The Nature Conservancy Colorado

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August 20, 2018

Anna Mauss, P.E.
Water Project Loan Program
Finance Section
Colorado Water Conservation Board

Dear Ms. Mauss,

This letter provides you with the final report on the WSRF Grant – POGG1 2017-494 –Wines Ditch #1 Diversion Structure & Conveyance System Improvement, Phase I Preliminary Design, Alternatives Analysis & Construction Cost Opinion. This letter covers a project summary, project obstacles, the proposed versus actual budget, and photos, summaries of meetings, and the engineering report.

Project Summary and Description of Project Completion

The Wines Ditch No. 1 (Wines Ditch) diverts irrigation water from the Dolores River through a structure located on land owned by the Bureau of Land Management (BLM) approximately four miles upstream of the Utah border. Both the ditch structure and associated water rights are owned and operated by Western Sky Investments, a private entity. The Wines Ditch Diversion Structure is a boulder weir that complicates boat passage at times and can require extensive maintenance. It also serves as a barrier that prevents nonnative fish migrating from the Colorado River into the Dolores/San Miguel system and hybridizing with native fish (bluehead suckers and flannelmouth suckers). During high water events, the diversion structure is typically breached, thus increasing the potential for introgression and hybridization of nonnative sucker species from the Colorado River.

The Nature Conservancy convened a project team, including Western Sky Investments, The Nature Conservancy, Colorado Parks and Wildlife, BLM, and American Whitewater, to explore design alternatives for rehabilitating the Wines Ditch Diversion Structure. With grant funding provided by the CWCB and matching funds, The Nature Conservancy retained Wright Water Engineers, Inc., to prepare an alternatives analysis and a preliminary design report for the rehabilitation of the structure. Wright Water Engineers established the stakeholder objectives of the project through a Basis of Design process, and then developed three conceptual design alternatives for the project stakeholder team. In August of 2017, those three conceptual design alternatives were presented to the project stakeholder team at an onsite meeting. This provided an opportunity for collaboration and the selection of design Alternative 3 as the preferred conceptual alternative (with input for the exploration for two different variations of Alternative 3). Wright Water Engineers then developed conceptual design drawings and cost estimates for the two Alternative 3 variations, as well as a final recommendation. The attached *Alternatives Analysis Report—Wines Ditch No. 1 Diversion Rehabilitation Project*, thoroughly documents the entire alternatives analysis process.

Project Obstacles

The alternatives analysis process was designed to foster collaboration and communication between the different stakeholders on the project team. The biggest challenges for the project were technical challenges in designing a rehabilitation project that met many (sometimes competing) design goals on a large river with drastic flow fluctuations. Regular dialogue and on-site visits allowed the project stakeholder team to discuss the pros, cons, and tradeoffs in the different conceptual design alternatives, and to then choose a preferred conceptual alternative to carry forward into the design and cost estimation process.

Permitting for the final design of the project was investigated in the alternatives analysis effort, and further effort securing permits for final construction is being incorporated into the final design budget.

Proposed Budget versus Actual Budget

The Actual Budget for this project is in line with the Proposed Budget. Consultant costs for the project did not change during the project, and the CWCB's budget was exactly as proposed.

Confirmation of Match Commitment Fulfilled

The Nature Conservancy provided a match of $38,637.64 that consisted of a cash contribution of $20,000 to cover a portion of the costs associated with the Wright Water Engineers Inc. contract and an in-kind match of salary, benefits and indirect costs of $18,638.42.

Photos, Summaries of Meetings, and Engineering Report

Please see the attached *Alternatives Analysis Report—Wines Ditch No. 1 Diversion Rehabilitation Project*.

Please do not hesitate to contact me at (970) 739-8624 or celene.hawkins@tnc.org any questions about our progress on the Wines Ditch Project.

