there was also a range of base flows for the Colorado River where age-0 densities were more likely to be higher than the long term mean. The PVA analysis also found that base flows on the Colorado River downstream of the Gunnison River confluence were typically within this preferred range in most years. Flows below the confluence were used because most of the nursery habitat for Colorado pikeminnow is believed to occur in the lower river, and annual monitoring for age-0 fish is focused in this reach. These results point to the contribution of the Gunnison River in supplementing Colorado River flows below their confluence, and the importance of flow recommendations and management actions for both rivers working in concert to maintain river conditions.

The PVA also considered the potential for increased survival, recruitment, and carrying capacity resulting from nonnative fish control. As mentioned previously, recruitment is an important factor in counteracting natural mortality of adults over time. Projections that increased survival of younger age classes, presumably as a result of nonnative predator control, produced significant improvements to the Colorado River population of Colorado pikeminnow. Finally, the PVA also considered the effects of increasing available habitat through fish passages and the possibility this could lead to greater carrying capacity for the Colorado River population. This conservation action resulted in increases for the population because fish produced from infrequent spawning spikes would have more habitat to support their recruitment into adult sizes. Flow management represents an important contribution to this conservation activity since three fish passages in the Grand Valley rely on flow through the 15-Mile Reach to allow for fish access and movement to upper reaches.

The SSA reviewed the PVA data assimilation and projections, and used this information in conjunction with other data sources to assess the stressors influencing Colorado pikeminnow populations. The SSA also categorized demographic and habitat factors thought to most affect these populations. For the Colorado River, recruitment was identified as a primary demographic factor influencing the population. In assessing habitat factors, base flows were considered to be in high condition category, but peak flows

were ranked as moderate. This was because peak flows had not consistently reached recommended targets in recent years. The SSA review also illustrated the importance of the Gunnison River in managing flows for Colorado pikeminnow throughout the upper Colorado River. Since most of the Colorado pikeminnow habitat in the Colorado River is downstream of this confluence, the population's response is a product of management activities in both the 15-Mile Reach and the Gunnison River.

In Section 3.1 we reviewed the Recovery Program's efforts to augment spring peaks and improve base flow conditions in the 15-Mile Reach particularly in August – October. Since the Service wrote the PBO, we have witnessed a range of spring peaks in the 15-Mile Reach that mimics the range of peaks Colorado pikeminnow have experienced over the past 80 years. With respect to summer base flows Recovery Program stakeholders have improved conditions in the 15-Mile Reach during dry hydrologies compared to the longer term record. In addition, flow management and operation of the Aspinall Unit on the Gunnison River provides river flows that augment both the spring peak and base flows for the Colorado River below their confluence. This is especially important since nursery habitats for Colorado pikeminnow are located below the confluence, as is the majority of currently occupied habitat in the upper Colorado River. The Colorado pikeminnow population in the Colorado River nearly doubled in abundance from 1992 – 2005 under these hydrological conditions. Nonnative species (as discussed in Section 3. 4) have been present and undoubtedly impacted the native fish community at some level throughout the past 80 years. However, the magnitude and character of the nonnative threat has changed dramatically in the past 10-15 years. In particular, nonnative smallmouth bass greatly increased in abundance following the record drought of the early 2000's. Nonnative walleye have greatly increased in abundance in the past 5-10 years, particularly in nursery reaches important for recruitment of younger fish. For these reasons the Recovery Program believes the recent decline in the population of Colorado pikeminnow in the Colorado River is more likely a result of increased competition and predation from nonnative species than from altered hydrology / habitat degradation.

Colorado pikeminnow Conclusions:

- The Service's demographic criteria included in the 2002 Recovery Goals for Colorado pikeminnow replaced the population response criteria the Service included in 15-Mile Reach PBO Appendix D.
- The population of adult Colorado pikeminnow is wild and self-sustaining.
- The population of Colorado pikeminnow in the Colorado River has demonstrated long term stability since 1992. However, this population has been in decline since 2005 and is currently at historically low levels.
- Adult Colorado pikeminnow abundance exceeded the Service's downlist demographic criteria (N≥ 700 adults) in three of the 15 annual population estimates (1993, 2000, and 2005) collected to date. The population was below the PBO negative response threshold of 350 adults in one year (2013).
- In 2015, age-0 Colorado pikeminnow densities in the lower Colorado River were at a 30-yr record high. Even with adult Colorado pikeminnow at historically low levels of abundance, the population continues to demonstrate the capacity to produce strong year classes of age-0 fish.

The PVA analysis indicated that base flows in the Colorado River below the confluence with the Gunnison are often in a preferred range for improved survival of age-0 Colorado pikeminnow.

- Current flow management supported a steady increase in the adult Colorado pikeminnow population from 1992 thru 2005.
- Nonnative smallmouth bass abundances in the Colorado River including the 15-Mile Reach increased in the early 2000's. Since 2010, nonnative walleye increased in abundance in the lower reaches of the Colorado River. Nonnative fish predation and competition are suspected as the primary threat to recovery of Colorado pikeminnow in the Colorado River (and throughout the upper Colorado River basin).
- As discussed in Section 3.1, Recovery Program partners have improved habitat conditions for Colorado pikeminnow in the 15-Mile Reach and throughout the upper Colorado River basin via spring peak and base flow management since the early 1990's.
- As discussed in Section 3.2, the Recovery Program has provided fish passage for Colorado pikeminnow at all the diversion structures in the Grand Valley, screened all major irrigation canals, and implemented an irrigation canal salvage program since the screens have been in place.
- As discussed in Section 3.4, the Recovery Program has developed an aggressive nonnative predator control program, which targets removal of northern pike, smallmouth bass, and walleye throughout the 15-Mile Reach and throughout the Colorado River. In addition, Program stakeholders have screened the outlets at Rifle Gap Reservoir and Highline Lake to contain some of these same species and revised fishing regulations to communicate to the public that these nonnative predators are not compatible with recovery.
- Recovery Program stakeholders believe that recovery of Colorado pikeminnow will require continued flow management, continued operation of fish passages and irrigation canal screens, and a reduction in the densities of nonnative predators.

In summary, recovery of Colorado pikeminnow is taking longer than the Service expected when they wrote the PBO and when they finalized the 2002 Recovery Goals. However, continuation of the Recovery Program at current or greater funding levels represents the most likely path to recovery of this species. **Therefore, the Recovery Program believes that with recognition of historical, ongoing, and a commitment to future recovery actions, in particular flow management and a strong commitment to nonnative predator control, the current status of Colorado pikeminnow in the Colorado River does not warrant re-initiation or amendment of the 15-Mile Reach PBO consultation.**

3.5.1.2 Humpback chub

The USFWS recently worked with partners and stakeholders to conduct a range-wide assessment of the status of humpback chub (SSA; Service 2018). The results of this assessment represent a compilation of the best scientific and commercial data available concerning the status of humpback chub, including the past, present, and future stressors to this species. We use resource and demographic data from the SSA report to describe the condition of humpback chub in this review.

Humpback chub exist in three populations in the upper Colorado River, all below the 15-Mile Reach. The Black Rocks and Westwater Canyon populations exist approximately 30-40 miles below the 15-Mile

Reach, while the Cataract Canyon population is located 170 miles below it, immediately downstream of the Green and Colorado rivers' confluence.

As mentioned, knowledge of humpback chub population dynamics in Black Rocks and Westwater canyons was very limited when the PBO was written in 1999. Since that date, substantial monitoring data has been collected for both populations. Black Rocks and Westwater Canyon show similar patterns of population trajectory, with the highest estimates in early monitoring (1998–2000) that declined through 2007 (Figures 6 and 7). Reasons for declines in both populations have been attributed to poor survival of young fish, because annual adult humpback chub survival rates (ranging from 0.6 to 0.74) remained relatively stable through the period. However, over the past 10 years both populations have stopped declining and have stabilized (Service 2018b).

The most recent preliminary estimates of the Black Rocks population, for years 2016 and 2017, indicate a stable population between 358 and 510 adults (Figure 6 from Francis et al. In review). The 2017 estimate was the highest since 2004. Adult survival has been above the long-term mean since 2008, demonstrating annual humpback chub recruitment in Black Rocks is offsetting annual adult mortality since 2007. Overall estimated humpback chub abundance in Black Rocks was highest in 1998 and 1999, declined through 2007, and has stabilized since 2007.

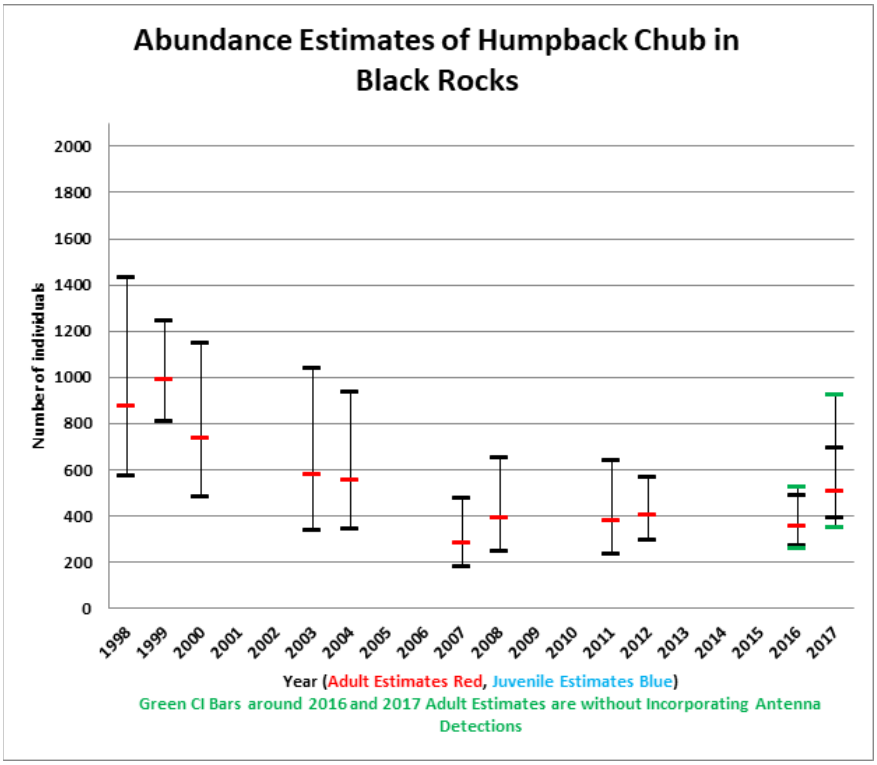


Figure 6. Population estimates for adult humpback chub in Black Rocks; 1998 - 2017 from Francis et al. In Review. Black error bars represent 95% Confidence Intervals. Green error bars represent 95% CI when antenna data were not incorporated into model (2016 and 2017 only).

The most recent monitoring of the Westwater Canyon population, for years 2016 and 2017, demonstrated multiple demographic improvements such as increased adult abundance, relatively high apparent survival, and documented recruitment (Hines et al. 2020). Yearly abundance estimates from 2016 and 2017 were significantly higher than 2007, 2008, 2011, and 2012 and not significantly different from 1998-2005, demonstrating a recent population increase to levels seen approximately 15-20 years ago (Figure 7). Survival for adult humpback chub in Westwater Canyon was relatively stable for all 19 years analyzed (1998-2016) with apparent survival highest between 2016 and 2017.

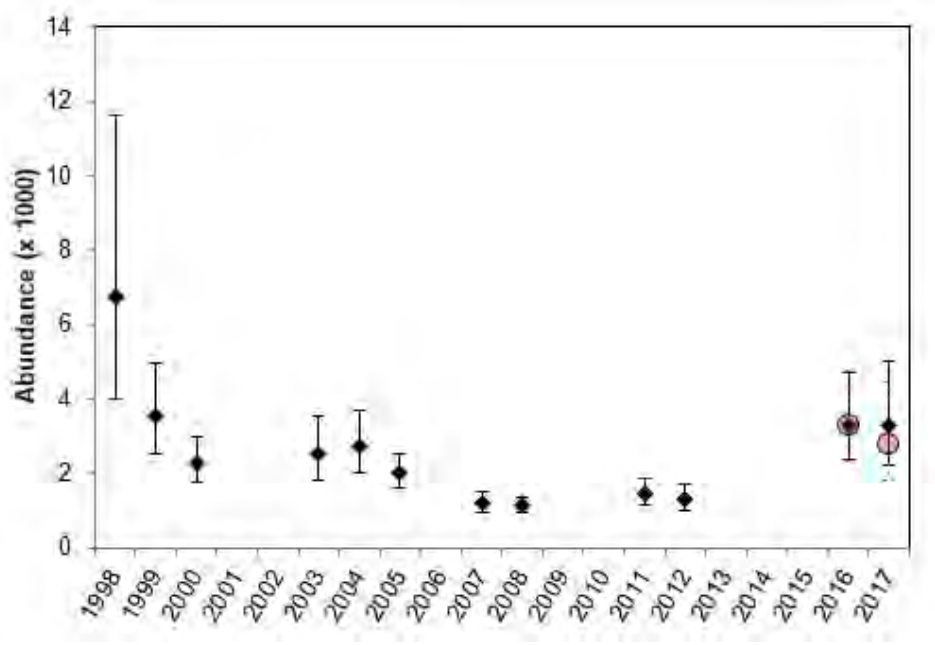


Figure 7. Population estimates for adult humpback chub collected in Westwater Canyon; 1998-2017 from Hines et al. 2020. Error bars represent 95% confidence intervals. Note 2016 and 2017 are presented with and without antennae data included. The black diamonds in 2016 and 2017 include antennae data. The red circles in 2016 and 2017 do not include antennae data in the estimates.

We suspect, as with most desert fishes, declines or increases of humpback chub populations can be attributed to survival of the early life stages. The Recovery Program has recently reinitiated efforts to monitor early life stages of these Colorado River humpback chub populations. It is encouraging that both populations appear to have stabilized or increased, and recently shown signs of positive growth, but we would benefit from a better understanding of the cause of the past declines. Tracking abundances of the early life stages will contribute to that understanding. Another sympatric native chub, the roundtail chub, has remained stable in both canyons through the same period of study.

A third population of humpback chub in the upper Colorado River inhabits Cataract Canyon, substantially downstream of the 15-Mile Reach. Considering the influence of flows from the Gunnison and Green rivers, we do not believe recovery actions in the 15-Mile Reach directly affect humpback chub population dynamics in Cataract Canyon. However, monitoring of this population is still important to understanding viability of the species. The Cataract Canyon population is small, with fewer than approximately 500 adults. Abundance of humpback chub in Cataract Canyon is estimated by CPUE rather than more robust mark-recapture techniques, which makes estimating a population trend for

Cataract Canyon difficult. Consistent catches of adult and young life stages indicate that this population persists. Monitoring efforts from 2017 documented the highest annual CPUE for humpback chub in Cataract Canyon over the last 26 years (Ahrens 2017). New sampling techniques documented an unprecedented number of juvenile chubs in Cataract Canyon, further indicating that this population is persistent (Ahrens 2017).

The three upper Colorado River populations generally have adequate resource conditions to promote population resiliency, as described in the SSA. All three have high-quality rocky canyon habitat, suitable temperature, adequate food base, unimpeded connectivity, and high genetic diversity. The resources of highest concern and uncertainty are adequate flow regimes and the existence of nearby populations of nonnative fish. Management actions have been enacted over the last decade, including those implemented via the 15-Mile Reach PBO, which have aided in the species' improved condition. For example, implementation of flow and temperature regimes and nonnative fish removal have mitigated stressors on humpback chub prior to 1999. The Recovery Program has never stocked humpback chub in the upper Colorado River basin.

In 2018, the Service used the SSA report to complete a 5-Year Review of the rangewide status of humpback chub. Based on the current condition of the humpback chub described in the SSA report, the Service concluded that the current risk of extinction is low, such that the species is not in danger of extinction throughout all its range. Therefore, the 5-year review recommended that the humpback chub be reclassified from an endangered to a threatened species. The reclassification was published in the Federal Register on January 22, 2020. The Service finalized this rule on October 18, 2021, reclassifying the species as threatened; this rule will take effect on November 17, 2021.

In 2018, the 5-year review also recommended revising the 2002 Recovery Goals to incorporate new information about the species. The Service will revise the recovery plan for humpback chub when the rulemaking process to reclassify the humpback chub is complete. The recovery criteria presented in the 2002 recovery goals remain as reasonable measures to gauge progress towards recovery and a valuable reference as the Service refines its vision of recovery for the humpback chub. In the 2002 Recovery Goals (USFWS 2002), the Service recommended that a Minimum Viable Population (MVP) size of 2,100 adults be maintained in Black Rocks and Westwater canyons (combined) for downlisting to be considered. As described earlier, the combined population estimates dropped below that MVP in 2007 and subsequently stabilized under the MVP. Data demonstrates that more recently the combined populations did meet the recovery criteria. The combined 2016 estimate is 3,659 animals (95% CI: 2,635– 5,210), and the 2017 estimate is 3,799 animals (95% CI: 2,608–5,699) reflecting measurable recruitment above the recovery criteria. This increase is primarily attributed to the increase from the Westwater Canyon population (Hines et al. 2020) but is also supported by increased abundance in Black Rocks.

In summary, the Recovery Program believes that with recognition of historical, ongoing, and a commitment to future recovery actions, in particular flow management and a strong commitment to nonnative predator control, the current status of humpback chub in the Colorado River does not warrant re-initiation or amendment of the 15-Mile Reach PBO consultation.

3.5.1.3 Razorback sucker

The Recovery Program's razorback sucker stocking program was just starting when the PBO was written. The razorback sucker stocking program is summarized in Section 3.3. Since 1995, hatchery production techniques have been refined. The Recovery Program has experimented with number and size of stocked fish, stocking locations, and time of stocking. The Recovery Program has evaluated survival of stocked razorback sucker (Zelasko et al. 2009) and determined: a) an optimal time to stock; b) that survival of the hatchery raised razorback sucker (typical stock size = 300mm TL) improves greatly after the first year; and c) and that larger fish (>300mm TL) survived better. The Recovery Program's Integrated Stocking Plan (ISPRC 2015) was recently revised to incorporate this information. For the past decade, researchers have reported increasing recaptures of hatchery reared razorback sucker; some that have survived more than 15 years since stocking. Preliminary population estimates were generated for razorback sucker >400 mm TL in the Colorado River from Palisade, CO downstream to its confluence with the Green River (Elverud et al. 2020). Data used to generate these razorback sucker population estimates was obtained during the Colorado pikeminnow population estimate studies conducted in 2008–2010 and 2013-2015 (Figure 8).

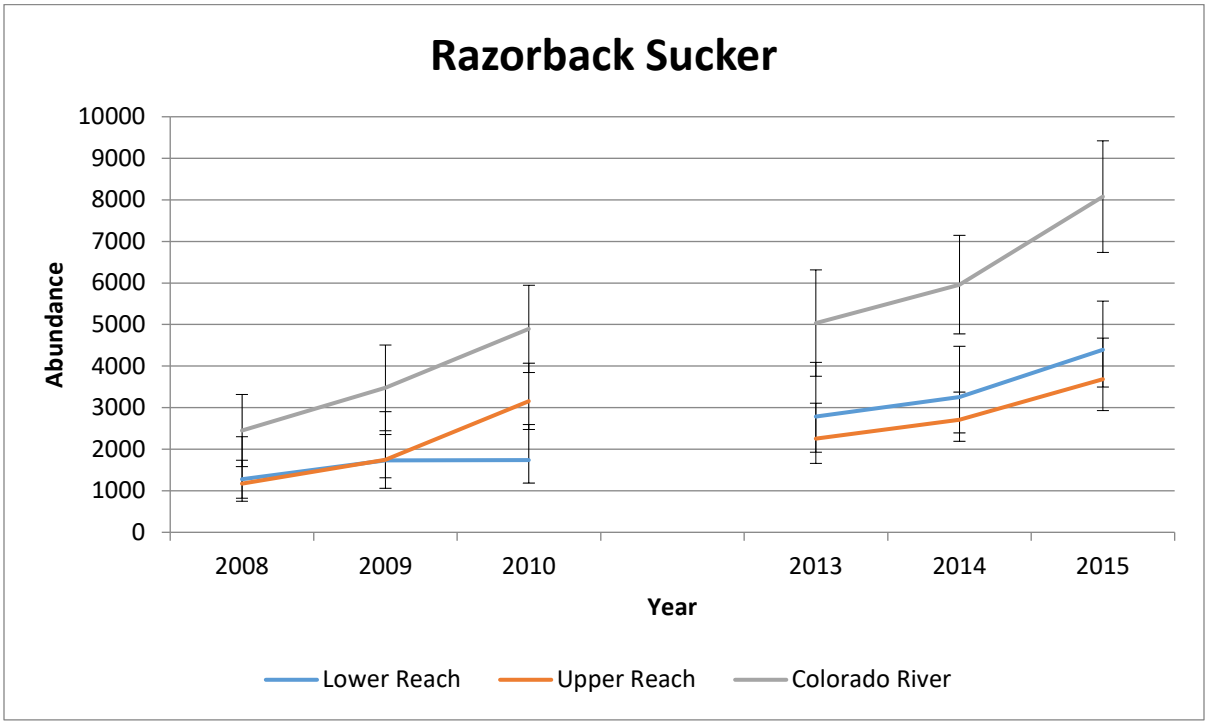


Figure 8. Estimates of abundance of hatchery stocked razorback sucker adults (and a small number of wild produced juveniles). Collections of razorback sucker occurred during pikeminnow population estimates conducted in 179 -miles of the lower Colorado River. Pikeminnow population estimates were not conducted in 2006-2007; 2011-2012; 2016-2018.

These hatchery produced adults are spawning in the wild as evidenced by the capture of 39 wild, juvenile razorback sucker (thought to be age-2 to age-3 fish) in 2013, three in 2018, and six suspected age-1 fish captured in 2019. Although not pertinent to this review, similar positive findings have been reported from the Green and San Juan rivers, from the Lake Powell inflow areas, and in lower Colorado River basin reservoirs.

Based on these positive findings, the USFWS – Legacy Region 6, in coordination with Legacy Regions 2 and 8 and with the Recovery Programs completed a rangewide Species Status Assessment for razorback sucker in the fall of 2018 (USFWS 2018b). The SSA served as the basis for a 5-Year Review in which the Service recommended reclassification from endangered to threatened status and that the species' recovery plan be revised. That decision was based on: 1) the accumulation of hatchery adults in the Green, Colorado, and San Juan rivers as well as in Lake Powell, 2) one small self-sustaining population and two other hatchery augmented populations in the lower basin; and consistent signals of reproduction and early indications of recruitment in the upper basin. The Service proposed razorback sucker be reclassified to threatened, with a 4(d) rule, on July 7, 2021.

In summary, the Recovery Program believes that with recognition of historical, ongoing, and a commitment to future recovery actions, in particular flow management in the Colorado and Gunnison rivers, a successful propagation program, and a strong commitment to nonnative predator control, the current status of razorback sucker in the Colorado River does not warrant re-initiation or amendment of the 15-Mile Reach PBO.

3.5.1.4 Bonytail

Of the four endangered Colorado River fish, the bonytail was the closest to extinction when the Recovery Program was founded in 1988. As such, considerable uncertainty remains about this species' habitat requirements in the wild. Similar to the razorback sucker, the Recovery Program determined early on that an aggressive stocking program would be needed to repatriate bonytail in the upper Colorado River basin. The Recovery Program's bonytail stocking program was just being initiated when the PBO was written in 1999. A summary of bonytail stocking efforts in the Colorado River basin is presented in Section 3.3. Since 1995, hatchery production techniques have been refined and the number and size of stocked fish have been adjusted. Unfortunately, survival of hatchery raised bonytail has not been as good as for razorback sucker. Recapture rates have been very low, and usually occur in the same year of stocking.

Elverud (2015) reported that during Colorado pikeminnow population estimation in the Colorado River in 2015, a total of 106 individual bonytail (151 – 358 mm TL) were collected from RM 1.5 – 169.3. Ninety-four (89%) of the 106 individual bonytail were captured in the lower reach, i.e. downstream of RM 110. The 106 individual bonytail captured included 12 bonytail (11.3%) that did not contain a PIT tag when captured. The untagged bonytail ranged from 151 mm to 270 mm TL. The origin of the untagged bonytail is unknown. Similar to past years, the majority (88%) of the bonytail captured in 2015 were also stocked in 2015. However, 13 of the bonytail recaptured in 2015 had survived at least one winter in the wild; typically only 1 or 2 overwintered bonytail are recaptured in a year. One of those 13 bonytail was stocked in the Green River near Green River, UT at RM 120.0.

The Recovery Program has not yet identified a successful stocking strategy for bonytail (e.g., optimal stock size, stocking time, or targeted release habitats), but experimentation continues. Most recently, the Integrated Stocking Plan was revised (ISPRC 2015) to stock more and larger (target release size is 250 mm TL) bonytail; stock them at a time when the river is near their spawning temperature (presumably physiologically optimal); and experiment with stocking in or near floodplain habitats.

In summary, the Recovery Program had certainly hoped to be farther along with bonytail recovery by this time. **However, considering the establishment of a productive bonytail hatchery program, the constant experimentation to improve bonytail stocking success, and the status of the other endangered fish, the Recovery Program believes that the current status of bonytail does not warrant re-initiation or amendment of the 15-Mile Reach PBO.**

4 Long Term Funding

All Recovery Program actions rely on a consistent funding stream to address threats on an ecosystem scale. Many of the threats the Recovery Program are managing require substantial funding and time. Many years of effort are often required before a measurable effect is detected, and even longer time is required before we can establish positive population responses. Our non-federal Recovery Program partners have been successful in securing the necessary funding stream[28]: Partner contributions (i.e., annual and capital funding and other contributions) since FY 1989 total $447 million through FY 21. The funding mechanisms are summarized below:

Annual (Base) Funding:

- Public Law 106-392 was passed by Congress in October 2000 authorized and provided funding from Colorado River Storage Project hydro power revenues for the Bureau of Reclamation to continue the implementation of both the Upper Colorado River and San Juan River recovery programs (programs). P.L. 106-392 authorized program funding through Fiscal Year 2005.
- The program's original Cooperative Agreements in 1988 and 1992 have been extended through September 30, 2023.
- Public Law 112-270 passed by Congress in January 2013 reauthorized PL 106-392 and program funding through FY 2019.
- P.L. 116-9 passed by Congress in March 2019 reauthorized PL 106-392 and program funding through FY 2023. PL 116-9 requires that the program stakeholders work with the Secretary of the Interior to submit a report to Congress at the end of FY 2021 that describes recovery actions and associated costs that will be needed post FY 2023.
- In addition to the power revenues, the Service annually contributes approximately $730K of Resource Management funds as well as $700K of Fisheries and Aquatic Conservation funds to support the Ouray National Fish Hatchery – Randlett, UT unit.
- The Upper Basin States also contribute approximately $440K annually.