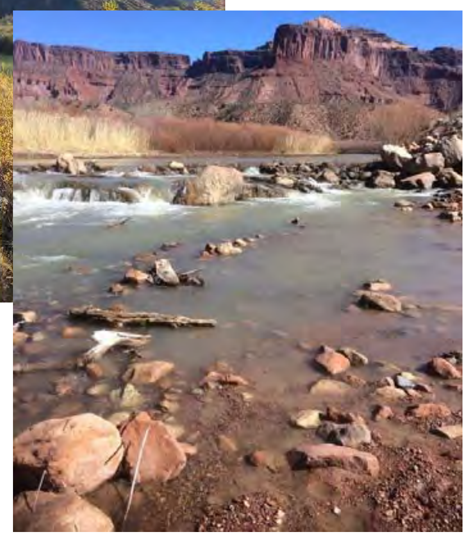
Sincerely,

Celene Hawkins

Celene Hawkins
Western Colorado Water Project Director
The Nature Conservancy

Alternatives Analysis Report

Wines Ditch No. 1 Diversion Rehabilitation Project



Prepared for:

The Nature Conservancy
1109 Oak Drive
Durango, CO 81301

Wright Water Engineers, Inc.

March 2018

111-030-030

– ALTERNATIVES ANALYSIS –

WINES DITCH NO. 1 DIVERSION STRUCTURE REHABILITATION GATEWAY, COLORADO

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1.0 INTRODUCTION AND PROJECT HISTORY

The Wines Ditch No. 1 Diversion Structure, constructed "in or around" 1900, is a rock weir structure located on the Dolores River, in Mesa County, Colorado. The structure is located approximately 3.5 miles downstream of the Town of Gateway, Colorado, and approximately 4 miles upstream of the Colorado-Utah Border (see Figure 1). The diversion structure, which is in need of repair, is decreed for 5.81 cfs to irrigate approximately 111.62 acres of land located on the northeast bank of the Dolores River with an appropriation date of May 1, 1900. The Wines Ditch No 1 is a "pre-compact" water right. This report documents the results of an alternatives analysis performed to evaluate and develop a series of alternatives and a final recommended approach for rehabilitation of the existing Wines Ditch No. 1 Diversion Structure.

The overall objectives and proposed alternatives for the Wines Ditch Diversion Structure rehabilitation project (the Project) were developed from collaboration between Wright Water Engineers, Inc. (WWE), Riverwise Engineering, Inc. (RWE), The Bureau of Land Management (BLM), Colorado Parks and Wildlife (CPW), The Nature Conservancy (TNC), American Whitewater (AW), and Western Sky Investments (operator of the Wines Ditch No. 1 Diversion Structure) and for purposes of this report is referred to as the "Project Team."

WWE developed a Basis of Design Report for the Project (See Appendix A), which was circulated as draft for Project Team review and comment in May of 2017 and finalized in August 2017 after all Project Team comments were incorporated. This Basis of Design Report provides the foundation for the alternatives analysis presented herein. Primary project objectives summarized in the Basis of Design Report included the following:

- Rehabilitate Wines Ditch No. 1 headgate and diversion structure to consistently and reliably divert and convey 5.81 cfs by the Wines Ditch No. 1 Diversion Structure from the Dolores River.

- Decrease sedimentation in the Wines Ditch No. 1 from stormwater interception in order to maintain ditch carrying-capacity to convey diverted water.

- Replace the existing diversion structure with one or more fish barriers to prohibit white suckers from upstream passage, particularly during high water events. The barriers could be either stream velocity or vertical barriers. The Basis of Design Report established the fish barrier(s) need to maintain function for flows ranging from 100 to 5,000 cfs.

- Incorporate options for potential fish passage, if future management of the fishery recommends fish passage as opposed to a barrier (BLM, 2017).

- The Project should allow for safe boater passage during flow conditions ranging between 500 and 5,000 cfs. AWA (2011) reports this is the flow range when boaters are expected to be recreating on the Dolores River.

- Address stream bank erosion below the existing diversion structure that may be exacerbated by the existing rock weir structure.

WWE developed three conceptual design alternatives and presented the conceptual design alternative to the Project Team at an onsite project meeting in August of 2017, which provided an opportunity for collaboration and selection of Alternative No. 3 as the Project Team preferred conceptual alternative.