Capital Funding:

- PL 106-392, as amended, authorizes the Bureau of Reclamation to cost-share capital construction projects. Water users, Colorado River Storage Project power customers and the

[28] An accounting of Recovery Program expenses is provided annually in the *Program Highlights* document, available at: http://www.coloradoriverrecovery.org/general-information/general-publications/program-highlights.html

states of Colorado, Utah, and Wyoming have provided significant non-federal funds. Capital funding amounts and the term for spending those funds has been amended since 2000.

In summary, Recovery Program partners have demonstrated a strong and consistent commitment to long term funding for actions needed to recover the endangered fish. **The Recovery Program believes its history of cost-shared funding and reauthorization does not warrant re-initiation or amendment of the PBO.**

5 Conclusions

1. New depletions have not yet reached the Service's threshold amount of 50,000 acre-feet.

2. The Recovery Program has provided a review of both shortcomings and accomplishments as they relate to: Habitat Protections (Flow Management), Habitat Development and Maintenance, Native Fish Stocking, Nonnative Fish Control, Research / Monitoring / Data Management, and the commitment to Long Term Funding. **As summarized at the end of each subject section in this review, it is our conclusion that Recovery Program performance to manage threats as identified in the PBO, and the current status of the endangered fish in the Colorado River do not warrant re-initiation or amendment of this programmatic consultation.**

6 Recommendations

1. As the Service recognized in the PBO, we recommend that the 2002 Recovery Goals provide the basis for discussions of endangered fish response criteria in future Section 7 consultations until revision of the species recovery plans is complete. The Recovery Program Director's office will lead revision of those plans for the Service.
2. Recovery Program partners and others need to continue to explore innovative ways to augment flows in the 15 Mile Reach to meet the spring and base flow targets more frequently.
3. Through this comprehensive review of Colorado River hydrology, the Recovery Program has determined that the Service's spring and summer base flow recommendations in dry years are unrealistic and appear to have been unrealistic through the entire period of record. In this review the Recovery Program has summarized actions that have clearly improved flow and habitat conditions in dry years and committed to explore ways to further improve conditions into the future. The Recovery Program should work closely with the Service to determine if there is utility in revising the 15-Mile Reach flow recommendations to more closely align with what we know about Colorado River hydrology and which studies would be needed to support such revisions.
4. The Recovery Program should continue to work with partners to operate, maintain, and repair (as needed) fish passages and screens in the Colorado and lower Gunnison rivers.
5. The Recovery Program should continue to control in-river and off-channel populations of invasive predatory species and seek new, cost-effective methods to manage the threat of predation and competition in the future.
6. The Recovery Program should continue to monitor the endangered fish populations in a manner that provides the Service with the information it needs to consider reclassification of the endangered species in the future.

7. Recovery Program non-federal partners should continue to secure adequate funding to accomplish recovery actions that will lead to recovery of the species, the goal of the Recovery Program, and that support the Service's annual Sufficient Progress reviews.
8. The Recovery Program should continue to coordinate with the Service to provide biennial reviews of the recovery actions identified in the 15-Mile Reach PBO.

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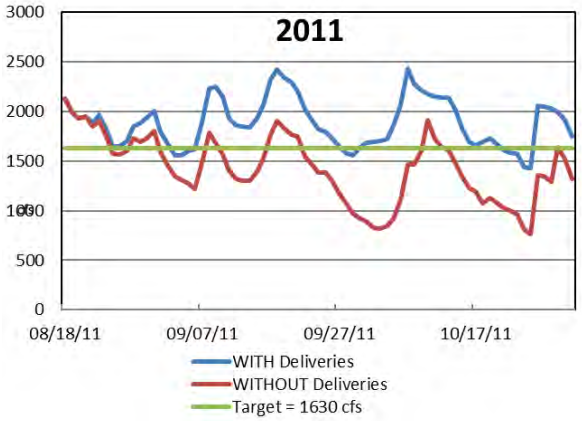
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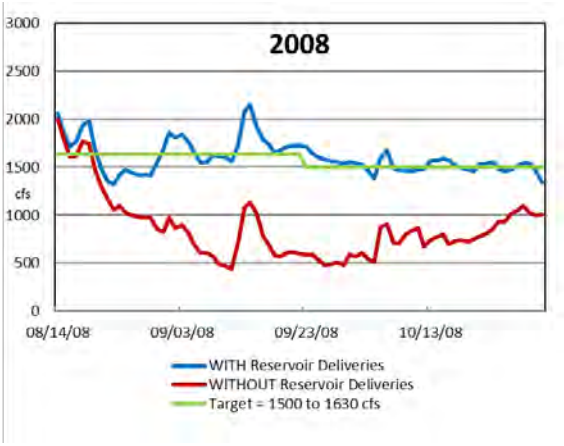
Appendix I

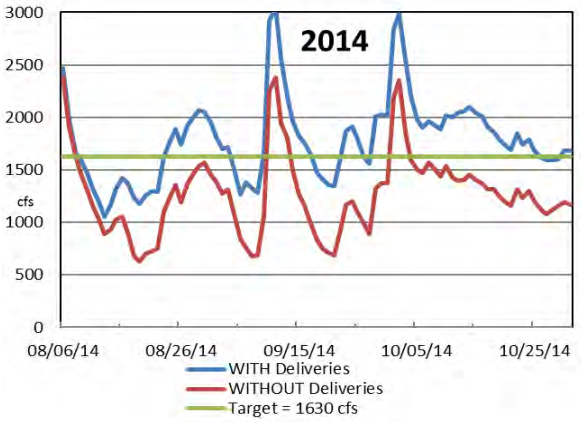
Base Flows in the 15-Mile Reach Since Program Inception

Base flow hydrographs for the Colorado River at the USGS gage Colorado River near Palisade (#09106150), with and without base flow augmentation. These hydrographs illustrate the 22 years from 1998-2019, grouped by hydrologic category, starting with wet years.[29] The recommended flows established by the Service during each base flow season also are shown.

Wet years (< 25% Exceedance)

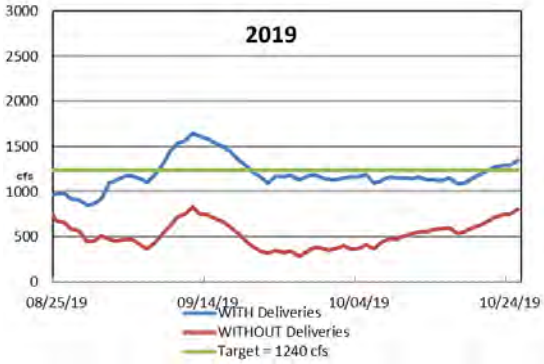


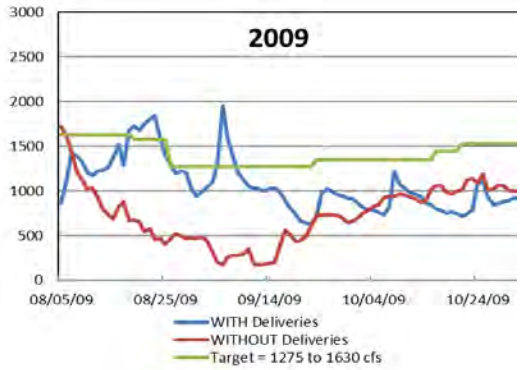


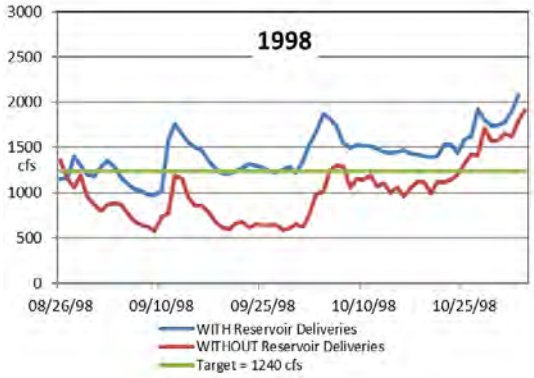


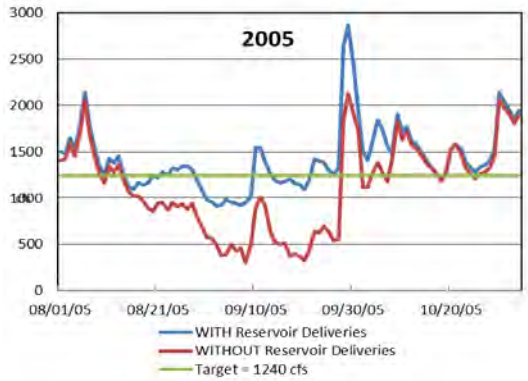
[29] For this report, hydrologic categories were determined by ranking the Bureau of Reclamation's estimated total natural flow in the Colorado River at the Cameo gage location for all calendar years 1906 through 2019, and determining the percent exceedance corresponding to each of the years shown here. As estimates for 2019 were unavailable at the time of this report, the corresponding ranking for 2019 ("Wet-Average) is based on the Program Director Office's estimate of natural runoff at Cameo.

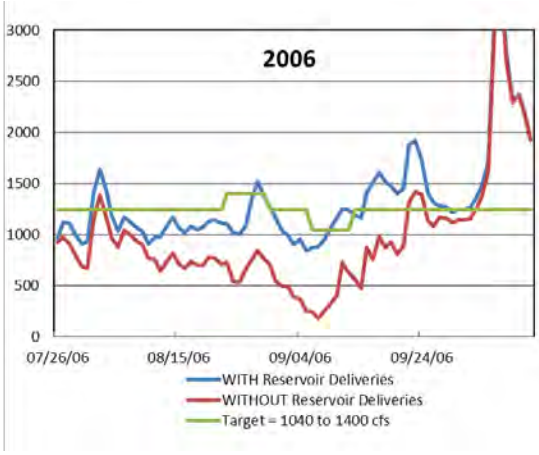
Wet/Avg Years (25-50 % exceedance)

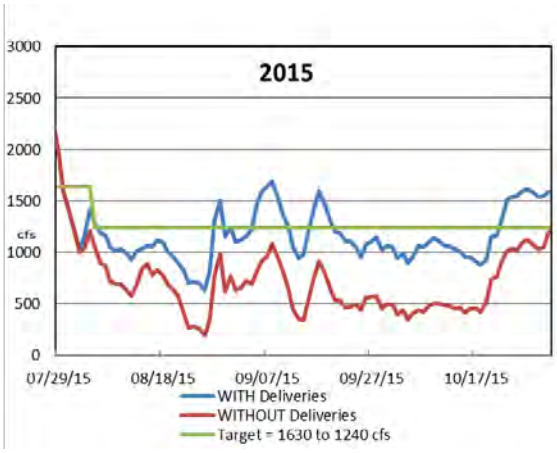






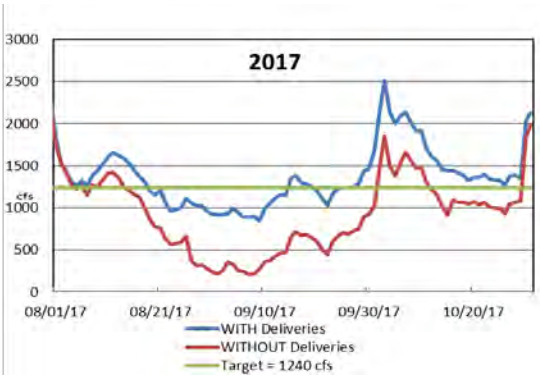




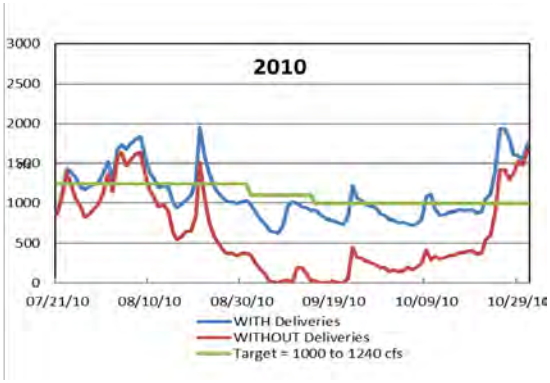


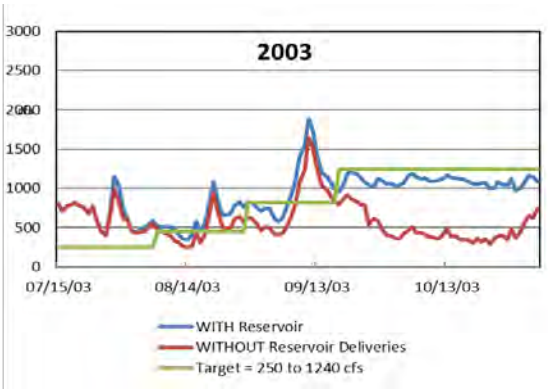
Dry/Avg Years (50-80 % exceedance)

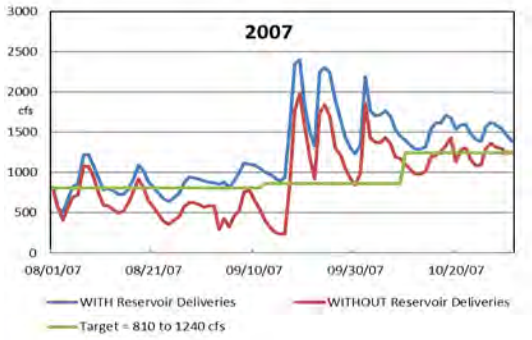


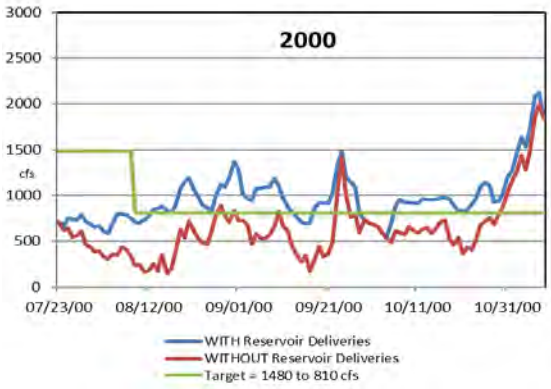




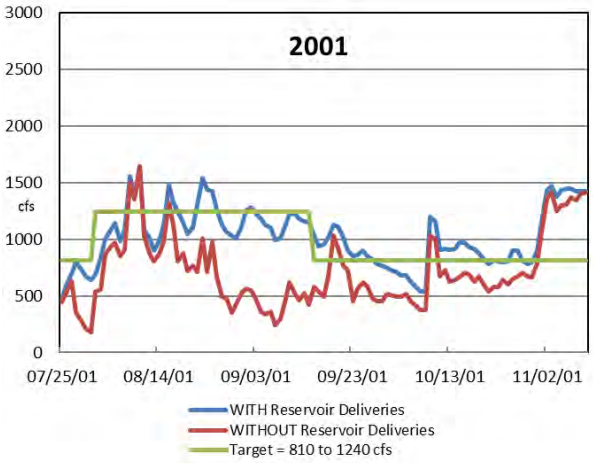


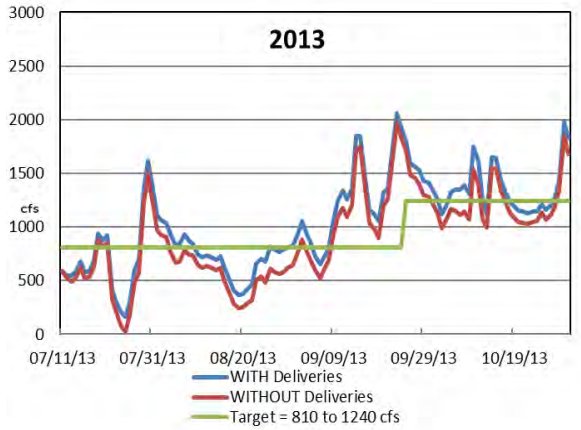


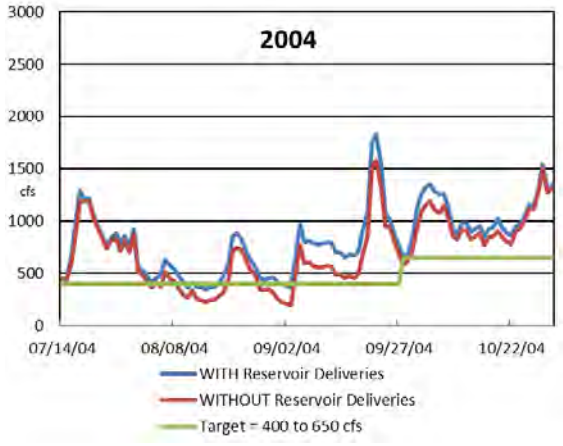


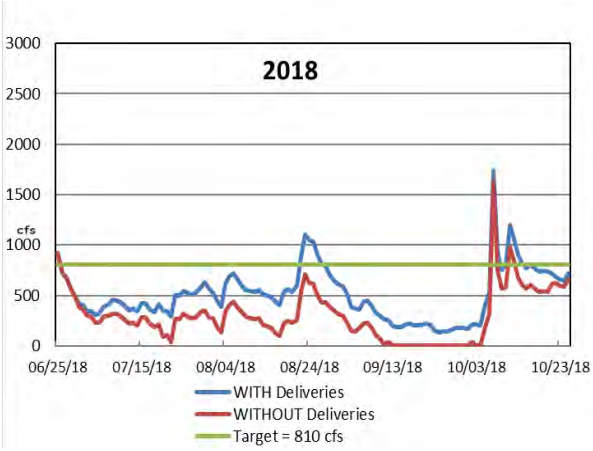


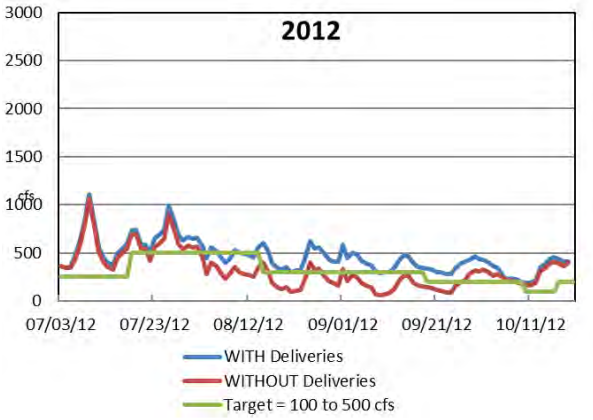
Dry Years (80% - 100% exceedance)

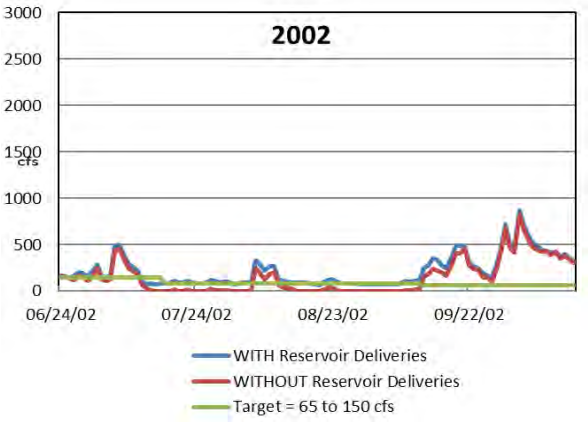










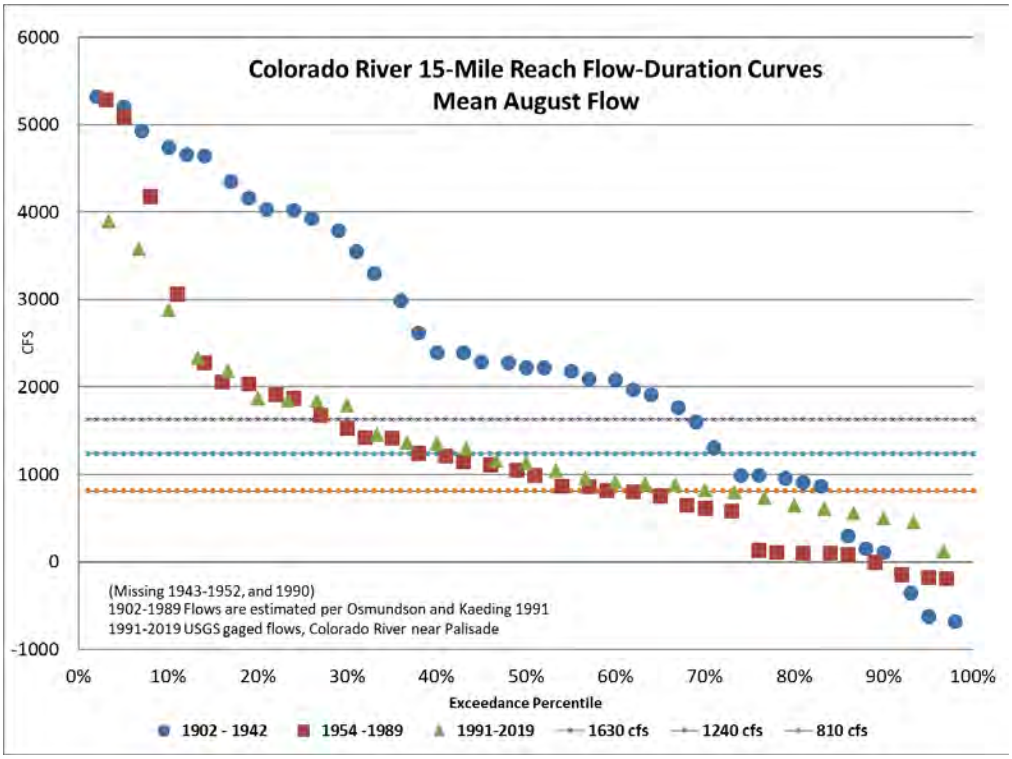


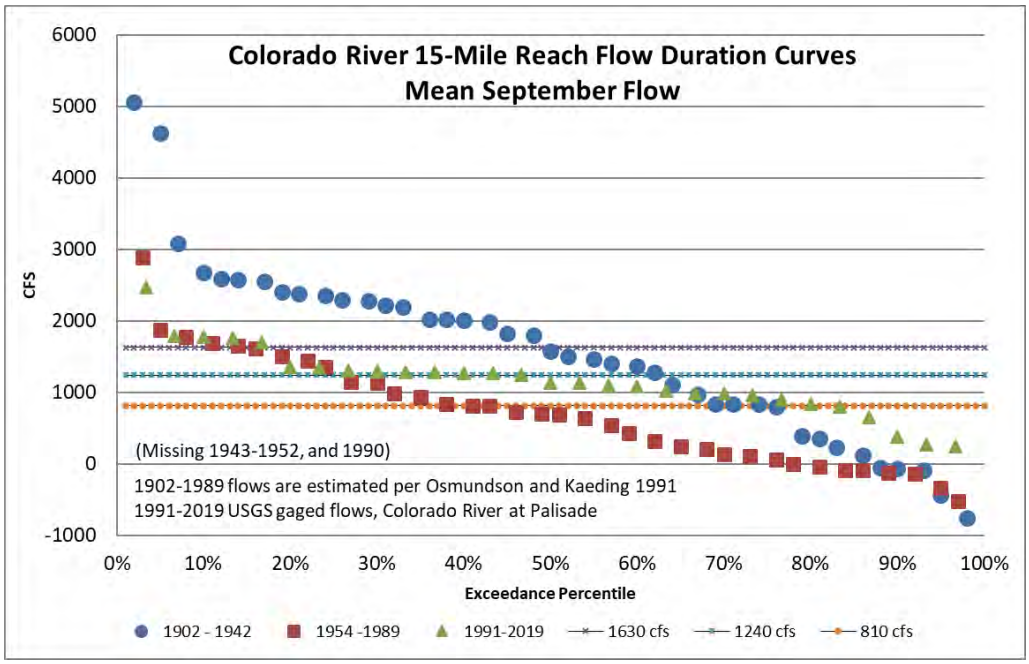
Appendix II

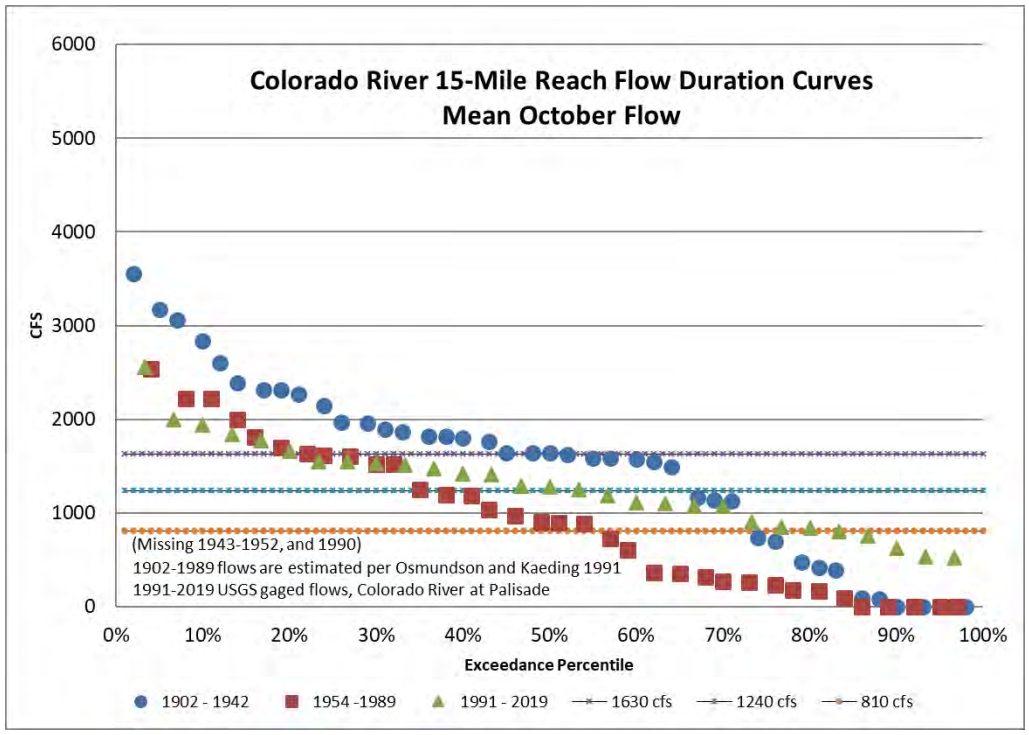
Comparison of Flow Regimes in the 15-Mile Reach over Three Distinct Periods

Graphed below are monthly flow-duration curves for the 15-Mile Reach for August, September, and October of three distinct time periods:

1. **1902-1942**, a period prior to the completion of most major storage projects upstream of the 15-Mile Reach, including Green Mountain Reservoir (1942), Lake Granby (1950), Williams Fork Reservoir (1959), Dillon Reservoir (1963), and Ruedi Reservoir (1968);
2. **1954-1989**, a period during which most major water storage facilities upstream of the 15-Mile Reach were completed, most of those by 1968, but prior to implementation of the Recovery Program, which began in 1991. (Records are not available to reconstruct 1943-1953 hydrology); and
3. **1991-2019**, the period during which the Upper Colorado River Recovery Program has been managing flows affecting the 15-Mile reach. Wolford Mountain Reservoir came on-line upstream in 1995.