The remainder of this report is dedicated to summary evaluations of the Project permitting considerations, potential water rights implications, and documentation of the basis for and development of each conceptual design alternative considered. The report concludes with a summary which demonstrates the ability of two Preferred Alternative 3 variations to meet the critical project objectives, a presentation of conceptual design drawings and conceptual level cost opinions for each Preferred Alternative 3 variation (Alternative 3: Option 1 and Option 2) and a final recommendation.

2.0 PROJECT PERMITTING CONSIDERATIONS

2.1 Bureau of Land Management

The existing Wines Ditch No.1 Diversion Structure was first constructed in 1900 and has been in regular operation since for the purposes of diverting and maintaining flows to the Wines Ditch No. 1. The existing diversion structure is located on BLM land. However, since it was constructed prior to the Federal Land Policy and Management Act of 1976 (FLPMA) the existing structure is operating under an 1866 Act (R.S. 2339) right-of-way grant allowing the Owner to maintain the structure as necessary to facilitate delivery of water to Wines Ditch No. 1. It is important to the Owner that this right-of-way grant remain in place as part of any alternative evaluated for the Project.

As discussed previously, representatives of the BLM Grand Junction, CO office are part of Project Team and have provided valuable insight and information regarding BLM authorization requirements throughout the duration of the project. The BLM Grand Junction, CO office has indicated that no formal authorization of the work will be required from the BLM in the event Conceptual Design Alternative 3 (discussed in Section 4.3 of this report) is selected as the preferred alternative by the Project Team.

In the event Alternative 3 is selected by the Project Team, The BLM has requested continued engagement during the final design and construction phase of the Project, and specifically requested the follow procedures to avoid and minimize any potential impacts:

- BLM requests an opportunity to review final construction design documents and provide comments before those designs are finalized.

- BLM requests an opportunity to provide a list of "best management practices" for the construction and site reclamation processes, so that these procedures can be considered for incorporation into the final construction plan.
- BLM requests the opportunity to have staff members on site during the construction process. The BLM staff members can advise the construction crew about resource concerns and can also advise the crew when unexpected resource issues arise.

2.2 USACE Section 404 Permitting

WWE met with the representatives of the United States Army Corps of Engineers (USACE) Grand Junction Office on May 30, 2017 to discuss permitting considerations for the Project under Clean Water Act (CWA) Section 404(f). During this meeting WWE provided USACE with the historical background of the Wines Ditch diversion structure and how it has been used since 1900 to deliver 5.81 cfs of water from the Dolores River to irrigate approximately 112 acres of farmland northeast of the river. The objective of this meeting was to determine if the Wines Ditch Rehabilitation Project could be considered agriculturally exempt under CWA Section 404(f).

At this meeting WWE provided USACE with a summary of the following Wines Ditch Rehabilitation Project objectives:

- The first and primary purpose of the project is to promote the Wines Ditch diversion structure's ability to physically divert the full decreed rate from the Dolores River with minimal ongoing maintenance and that all of the diverted water is used to support ongoing and normal farming activities that have been occurring for over 110 years.

- Secondary objectives, which were recognized in the early stages of the Project's planning process also included the following:

    - Development of a more permanent invasive fish barrier. Currently, the Wines Ditch No. 1 diversion structure provides benefits to the upstream Dolores River by preventing upriver passage of the invasive white sucker. This barrier is promoting the integrity of populations of native bluehead and flannel mouth suckers, which reside upstream and are susceptible to hybridization with the white sucker. While the existing diversion structure provides this benefit during low- and medium-flow conditions, WWE is working with Project proponents to develop a diversion structure design that will meet this ancillary objective over a range of flow conditions.

    - Provide a safer structure for recreational boater passage. Currently, the Wines Ditch No. 1 diversion structure presents a difficulty of passage for recreational boaters under certain flow conditions. Consequently, an ancillary objective of the Project is to incorporate safe recreational boating passage through this reach of the Dolores River under the flows most commonly used for boating. WWE is working with the Project proponents to develop a Project design that will promote attainment of this objective over a range of flow conditions.