Notes on the flow estimates shown in the above graphs:

The USGS gage Colorado River below Grand Valley near Palisade (#09106150), which measures discharge in the Colorado River in the 15-Mile Reach, did not come on-line until 1991. Thus, on the

graphs above, only the points plotted for the 1991-2019 period represent direct flow measurements in the 15-Mile Reach. For the other two periods, mean monthly flows in the 15-Mile reach were estimated by Osmundson and Kaeding (1991). Their methodologies are briefly summarized below. For more details, see Appendix I, pages 73-76 of their report.

To estimate flows in the 15-Mile Reach downstream of diversions 1902-1933:
Gaged flow measurements made at highway bridge in Palisade were corrected for Grand Valley Diversion withdrawal downstream of that gage: 450 cfs subtracted from April records; 550 cfs subtracted for May; 600 cfs subtracted for June. 1902-1920 used 250 cfs as average Grand Valley Diversion (based on a 1916 record indicating the canal capacity was 300 cfs). See Table VIII of Osmundson and Kaeding 1991.

To estimate flows in the 15-Mile Reach downstream of diversions 1934-1989:
Gaged flow measurements were summed for the Colorado River at Cameo and Plateau Creek near Cameo, downstream diversions subtracted, and Orchard Mesa Power Canal returns added. Monthly adjustments for downstream diversions involved subtracting 1150 cfs for April records, 1450 cfs for May, and 1500 cfs for June, except for the 1986-1988 period when daily withdrawal records were available. In 1934 and 1935, there were no records for Plateau Creek near Cameo, so Platueau Creek at Collbran plus Buzzard Creek at Collbran were used. No Plateau Creek records are available for 1984 and 1985; the authors substituted with the Plateau Creek 30-year average.

The authors note that “negative results during the 1975-1989 period are attributed to inaccurate gauging devices and/or errors in record keeping; negative results for the 1954-74 period are due to similar error and/or the use of Govt. Highline Canal means rather than actual flow data, i.e., during years of very low flow, Got. Highline probably diverted less than the 1975-1989 mean of monthly means.”

Reference:

Osmundson, D.B. and L.R. Kaeding. 1991. Recommendations for Flows in the 15-Mile Reach During October-June for Maintenance and Enhancement of Endangered Fish Populations in the Upper Colorado River. Final Report to the Upper Colorado River Endangered Fish Recovvery Program.

UPDATE to 2020 Document -- Discussion Draft 22 March 2021

Purpose of This Guidance Document :

At the HUP Managing Entities (HUP ME) 2019 Wrap-Up Meeting in Glenwood Springs March 2020, the HUP ME and other stakeholders shared concerns about possible development of short-duration, low-flow conditions in the Colorado River 15-Mile Reach (15MR) in April (frequently referred to as an 'April Hole'). Similar concerns apply in this year, 2021. The April Hole historically occurs when irrigation diversions begin in early April (as is anticipated this year), and snowmelt is delayed or substantially reduced by unusually cool temperatures and other impediments to runoff at higher basin elevations.

In Fall 2020 the HUP ME reserved approximately 8,000 acre-feet of HUP allocated water stored in Green Mountain Reservoir for potential delivery during April 2021 irrigation startup. HUP Surplus was declared in 2020, which allows for delivery of HUP allocated water to the 15MR in April 2021 as an authorized use. Reserved HUP water also remains available for other authorized HUP uses, including direct delivery to Grand Valley irrigators.

In 2020, 1,562 acre-feet of a total approximately 6,700 acre-feet of available carry-over HUP surplus water was released from Green Mountain Reservoir between April 15 and April 22 to help alleviate low flows in the 15-Mile Reach. This was supplemented with 171 acre-feet of water for the same purpose released April 15 through 17 by the Upper Colorado River Recovery Program from its annual 5,000-acre-foot storage pool in Ruedi Reservoir.

At the 2020 HUP meeting, considerable discussion centered around whether and under what circumstances the HUP ME should consider release of HUP allocated water to relieve the intensity or duration of an 'April hole' in the 15MR. The Recovery Program was asked to provide additional guidance regarding their recommendations under such a scenario. This document was developed at that time to offer draft guidance for discussion. This version of the document is updated for 2021.

Background regarding 15-Mile Reach Low Flow Recommendations:

Osmundson et al. (1995) evaluated 15MR habitat availability / endangered fish habitat use, which ultimately led to the base flow recommendations incorporated into the 15MR Programmatic Biological Opinion (1999). More specifically, they recommended an August through October mean monthly flow of **810 cfs** in the driest 20% of years. Over the subsequent period of implementing of the 1999 Programmatic Biological Opinion, this recommended flow has frequently not been met in dry years. (Note: Osmundson et al.'s recommended mean

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monthly flow in *April* of dry years is 1,860 cfs, however as a monthly mean this does not reflect FWS concerns about very low flows over shorter periods.)

As part of their research, Osmundson et al. measured habitat availability over a range of flows. Their lowest habitat measurements occurred at 557 cfs. The authors reported that at 557 cfs the availability of pool, backwater and eddy habitat (preferred by adult pikeminnow at higher summer flows) was considerably diminished (caveat: this is a gross simplification of their findings). On this basis, they recommended 810 cfs as a minimum monthly flow. However, as part of the Program Director's Office 15MR PBO review, we reached out to Doug Osmundson circa 2016 for his expert opinion about observed conditions (many years earlier) at 557 cfs. Doug recalled that there was likely enough water in the 15MR channel at that flow to at least allow large adult Colorado pikeminnow to vacate the reach and move downstream below the Gunnison River confluence.

More recently, and in the context of low flows observed in summer 2018, FWS field biologists in the Grand Junction office have offered the additional following observations regarding very low flows in the 15-Mile Reach:

- Maintaining instantaneous flow at or above 810 cfs year-round within the 15MR provides both short-term and long-term benefit toward endangered fish recovery. Higher flows provide additional benefit.
- Loss of habitat becomes particularly concerning below 800 cfs.
- There is no magic/key threshold value below 700-800 cfs to suggest as the next "fallback" level; there is more or less a linear degradation in habitat conditions as flows fall to lower levels.
- Flows below 400 cfs result in serious impediments to fish passage. Fish will move to where the water is, in many cases likely downstream below the Gunnison River confluence. However fish crowding then becomes a concern in the limited areas they move to.
- Low, clear water = increased vulnerability to avian predation and fish sun damage.
- When we see very low flows that dewater the river reach, it is important to try to <u>minimize the duration</u> of the de-watering, as dewatering severely impacts biological productivity in the 15-Mile Reach. Aquatic insects and other important elements of the food base get hammered, and it takes some time for that food base to bounce back even after water returns. This is especially concerning when the weather is sunny and hot, meaning exposed channel beds can dry quickly.
- In the 250-400 cfs range, things get "very concerning": Lots of dry channel, and because portions of the river are braided, there may only be a couple of inches of water in each

of those multiple channels. Terrestrial predators then also become a concern, in addition to avian predators.





Photos of 15-Mile Reach by Doug Osmundson, USFWS, 29 April 2013, at about 400-450 cfs flow.

Citation:

Osmundson, D.B., P. Nelson, K. Fenton, and D.W. Ryden. 1995. Relationships between flow and rare fish habitat in the '15-Mile Reach' of the Upper Colorado River. Final Report of the U.S. Fish and Wildlife Service. 71 pp. plus appendices.

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Program Director's Office Suggested Thresholds for Action on an 'April Hole':

1. **Low level of concern** (actual flows @ Palisade above 1,000 cfs and forecasted flows not expected to drop below 810 cfs): no special action.

2. **Moderate level of concern** (actual flows @ Palisade approaching or below 1000 cfs, but greater than 810 cfs; flows are forecast to drop below 810 cfs) – consider taking action based on the severity of the projected hole and available water (e.g., does HUP surplus remain available from Green Mountain Reservoir? Can we exercise Ruedi Reservoir flexibility within hydropower operations, and/or are there flexibilities in Grand Valley irrigation operations, and/or other voluntary flexibility at places like Williams Fork, Wolford Mountain, etc?) **See the attached Discussion Draft Decision Matrix for 2021**.

3. **High level of concern** (actual flows @ Palisade are approaching or below 810 cfs, flows are forecast to drop below 550 cfs) – move to take more urgent measures: in addition to possibly utilizing HUP Surplus carryover at Green Mountain Reservoir, fully explore flexibilities in Grand Valley irrigation operations and upstream reservoir operations, consider starting the Highline Lake pumps (which we understand can provide ~75 cfs relief), consider releasing and debiting water from the summer fish pools at Ruedi or elsewhere, etc.

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The following 2021 decision matrix is presented for discussion purposes only; real-time conditions may point to better alternatives. The U.S. Fish and Wildlife Service emphasizes that any decline in 15-Mile Reach flows below 810 cfs (in April or any other time of the year) is considered detrimental to the endangered fish, and should be avoided whenever possible. The following decision matrix is not meant to suggest there are flow levels below 810 cfs in the 15-Mile Reach that are satisfactory; rather we provide the following as a possible path forward in a year like 2021, in which we expect natural flows to be meager and water available to fully augment 15-Mile flows insufficient.

DRAFT April Hole Decision Matrix for 2021

What is the Forecast 15MR Flow Condition?			
Drop to 500-600 cfs range for more than 4 days	**Drop to 400-500 cfs range for more than 3 days**	**Drop to 300-400 cfs range for more than 2 days**	**Drop below 300 cfs for more than 1 day**
↓	↓	↓	↓
Has more than half of 8,000 AF HUP Surplus been expended already?			
↓	↓	↓	↓
NO: Consider HUP surplus releases of up to **100 cfs**	**NO:** Consider HUP surplus releases of up to **150 cfs**	**NO:** Consider HUP surplus releases of up to **200 cfs**	**NO:** Consider HUP surplus releases of up to **250 cfs**
↓	↓	↓	↓
YES: Consider HUP surplus releases of up to **50** cfs	**YES:** Consider HUP surplus releases of up to **100** cfs	**YES:** Consider HUP surplus releases of up to **150** cfs Also consider releases from FWS **Ruedi Reservoi**r 5K pool account and/or other supplemental sources	**YES:** Consider HUP surplus releases of up to **200** cfs Also consider releases from FWS **Ruedi Reservoir** 5K pool account and/or other supplemental sources

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DISTRICT COURT, WATER DIVISION NO. 5, STATE OF COLORADO

Case No. 91CW247

STIPULATION AND AGREEMENT

CONCERNING THE APPLICATION FOR WATER RIGHTS OF THE GRAND VALLEY WATER USERS ASSOCIATION, ORCHARD MESA IRRIGATION DISTRICT, AND THE UNITED STATES OF AMERICA, IN MESA COUNTY, COLORADO

This Stipulation and Agreement, dated as of September 4, 1996, is made between the Co-Applicants, the Grand Valley Water Users Association, the Orchard Mesa Irrigation District ("OMID"), the United States of America ("United States"), and the following parties who are collectively referred to herein as the "Objectors":

Aurora, City of
Basalt, Town of
Basalt Water Conservancy District
Carbondale, Town of
Colorado Division of Wildlife
Colorado River Water Conservation District
Colorado Springs, City of
Colorado State Engineer
Colorado Water Conservation Board
Copper Mountain, Inc.
Copper Mountain Consolidated Metropolitan District (successor-in-interest to Copper Mountain Water and Sanitation District)
Cyprus Climax Metals Company
DeBeque, Town of
Division Engineer, Water Division No. 5
Eagle, Town of
Exxon Company, U.S.A.
Frisco, Town of
Glenwood Springs, City of
Grand County Water & Sanitation District No. 1
Grand Valley Irrigation Company
Middle Park Water Conservancy District
Mid Valley Metropolitan District
Mobil Mining & Minerals Company

New Castle, Town of
North Barton Creek Ltd. Liability Company
Palisade, Town of
Parachute, Town of
Pueblo, Board of Water Works of
Public Service Company of Colorado
Ralston Resorts, Inc. (successor-in-interest to Keystone Resorts Management, Inc., and Breckenridge Ski Corporation)
Rifle, City of
Rifle Land Associates, Ltd.
Silverthorne, Town of
Spruce Valley Ranch Foundation
Summit County Commissioners, Board of
Union Oil Company of California
Upper Eagle Regional Water Authority
Vail Associates, Inc.
Vail Valley Consolidated Water District

In consideration of the mutual agreements contained herein, Co-Applicants and Objectors agree as follows:

1. Definitions. Unless otherwise indicated, the following terms shall have the following definitions in this Stipulation and Agreement and in any decree which may be subsequently entered in this case:

- "15-Mile Reach" shall mean the reach of the Colorado River which extends, from the point at which the tailrace common to the Grand Valley Power Plant and the OMID pumping plant returns to the Colorado River below the Grand Valley Irrigation Company ("GVIC") diversion dam, downstream to the confluence of the Colorado River and Gunnison River.