During the meeting, WWE stated that the since the primary Project objective is for maintenance and associated rehabilitation of a structure to facilitate the continued delivery of irrigation water to farmland, the Project would not require authorization from the USACE because it qualifies as exempt under CWA Section 404(f).

WWE followed up with a letter to the USACE, which is provided in Appendix B. As of the date of this reports development, WWE has not received a response from USACE.

2.3 Floodplain Permitting

WWE spoke with the Mesa County Floodplain Administrator regarding the need for a Floodplain Development Permit for the Project. The Project is located in a FEMA Zone D area, which indicates it is in an area where there are possible but undetermined flood hazards, as no analysis of flood hazards has been conducted. Based on WWE's discussion with the Floodplain Administrator, this project will not require a Floodplain Development Permit under the condition that water surface elevations, upstream and downstream of the Project area, are not significantly increased. WWE does not anticipate a significant increase in downstream or upstream water surface elevations as a result of the Project, however this will need to be further evaluated once additional survey topography is collected as part of the next phase of the Project.

The Floodplain Administrator asked that the Project Team keep Mesa County informed as the Project progresses and provided documentation of proposed changes in the water surface elevations once final design plans are developed.

2.4 Other Permitting Considerations

Please note that not all permitting requirements could be identified as of the date of this report. Depending on the funding source(s) for the next phase of the Project additional environmental review, such as National Environmental Policy Act (NEPA), may be required. In addition, stormwater and construction dewatering permits may be required for the construction of the Project. Until such a time that final design plans are developed and construction funding is secured, the full scope of Project environmental and cultural review and permitting requirements cannot be known. An estimate of $70,000 was included in the next phase of design and construction funding for environmental, and cultural review and environmental permitting.

3.0 WATER RIGHTS IMPLICATIONS

WWE utilized the Colorado's Decision Support System (CDSS) water rights database to determine if any existing water rights were located in the vicinity of the Wines Ditch No.1 Diversion location. Based on this investigation, WWE did not identify any intervening water rights diversions or instream flow rights within the Project area. WWE also spoke with Bob Hurford, P.E., Division 4 Engineer to discuss potential water rights implications resulting from the construction of the project team's preferred alternative. At the time of this discussion, the Division Engineer confirmed the nonexistence of nearby water rights and did not identify any specific water rights implications or issues.

4.0 CONCEPTUAL DESIGN ALTERNATIVES ANALYSIS

Using information from the Project Basis of Design Report, WWE developed three conceptual design alternatives and presented them to the Project Team during an onsite meeting in August of 2017. The following sections provide a summary of the Project Team discussion associated with each of the three conceptual design alternatives evaluated. A summary of the No Action Alternative is also presented.

4.1 Conceptual Design Alternative 1

Conceptual design Alternative 1 consists of a single continuous drop structure with an overall drop height of approximately 9 feet (See Appendix C). This approach minimizes the proposed structures footprint and provides the most robust fish barrier. However, it is the least preferred option from a boater safety perspective and would be the most difficult option to provide optional fish passage features as part of the design or in the future. The specific pros and cons, for this alternative identified by the Project Team were as follows:

4.1.1 *Pros*

- Minimizes the length of the side channel needed to deliver water upstream of the diversion to the Wines Ditch headgate (less than 200 feet).
- It is likely the least expensive alternative when compared to the other alternatives.
- This alternative is likely easier to construct when compared to the other alternatives.
- This has the smallest overall structural footprint when compared to the other alternatives.
- This alternative is the most robust fish barrier.