- "Blue River Decrees" shall mean the stipulations, judgments, orders and decrees entered in consolidated Civil Action Nos. 2782, 5016 and 5017, United States District Court, District of Colorado, including without limitation the decrees dated October 12, 1955, and April 16, 1964.

- "HUP" shall mean the so-called "historic users pool" defined as water to be released from the Green Mountain Reservoir power pool as described in paragraphs 2 and 3 of the Operating Policy.

- "HUP beneficiaries" shall mean those persons or entities for whose benefit releases are made from the HUP pursuant to the Operating Policy.

- "OMID Right" shall mean the 450 c.f.s. decreed as Priority No. 197 as renumbered to the OMID System of Canals and Ditches by decree of the Mesa County District Court entered on July 25, 1941, in Case No. 5812.

- "Operating Policy" shall mean the Operating Policy for Green Mountain Reservoir; Colorado-Big Thompson Project, Colorado (Volume 48, No. 247 Federal Register 12/22/83; as amended in Volume 52, No. 176 Federal Register 9/11/87).

- "Orchard Mesa Check" shall mean the three mechanically operated radial gates and the bypass channel by which the water level in the common afterbay of the Grand Valley Power Plant and the OMID pumping plant can be raised to a level which causes water to flow through the bypass channel and return to the Colorado River immediately upstream of the GVIC diversion dam, and shall include any replacement structure in the same location which performs that same function.

- "Parties" shall mean each of the parties to this Stipulation and Agreement as identified in the first unnumbered paragraph, above. A "party" shall mean one of the parties.

- "Power Right" shall mean the 800 c.f.s., 400 c.f.s. during the irrigation season, decreed to the United States for the Grand Valley Project by decree of the Mesa County District Court entered July 25, 1941, in Case No. 5812.

- "Shoshone Rights" shall mean the water rights decreed for and associated with the Shoshone Power Plant (a.k.a. the Glenwood Power Canal), adjudicated for 1,250 c.f.s. on December 9, 1907, with an appropriation date of January 7, 1902, and adjudicated for 158 c.f.s. on February 7, 1956, with an appropriation date of May 15, 1929.

2. Application. The Co-Applicants filed an application on December 30, 1991, which application was amended on May 24, 1993, for approval of an exchange of water based upon the discharge of water from the common afterbay of the Grand Valley Power Plant and the OMID pumping plant into the Colorado River upstream from the GVIC diversion dam by means of the Orchard Mesa Check. The Co-Applicants have claimed an absolute right for an existing exchange of water with a 1926 priority date. Attached hereto as Exhibit A and incorporated herein by this reference is a list of all of the decreed water

rights of the Co-Applicants (the "Co-Applicants' Water Rights"), Mesa County Irrigation District and Palisade Irrigation District which are legally divertible at the headgate of the Government Highline Canal (commonly referred to as the "Roller Dam"). Attached hereto as Exhibit B and incorporated herein by this reference is a list of all the decreed water rights of the GVIC (the "GVIC Water Rights") which are legally divertible at the GVIC diversion dam.

3. Decree Provisions. The parties agree to the entry of a decree in Case No. 91CW247, in the form of the proposed decree attached hereto as Exhibit C, granting the application as amended and incorporating the terms of this Stipulation and Agreement.

3.a. Except as provided in paragraphs 3.a.(1), (2) and (3), below, the United States agrees not to exercise the Power Right from April 1 through October 31 of each year so as to place an administrative call which results in the curtailment of diversions by upstream water rights.

3.a.(1) During the months April through October, at any time diversions at the Roller Dam under the irrigation rights listed on Exhibit A are less than 1,310 c.f.s., the Power Right may be exercised so as to maintain a total call of 1,310 c.f.s. at the Roller Dam by the water rights listed on Exhibit A.

3.a.(2) In addition, at any time during the months April through October that diversions by the GVIC Water Rights are less than 400 c.f.s., the Power Right may be exercised for up to the amount that diversions by such GVIC rights are less than 400 c.f.s.; provided, however, that if GVIC gives written notice to the parties pursuant to paragraphs 3.e.(1) or (2) that the GVIC Water Rights shall no longer be subject to the terms of paragraph 3.b., then, at any time during the months April through October, the Power Right may be exercised for up to the amount that GVIC's diversions are less than the amount of GVIC's then existing decreed water rights or less than 400 c.f.s., whichever is less.

3.a.(3) If the Orchard Mesa Check is physically inoperable due to an Act of God or an emergency situation beyond the control of the Co-Applicants, the United States may exercise the Power Right to the full decreed amount for a period not to exceed a total of 14 days during the April 1 through October 31 period in any given year or until the Orchard Mesa Check becomes operable, whichever occurs first. For purposes of this provision, an emergency situation shall not be deemed to occur if the Orchard Mesa Check is inoperable due to a lack of funding or the non-performance of ordinary maintenance.

3.a.(4) Any calls of the Power Right pursuant to paragraphs 3.a.(1), (2) and (3), above, may be made only when and to the extent the Power Right is in priority, there is capacity in the power canal, and all water called thereunder is delivered to and through the Grand Valley Power Plant.

3.a.(5) For purposes of paragraph 3 of this Stipulation and Agreement, the priority date of the Power Right shall be considered to be August 3, 1934. So long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended, the United States agrees not to seek administration under a more senior priority, which the United States asserts is decreed as February 27, 1908. By agreeing not to assert a 1908 priority for the Power Right while paragraph 3 of this Stipulation and Agreement is not suspended, the United States does not waive and shall not be estopped from asserting the right to seek administration under a 1908 priority, nor shall Objectors be estopped from challenging a 1908 priority, in the event any of the provisions of paragraph 3 of this Stipulation and Agreement shall be suspended, as addressed in paragraphs 3.b.(6), 5.c. and 5.d., below. The parties agree that the time for raising claims and defenses concerning the priority of the Power Right is tolled so long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended.

3.a.(6) No provision of this Stipulation and Agreement shall be considered to affect in any way the right of the United States to call for the 800 c.f.s. power right from November 1 through March 31.

3.b. During the period April 1 through October 31 of any year that the conditions set forth in paragraphs 3.b.(1), (2) and (3), below, are met, diversions by HUP beneficiaries (except the HUP beneficiaries who own and/or operate the water rights listed in Exhibits A and B) shall not be curtailed by any administrative call by the water rights listed in Exhibits A and B:

3.b.(1) the Orchard Mesa Check is physically operable. For purposes of this provision, the Orchard Mesa Check shall be considered to be physically operable unless it is rendered inoperable due to an Act of God or an emergency situation beyond the control of the Co-Applicants. An emergency situation shall not be deemed to occur if the Orchard Mesa Check is inoperable due to a lack of funding or the non-performance of ordinary maintenance. If the Orchard Mesa Check is rendered inoperable, Co-Applicants shall make best efforts to bring the facility back into operation as soon as possible.

3.b.(2) there is at least 66,000 acre feet of water available for releases for the benefit of HUP beneficiaries when Green Mountain Reservoir ceases to be in-priority for its initial fill under the Blue River Decrees. Nothing in this Stipulation and Agreement shall be construed to limit or diminish the ability of the United States to exercise its full right to fill Green Mountain Reservoir as provided by the Blue River Decrees.

3.b.(3) the Shoshone Rights continue to be exercised in a manner substantially consistent with their historical operations for hydropower production at their currently decreed point of diversion.

3.b.(4) As provided in paragraph 3.c., below, this paragraph 3.b. shall not cause increased curtailment of diversions by non-HUP beneficiaries.

3.b.(5) If any of the three conditions set forth in paragraphs 3.b.(1), (2) or (3), above, is not met, Co-Applicants and GVIC (based on concurrence of any three out of four of those entities) may give written notice to the parties that the Operating Criteria developed pursuant to paragraph 5, below, and the non-curtailment provisions of this paragraph 3.b. shall be inoperative until each of said three conditions is being met (if paragraph 3.b. is rendered inoperative under this provision, it shall not be considered to be suspended for the purposes of this Stipulation and Agreement). During any period that the Operating Criteria are inoperative, no water in the HUP shall be deemed to be surplus to the needs of the HUP beneficiaries, and releases from the HUP shall only be made to replace out-of-priority depletions by HUP beneficiaries and to make direct deliveries to HUP beneficiaries. To the extent that such releases are less than the out-of-priority depletions of HUP beneficiaries, the water rights listed in Exhibits A and B may place an administrative call and seek curtailment of diversions by HUP beneficiaries, provided, however, that nothing herein shall diminish or limit the statutory authority and responsibility of the Division 5 Engineer.

3.b.(6) If any of the three conditions set forth in paragraphs 3.b.(1), (2) or (3), above, is not met, Co-Applicants and GVIC (based on concurrence of any three out of four of those entities) may give written notice to the parties that the terms of paragraph 3.a. of this Stipulation and Agreement are suspended until each of said three conditions is being met. During any period that the terms of paragraph 3.a. are suspended, the United States may fully exercise the Power Right, and the parties may raise the matters addressed in paragraphs 3.a.(5), 3.e., 3.f. and 3.g. of this Stipulation and Agreement. If an action raising any such matter is commenced during any period of

suspension of paragraph 3.a., the parties to such action shall be free to continue to prosecute and defend such action to its conclusion, notwithstanding that the conditions set forth in paragraphs 3.b.(1), (2) and (3) become fully satisfied and paragraph 3.a. goes back in effect after commencement of such action.

3.c. The parties recognize that under the terms of paragraph 3.b. of this Stipulation and Agreement, there may be instances when the actual releases from the HUP will be less than the out-of-priority depletions of the HUP beneficiaries. In such instances, the Division Engineer shall not curtail the water right(s) of any entity not entitled to benefits of the HUP to the extent that entity's water right(s) would otherwise have been in priority to divert if the out-of-priority depletions of HUP beneficiaries would have been fully replaced in the absence of the execution of this Stipulation and Agreement and the decree based thereon.

3.d. The provisions of paragraphs 3.a. and 3.b. of this Stipulation and Agreement shall not be considered to intend, evidence, or represent abandonment in whole or in part of any of the Co-Applicants' Water Rights, the GVIC Water Rights or other water rights listed on Exhibit A and Exhibit B, including, but not limited to, the Power Right.

3.e. Issues concerning waste and reasonable efficiency in the exercise of the water rights, diversion, carriage and delivery systems of the Co-Applicants, GVIC and other owners of the water rights listed on Exhibits A and B, are not determined in this proceeding and all claims and defenses regarding those issues are dismissed without prejudice and shall not be raised by any of the parties in any proceeding before the Division 5 Engineer or the State Engineer or in any judicial proceeding so long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended. The parties agree that the time for raising claims and defenses concerning these issues is tolled so long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended. Nothing herein shall diminish or limit the statutory authority and responsibility of the Division 5 Engineer. Nothing herein shall affect the rights of the parties regarding the disposition of water saved through implementation of conservation measures. Nor shall anything herein affect the rights of the parties regarding issues relating to administration of water rights, except those issues which the parties have agreed not to raise pursuant to paragraphs 3.a.(5), 3.e., 3.f. and 3.g.

3.e.(1) If, during any period of suspension of paragraph 3.a., an action is brought by any party to this Stipulation and Agreement raising issues concerning waste or reasonable efficiency in the exercise of the GVIC Water Rights, GVIC may then give written notice to the parties that the GVIC Water Rights shall no longer be subject to the terms of paragraph 3.b.

3.e.(2) In the event that any person or entity not a party to this Stipulation and Agreement brings an action raising issues concerning waste or reasonable efficiency in the exercise of the GVIC Water Rights, GVIC may give written notice to the parties that the GVIC Water Rights shall no longer be subject to the terms of paragraph 3.b. If GVIC elects to give such notice, the parties to this Stipulation and Agreement may then join in any such action or bring a separate action concerning issues of waste or reasonable efficiency in the exercise of the GVIC Water Rights.

3.f. Issues concerning the historical administration of Co-Applicants' Water Rights and GVIC's Water Rights and operation of the Orchard Mesa Check as a precondition to exercise of a call by such water rights and as a term and condition of the decree adjudicating the exchange herein are not determined in this proceeding, and all claims and defenses regarding those issues are dismissed without prejudice and shall not be raised so long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended. The parties agree that the time for raising claims and defenses concerning the historical administration and operation of the Orchard Mesa Check is tolled as long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended.

3.g. Certain Objectors moved the Court for partial summary judgment on the issue of whether OMID is precluded by the terms of the decrees heretofore awarded it from pumping more than 125 c.f.s. for actual irrigation usage. On June 22, 1995, the Court entered an order denying the motion based on the Court's conclusion that "it cannot be said as a matter of law that OMID is limited to an irrigation right of 125 c.f.s." The Court's Order did not preclude the parties from raising and litigating at trial issues concerning whether or not the OMID Right should be limited to 125 c.f.s., nor did it preclude the parties from raising these issues in a separate action. These issues are not determined in this proceeding and all claims and defenses regarding those issues are dismissed without prejudice and shall not be raised so long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended. The parties agree that the time for raising claims and defenses concerning such issues is tolled as long as none of the provisions of paragraph 3 of this Stipulation and Agreement are suspended.

4. Operating Policy.

4.a. Nothing contained in this Stipulation and Agreement shall in any manner be construed or intended to limit the availability of water from Green Mountain Reservoir for contract pursuant to paragraphs 4 through 7 of the Operating Policy, subject to the terms and conditions of such contracts, or otherwise adversely affect any Green Mountain Reservoir water service contract.

4.b. Nothing in this Stipulation and Agreement or in the Operating Criteria attached hereto as Exhibit D shall be construed as a consent to the validity or enforceability of the Operating Policy or a waiver or relinquishment of any claims or defenses regarding the validity or enforceability of the Operating Policy.

5. Green Mountain Reservoir Historic User Pool Operating Criteria.

5.a. Co-Applicants and Objectors have jointly developed the Green Mountain Reservoir Historic User Pool Operating Criteria, attached hereto and incorporated herein as Exhibit D ("Operating Criteria"), in order to meet the purposes set forth therein, including defining the terms and conditions under which water in the HUP is surplus to the needs of HUP beneficiaries ("HUP surplus water"). HUP surplus water shall be available for delivery to beneficial uses in Western Colorado under contracts ("HUP surplus water contracts") to be developed by the Bureau of Reclamation. The parties agree that HUP surplus water contracts will provide that HUP surplus water will be delivered to and through the Grand Valley Power Plant to the extent that there is capacity in the power canal and water is needed to produce power at the Grand Valley Power Plant, and that HUP surplus water contracts may provide for delivery of HUP surplus water to other locations and facilities to the extent that there is not capacity in the power canal or that water is not needed to produce power at the Grand Valley Power Plant. Any HUP surplus water contract, entered into pursuant to this Stipulation and Agreement, for delivery of HUP surplus water upstream of the 15-Mile Reach shall be for non-consumptive use only. HUP surplus water contracts shall provide that return flows from delivery of HUP surplus water to and through the Grand Valley Power Plant shall be returned to the river through the tailrace common to the Grand Valley Power Plant and the OMID pumping plant, and that deliveries or return flows of HUP surplus water delivered to other locations and facilities shall flow through the 15-Mile Reach or be returned or delivered to the Colorado River as near as practicable to the upstream point of the 15-Mile Reach, thereby augmenting flows for the recovery of endangered Colorado River fish species.

5.b. The Operating Criteria shall be binding upon and observed by the parties; provided, however, that the Operating Criteria may be amended by mutual agreement of the parties or otherwise modified as provided in this paragraph 5 and paragraph 6 of this Stipulation and Agreement. The parties agree to implement the Operating Criteria and, if necessary, to use good faith efforts to modify such criteria to promote the purposes set forth in paragraph 2 of the Operating Criteria.

5.c. If any party desires to request a modification to the Operating Criteria, based upon an allegation that use of one or more of the party's water rights in existence as of May 31, 1996 have been injured by the Operating Criteria and/or this Stipulation and Agreement, whether such injury be in water quantity, water quality or any injury which occurs as a result of a significant expansion of the amount of water required to offset or satisfy the demands of HUP beneficiaries, as a result of amendment or modification of the Operating Policy, or as a result of a substantial change in the manner in which the Shoshone Rights are exercised, the parties shall follow the procedures set forth below.

5.c.(1) Notice of the asserted injury shall be mailed to all parties to this Stipulation and Agreement. A party's failure to assert a particular type of injury during a given water year shall not limit that party's right to assert such an injury in subsequent water years unless the conditions upon which the claimed injury are based have existed during any five years out of any seven year period following execution of this Stipulation and Agreement.

5.c.(2) The parties shall each have the opportunity to designate a representative to serve on a committee which will review the injury claim and make an initial determination as to whether the alleged injury exists and, if so, whether it was caused by operation of the Operating Criteria and/or the provisions of this Stipulation and Agreement. Any party choosing not to designate a representative shall be deemed to accept the finding of the committee.

5.c.(2)(A) In the event the committee unanimously determines that no injury has occurred or that the injury alleged was not caused in whole or part by operation of the Operating Criteria and/or this Stipulation and Agreement, then the Operating Criteria and all provisions of this Stipulation and Agreement shall remain in full force and effect. If the committee cannot unanimously agree, then the party claiming injury may submit the issue to arbitration in accordance with paragraph 5.c.(3), below.

5.c.(2)(B) If the committee unanimously determines that injury has been caused in whole or in part by the operation of the Operating Criteria and/or this Stipulation and Agreement, then the committee shall attempt to reach agreement as to how to modify the Operating Criteria and/or this Stipulation and Agreement to alleviate such injury to the satisfaction of the parties. If such an agreement is reached, the Operating Criteria and/or this Stipulation and Agreement shall be modified in accordance with that agreement and a stipulated motion to modify this Stipulation and Agreement shall be filed with the Court and any modifications to appropriate documents shall be made.

5.c.(2)(C) In the event the committee unanimously determines that injury has occurred and that it was caused in whole or in part by operation of the Operating Criteria and/or this Stipulation and Agreement, but cannot determine how to alleviate the injury to the satisfaction of the parties, the Operating Criteria and the provisions of paragraph 3 of this Stipulation and Agreement shall be suspended. In that event, any participating party may file a motion in this case or a separate action for determination of such issue and for appropriate relief. The Operating Criteria and the provisions of paragraph 3 of this Stipulation and Agreement shall remain suspended unless and until the Court determines otherwise.

5.c.(2)(D) The committee shall have a maximum period of one year from the date notice of the asserted injury is sent to the parties in which to make its determination of injury and, if injury is found, to reach agreement concerning how to alleviate the injury. During this period, the Operating Criteria and all provisions of this Stipulation and Agreement shall remain in full force and effect.

5.c.(3) Upon written notification from the committee organized under paragraph 5.c.(2), above, notifying all parties that the committee has been unable to agree upon a determination of injury or noninjury, or upon expiration of the one year period to make such determination, any party claiming injury may submit the issue of whether injury has occurred by operation of the Operating Criteria and/or this Stipulation and Agreement to arbitration.

5.c.(3)(A) Arbitration shall be governed by the rules of the American Arbitration Association (or, if it no longer exists, a similar organization). A panel of three arbitrators shall be selected as follows: (i) One person shall be selected by Co-Applicants and GVIC; (ii) One person shall be selected by Objectors; and, (iii) The two

selected arbitrators shall select a third. The arbitrators shall be engineers, hydrologists, geologists, or practicing or retired water lawyers familiar with Colorado water law. None of the arbitrators shall have had any previous association with this case, absent the express consent of the parties.

5.c.(3)(B) Any party to the Stipulation and Agreement may participate as a party in the arbitration. All participating parties shall share in the costs of arbitration equally. Participating parties shall cooperate to conclude the arbitration expeditiously.

5.c.(3)(C) The arbitrators shall issue a written determination within 60 days following the conclusion of the taking of evidence. The arbitrators are only authorized to make determinations as to whether injury has occurred and, if so, whether it was caused by the Operating Criteria and/or this Stipulation and Agreement.

5.c.(3)(C)(i) If the arbitrators determine that injury has occurred and that it was caused by operation of the Operating Criteria and/or this Stipulation and Agreement, the Operating Criteria and the provisions of paragraph 3 of this Stipulation and Agreement shall be suspended. The parties shall then re-convene the committee organized under paragraph 5.c.(2), above, and the committee shall attempt to reach agreement as to how to alleviate such injury to the satisfaction of the parties. If such an agreement is reached, the Operating Criteria and/or this Stipulation and Agreement shall be modified in accordance with that agreement and a stipulated motion to modify this Stipulation and Agreement shall be filed with the Court and any modifications to appropriate documents shall be made. The committee shall have a maximum of six months from the date the arbitrators' determination is sent to the parties in which to reach agreement concerning how to alleviate the injury. Upon written notification from the committee notifying all parties that the committee has been unable to agree as to how to alleviate the injury, or upon expiration of the six month period for the committee to reach agreement, any participating party may proceed as provided in paragraph 5.c.(2)(C), above. The Operating Criteria and the provisions of paragraph 3 of this Stipulation and Agreement shall remain suspended unless and until the committee is able to unanimously agree on necessary modifications to the Operating Criteria and/or this Stipulation and Agreement, or unless and until the Court determines otherwise.

5.c.(3)(C)(ii) If the arbitrators determine that no injury has occurred, or that injury has occurred but was not caused by operation of the Operating Criteria and/or this Stipulation and Agreement, the Operating Criteria and all provisions of this Stipulation and Agreement shall remain in full force and effect.

5.c.(3)(D) Any party to the arbitration who disagrees with the arbitrators' decision may file a motion in this case or a separate action for de novo review of the issue of injury and its causation and any issues related thereto, including whether the Operating Criteria and/or whether any provisions of this Stipulation and Agreement should be suspended, reinstated, or modified.

5.d. In the event the Operating Criteria are suspended, no water in the HUP shall be deemed to be surplus to the needs of the HUP beneficiaries, and releases from the HUP shall only be made to replace out-of-priority depletions by HUP beneficiaries and to make direct deliveries to HUP beneficiaries. In the event the Operating Criteria are suspended, the provisions of paragraph 3 of this Stipulation and Agreement shall also be suspended, and the Power Right may be fully exercised and the water rights listed in Exhibits A and B may place an administrative call and seek curtailment of diversions by HUP beneficiaries to the extent that HUP releases are less than the out-of-priority depletions of HUP beneficiaries.

5.e. In the event the Operating Criteria or HUP surplus water contracts are determined to be invalid or unenforceable by a court of competent jurisdiction, then the Operating Criteria shall be deemed suspended under paragraph 5.d., and paragraph 5.d. shall apply.

6. Entry of Decree. The parties agree that the decree attached hereto as Exhibit C shall be entered by the Court and that the Court shall retain jurisdiction for the purposes of considering any motion filed pursuant to paragraph 5 of this Stipulation and Agreement. In the event the Operating Criteria and the provisions of paragraph 3 of this Stipulation and Agreement are suspended, the parties shall then be free to raise any and all claims, whether in this case or in a separate action, including but not limited to, the matters addressed in paragraphs 3.a.(5), 3.e., 3.f. and 3.g. of this Stipulation and Agreement, except that the priority date and rate of the exchange shall not be relitigated. The parties agree that the Court shall not use the entry of the decree adjudicating the exchange and the priority thereof in a manner prejudicial to the positions or claims of either Co-Applicants or Objectors in any such subsequently filed motion or action. Any and all claims and defenses

asserted in this proceeding, including issues as to the relevancy of various matters to this application, may be asserted by the parties and shall not be deemed waived.

7. Binding Effect. Upon the execution of this Stipulation and Agreement by all of the parties hereto, which execution must take place on or before September 4, 1996, and upon the Court's approval of this Stipulation and Agreement, this Stipulation and Agreement shall become effective and the rights and obligations created hereby shall be binding upon and inure to the benefit of the parties hereto and their respective successors and assigns; provided, however, that the Operating Criteria and the limitations set forth in paragraphs 3.a. and 3.b. shall not take effect until the beginning of the 1997 irrigation season, i.e., April 1, 1997. The parties to this Stipulation and Agreement may consist of less than all the parties to Case No. 91CW247 only if the parties to this Stipulation and Agreement consent in writing to the full effectiveness hereof notwithstanding the failure of other parties to Case No. 91CW247 to execute the same.

8. Authority of Counsel to Bind Parties. Counsel executing this Stipulation and Agreement represent that they are authorized by their client(s) to do so.

9. Notice. All notices required or permitted under this Stipulation and Agreement shall be effective when sent to a party by certified United States mail, return receipt requested, to the address shown for that party on the attached Exhibit E, or to any new address of any party or any party's successor-in-interest, provided that notice of any such new address has been sent to all parties in accordance with this paragraph.

EXHIBIT D

Stipulation and Agreement

Case No. 91CW247

GREEN MOUNTAIN RESERVOIR HISTORIC USER POOL

OPERATING CRITERIA

1. DEFINITIONS. The definitions set forth in paragraph 1 of the forgoing Stipulation and Agreement are incorporated herein. For purposes of these Operating Criteria and the Stipulation and Agreement, "HUP surplus water" shall mean that amount of the HUP which, in accordance with paragraph 8 of the Operating Policy is included in that portion of the stored water in Green Mountain Reservoir in excess of that necessary to meet the objectives of paragraphs 2 and 4 of the Operating Policy, and which is determined under these Operating Criteria to be available for releases for HUP surplus water contracts at any particular time after taking into consideration releases to be made to meet the replacement and direct delivery needs of HUP beneficiaries.