4.1.2 *Cons*

- Most difficult alternative to incorporate fish passage during the design and construction phases or in the future.
- Most difficult to modify post construction in the event changes need to be made to control hydraulics at the toe of the drop.
- Alternative 1 has a low to moderate level of boater navigability. Most boaters will likely portage this structure and require scouting because of the structure's horizon line.
- At higher flows a larger and more chaotic hydraulic situation at the toe of the structure will likely form, resulting in a higher potential for boaters to "swim" and get caught in the hydraulics of the structure.
- In the event a boat flips on the structure there is a higher potential for injury to a person in the water when compared to the other alternatives.
- Not an aesthetically pleasing structure.
- Integrating the existing side tributary will be more difficult and will likely require additional grading and construction activities after the structure has been installed to address the potential for the tributary to undermine or destabilize the structure.
- There is a potential for debris accumulation at the top of the drop which may inhibit boater passage and require portaging.

4.2 Conceptual Design Alternative 2

Conceptual design Alternative 2 consists of seven different individual drop structures spaced approximately 100 feet apart from crest to toe of each structure (See Appendix C). Four of the structures have overall drop heights of 1 foot and three of the structures have drop heights of approximately 1.5 feet, for a total overall drop height of approximately 9 feet. This approach is the most boater friendly and would be the best approach to facilitate fish passage in the future, however it has the largest footprint and is the least robust fish barrier. The specific pros, cons, and other considerations for this alternative identified by the Project Team were as follows:

4.2.1 *Pros*

- Fish bypass can be easily incorporated during the design and construction phases or in the future.
- It is the best alternative from a boater safety and fish passage perspective.
- This is more aesthetically pleasing when compared to Alternative 1.
- Easiest to modify post construction in the event changes need to be made to control hydraulics at the toe of one or more of the drops.
- Integration of the side tributary is less concerning since the tributary will enter between two drop structures.

4.2.2 *Cons*

- Largest structural footprint of all the alternatives.
- This is likely the most expensive alternative when compared to the other two alternatives.
- This alternative is likely more difficult and expensive to construct when compared to the other two alternatives.
- Longest portage route.
- Maximizes the length of the side channel needed to deliver water upstream of the diversion to the Wines Ditch headgate (Approximately 500 feet).
- Least robust fish barrier
- In the event a large sediment load is delivered via the side tributary the two most downstream drops structures could become ineffective fish barriers.

4.2.3 *Other Considerations / Recommendations if Selected*

- CPW recommended the two most upstream drop structures be combined into a single drop to provide a more robust fish barrier.
- A portage trail, approximately 10 feet wide, should be incorporated onto the river right side between the top bank of the structure and the side channel which will facilitate delivery of water to the Wines Ditch headgate. This will also help minimize the potential for boaters to traverse across the side channel delivering water to the headgate and into the BLM's restoration area on this side of the river.
- Escape routes should be considered for each drop structure. If a boater does "swim," they will likely head towards the right bank and onto the previously discussed portage trail.

Moving fish passage structures to the left side of the primary channel should be considered to prevent conflict with a boater attempting to escape.

- Restoring and stabilizing the stream in-between each proposed drop structure should be incorporated.
- Installation of J-hooks on the side tributary should be considered to divert water away from the second most downstream drop structure.
- If feasible, using the diversion side channel in combination with fish screens as a means of controlling fish passage could be considered.

4.3 Conceptual Design Alternative 3

Conceptual design Alternative 3 consists of three different individual drop structures spaced approximately 200 feet apart from crest to toe of each structure (See Appendix C). Each structure has a drop of approximately 3 feet for an overall drop height of approximately 9 feet. This alternative was intended to serve as the "middle ground" between Alternatives 1 and 2. The specific pros, cons, and other considerations for this alternative identified by the Project Team were as follows:

4.3.1 *Pros*

- Provides a higher quality experience for boaters from a recreational perspective when compared to Alternative 1, while Alternative 2 would have the highest quality whitewater out of the three Alternatives considered.
- Likely provides a more robust fish barrier for a wider range of flow conditions when compared with Alternative 2.
- Strikes a middle ground with respect to construction costs and constructability when compared with the other alternatives.
- Provides a structure footprint that is more likely to fit within a smaller pre-FLPMA footprint.
- Strikes a middle ground with respect to length of the side channel needed to deliver water upstream of the diversion to the Wines Ditch headgate when compared with the other alternatives.
- Integration of the side tributary is less concerning since the tributary will enter between two drop structures.
- Higher potential for integration of an operational fish passage structure when compared with Alternative 1.