2. PURPOSES AND OBJECTIVES. The purposes and objectives of these Operating Criteria are to:

2.a. Ensure that a sufficient quantity of water is retained in the HUP for release to meet the replacement needs of HUP beneficiaries throughout the irrigation season.

2.b. Ensure that a sufficient quantity of water is retained in the HUP for release to meet the direct delivery needs of the Grand Valley Water Users Association, Orchard Mesa Irrigation District, Grand Valley Irrigation Company, Mesa County Irrigation District and Palisade Irrigation District throughout the irrigation season.

2.c. Ensure that a sufficient quantity of water is retained in the HUP at the end of the irrigation season for release to meet the winter needs of HUP beneficiaries.

2.d. Define the terms and conditions under which water in the HUP is surplus to the needs of HUP beneficiaries, and therefore available for delivery to beneficial uses in Western Colorado, in accordance with paragraph 8 of the Operating Policy, under contract(s) to be developed, and indirectly to the 15-Mile Reach to augment flows for the recovery of endangered Colorado River fish species.

3. HUP Operating Criteria. Figure 1, attached to these Operating Criteria, depicts the estimated "Upstream HUP Replacement Allocation," estimated "Winter HUP Allocation," and estimated "Total HUP Draw Down Band".

3.a. The Upstream HUP Replacement Allocation represents the maximum volume required to fully meet the irrigation, domestic and municipal replacement needs of HUP beneficiaries upstream of Shoshone (a.k.a. the Glenwood Power Canal) for the remainder of the irrigation season. The total volume of water estimated for this purpose is 14,685 acre-feet at the beginning of the irrigation season. This volume diminishes throughout the irrigation season as depicted in Figure 1. Attachment A to these Operating Criteria documents the data and technical analyses used to estimate this volume.

3.b. The Winter HUP Allocation represents the maximum volume required to fully meet the domestic and municipal replacement needs of HUP beneficiaries during the winter or non-irrigation season. The total volume of water estimated for this

purpose is 500 acre-feet. Attachment A to these Operating Criteria documents the data and technical analyses used to estimate this volume.

3.c. The Total HUP Draw Down Band represents the estimated range of storage volumes that will serve as a guideline for managing HUP releases in dry years similar to those analyzed in Attachment A to these Operating Criteria to accomplish the purposes of Section 2 as more fully described in Section 3.d and 3.e of these Operating Criteria. Attachment A to these Operating Criteria documents the data and technical analyses used to estimate this range of volumes.

3.d. In order to meet the purposes and objectives of Section 2, above, the Bureau of Reclamation, after direct consultation with the Grand Valley Water Users Association, Orchard Mesa Irrigation District, Grand Valley Irrigation Company, Colorado Division of Water Resources, Colorado Water Conservation Board and Fish and Wildlife Service (the Bureau of Reclamation and the above mentioned entities with whom the Bureau of Reclamation shall consult in managing releases of water from the HUP are hereafter collectively referred to as the "managing entities"), will attempt to manage the release of water from the HUP to maintain actual storage conditions within the range of storage volumes as represented by the Total HUP Draw Down Band and will attempt to manage the release of water from the HUP so that the entire HUP, except the Winter HUP Allocation, will be released by the end of the irrigation season unless the managing entities determine that the release of such water is not necessary to meet the purposes and objectives of Section 2, above, considering hydrologic, demand and operational conditions. However, it is expressly recognized that in some years release of

the entire HUP by the end of the irrigation season may not be necessary or possible. Grand Valley Water Users Association, Orchard Mesa Irrigation District and Grand Valley Irrigation Company retain exclusive control of determining their irrigation demands, subject to the otherwise applicable administrative powers of the Colorado Division of Water Resources and the provisions of the Stipulation and Agreement. It is recognized that actual storage conditions may deviate from the indicated range due to hydrologic, demand and operational conditions; however, the managing entities will take all reasonable actions to maintain actual HUP storage conditions within the indicated range. The obligation of the managing entities to take reasonable actions to maintain actual HUP storage conditions within the indicated range shall be limited to operation of the Orchard Mesa Check and such other actions as to which the managing entities agree. At any particular time during the irrigation season, the actual HUP storage volume shall not fall below the volume indicated by the sum of the Upstream HUP Replacement Allocation at that time and Winter HUP Allocation, as depicted in Figure 1, unless required by Acts of God or emergency situations beyond the control of the managing entities, or unless modified as provided for in paragraph 5 of the Stipulation and Agreement.

3.e. To accomplish management of the HUP as described in Section 3.d, the managing entities agree to participate in the following process.

3.e.(1) On or before June 30 of each year, the Bureau of Reclamation will conduct a meeting, involving the managing entities, to review HUP storage conditions, projected runoff forecasts, climatological conditions, projected irrigation

demands and 15-Mile Reach flow needs, and other operational conditions to determine an annual operational plan for the Green Mountain Reservoir HUP, the Orchard Mesa Check and the Grand Valley Power Plant ("Annual HUP Operating Plan"). The Annual HUP Operating Plan will cover water operations for the July through October irrigation season. Water in the HUP shall not be deemed to be surplus to the needs of HUP beneficiaries prior to the determination that there is at least 66,000 acre feet of water available for releases for the benefit of HUP beneficiaries when Green Mountain Reservoir ceases to be in priority for its initial fill under the Blue River Decrees, as provided by paragraph 3.b.(2) of the Stipulation and Agreement.

3.e.(2) The managing entities agree to participate in subsequent meetings during the irrigation season to reexamine HUP storage conditions, projected runoff forecasts, climatological conditions, projected irrigation demands and 15-Mile Reach flow needs, and other operational conditions on an as-needed basis to modify the Annual HUP Operating Plan. Any of the managing entities may call for a meeting, and all of the managing entities agree to participate to reexamine changing conditions and to modify the Annual HUP Operating Plan. All such meetings will be open to the public.

3.e.(3) The managing entities agree to make good faith efforts to develop an Annual HUP Operating Plan that is unanimously supported by the managing entities. If however, an Annual HUP Operating Plan cannot be developed that is unanimously agreed to, the Bureau of Reclamation reserves the right to establish a release schedule from the HUP for the irrigation season in question consistent with the Total HUP Draw Down Band and the State water right priority system. The Bureau of

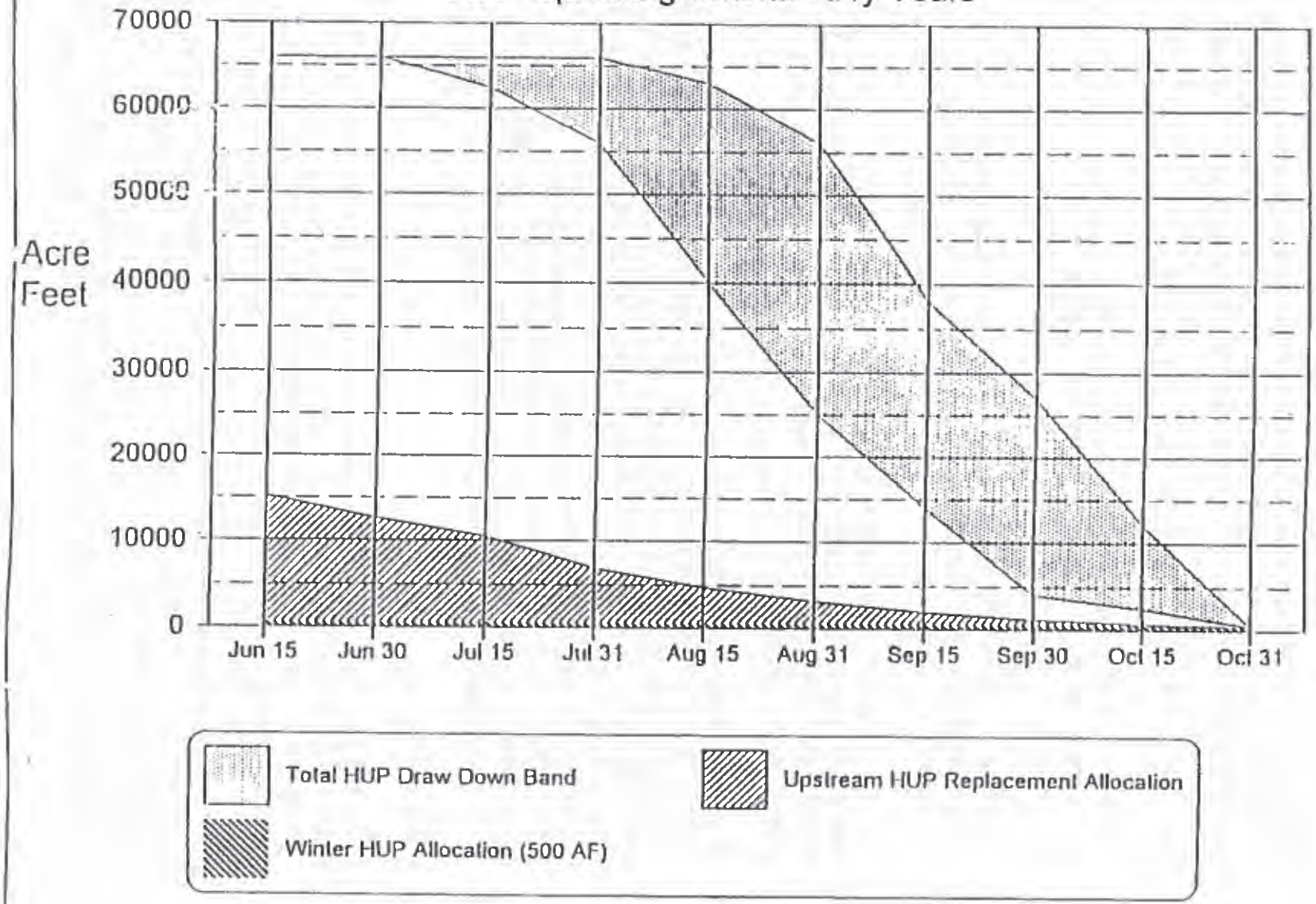
Reclamation's establishment of a release schedule pursuant to the preceding sentence shall not prevent any other of the managing entities from requesting a subsequent meeting to reexamine changing conditions and to develop the Annual HUP Operating Plan.

4. Nothing contained in these Operating Criteria shall diminish or limit the statutory authority and responsibility of the Colorado Division of Water Resources or be deemed to alter the duties and responsibilities of the Bureau of Reclamation under the Operating Policy, Senate Document 80 and the Blue River Decrees.

Figure 1

Green Mountain Reservoir

HUP Operating Criteria - Dry Years



January 11, 1996

July 18, 1996

Orchard Mesa Check Case:
Effects of Settlement Proposal on 15-Mile Reach Flows

Hydrology studies were conducted to evaluate effects of the settlement proposal on flows and water quality in the Colorado River near Cameo, use of the Green Mountain Reservoir 66,000 acre-foot Historic User Pool (HUP), and use of Ruedi Reservoir for fish releases. This document contains study results pertaining to flows in the 15-Mile Reach ("Reach") of the Colorado River for seven drier than average years between 1977 and 1994.

To analyze the effects of the settlement proposal compared to historic conditions, a computer model was developed to simulate four different scenarios:

1) Historic Conditions (*Historic*)
2) Historic Conditions Without Ruedi Reservoir Fish Releases (*Historic without Ruedi*)
3) Settlement Proposal Without Ruedi Reservoir Fish Releases (*Settlement without Ruedi*)
4) Settlement Proposal with Ruedi Reservoir Fish Releases (*Settlement with Ruedi*)

The "*without Ruedi*" scenarios (2 and 3 above) were necessary because no Ruedi fish releases were made historically until 1989. Also, in 1989 and 1990, only 10,000 acre-feet were released for fish. The *Settlement with Ruedi* scenario assumes 20,000 acre-feet available for fish releases in all seven years analyzed.

Comparing results between *Historic without Ruedi* and *Settlement without Ruedi* shows the effect of the settlement due to changes in Green Mountain Reservoir HUP releases only (effects of Ruedi fish releases, if any, were removed). Comparing results between *Historic* and *Settlement with Ruedi* shows the effect of the settlement with both HUP releases and Ruedi fish releases. *Historic without Ruedi* and *Settlement without Ruedi* must be compared to evaluate the effect of the settlement in the years where historic Ruedi fish releases were less than 20,000 acre-feet (zero in 1977, 1981, and 1988; 10,000 acre-feet in 1989 and 1990). Although *Settlement with Ruedi* does provide an estimated flow projection, it should be compared with *Historic* only in the years where historic Ruedi fish releases actually totaled 20,000 acre-feet (1991 and 1994).

Analysis Results

Tables and graphs are attached showing estimated flows in the Reach from March through November for the seven years analyzed. In four of the years analyzed, the estimates show that releasing surpluses from the Green Mountain HUP under the terms of the settlement could result in higher average flows in the Reach than occurred historically (increases ranged from 6 cfs to 78 cfs). In two of the years evaluated (1977 and 1989), average flows under the settlement were essentially the same as historically (1 cfs to 2 cfs lower). In these years, no surplus HUP water was available to increase flows under the terms of the settlement. Lower average flows in 1994 are due to limited canal capacity to deliver surplus water from the HUP to the Grand Valley Power Plant (discussed below), not due to lack of water in the HUP. Results for 1994 with increased canal capacity to utilize the HUP show an average flow increase of about 37 cfs.