4.3.2 *Cons*

- In the event a large sediment load is delivered via the side tributary the most downstream drop structure could become an ineffective fish barrier.
- There is a higher concern for eddies and erosional features to develop at the left and right embankments the structures when compared to Alternative 2.
- Due to the larger structure drop heights associated with Alternative 3, there is a higher likelihood for necessary follow-up maintenance to address unforeseen adverse hydraulic

conditions after construction. If selected, it is recommended that the project budget include considerations for maintenance after construction to address any adverse hydraulic conditions that develop.

4.3.3 *Other Considerations / Recommendations if Selected*

- Due to the larger drop height of these structures, a minimum distance of 200 feet between the downstream toe and upstream crest of each structure is recommended to allow a reasonable amount of distance for a boater who “swims” to escape.
- A portage trail, approximately 10 feet wide, should be incorporated onto the river right side between the top bank of the structure and the side channel which will facilitate delivery of water to the Wines Ditch headgate. This will also help minimize the potential for boater’s traverse across the side channel delivering water to the headgate and into the BLM’s restoration area on this side of the river.
- Escape routes should be considered for each drop structure. If a boater does “swim,” they will likely head towards the right bank and onto the previously discussed portage trail. Moving fish passage structures to the left side of the primary channel should be considered to prevent conflict with a boater attempting to escape.
- Restoring and stabilizing the stream in-between each proposed drop structure should be incorporated.
- Installation of J-hooks on the side tributary should be considered to divert water away from the middle drop structure.
- If feasible, using the diversion side channel in combination with fish screens as a means of controlling fish passage could be considered.

4.4 No Action Alternative

The Project Team considered the following outcomes as a result of implementing the No Action Alternative:

- The existing diversion structure is currently serving as a grade control check structure in the Dolores River. In the event of a failure, a headcut will form and migrate upstream resulting in negative water quality impacts downstream and significant erosion and destabilization of the Dolores River upstream of the diversion.

- The existing diversion structure is acting as a fish barrier which has historically prevented the migration of non-native fish species into the upper portion of the Dolores River. Continued degradation of the diversion may allow for non-native species to migrate up the river, risking hybridization with native species in the future.

- The existing diversion structure does not allow for safe boater passage through this section of the Dolores River. The Dolores River provides a number of high quality whitewater recreational opportunities, and the diversion will continue to provide difficult boater passage at various flow levels.

- The existing diversion structure creates erosive water velocities downstream of the structure under high flow conditions, resulting in continued stream bank erosion and loss of aquatic habitat.

The Project Team did not select the No Action Alternative as the preferred alternative. Moving forward with the Project provides an opportunity for a combination of benefits, including continued diversion of pre-compact water rights, recreation, aquatic habitat enhancement, and protection of native fish species.

5.0 PREFERRED ALTERNATIVE SELECTION

During the August 2017 onsite meeting, the Project Team agreed that Alternative 3 was the preferred alternative. The Project Team considered Alternative 3 to be the most balanced approach to meet the overall project objectives of maintaining diversion of pre-compact water rights, creating a more boater friendly structure and was the most likely alternative to achieve the fish barrier requirements and provide options for fish passage in the future.

6.0 PREFERRED ALTERNATIVE 3 CONCEPTUAL DESIGN DEVELOPMENT

After the August 2017 meeting, WWE advanced the conceptual design for Preferred Alternative 3 in an effort to better evaluate hydraulic conditions and approaches for stream restoration and to assess the constructability of additional Project Team recommendations and concepts discussed during the meeting. As the conceptual design for the preferred alternative was advanced, WWE identified potential construction cost saving opportunities for the Project and developed two conceptual design options for Preferred Alternative 3.

- Preferred Alternative 3, Option 1 consists of three different individual drop structures spaced approximately 200 feet apart from crest to toe of each structure. This option is most similar to Alternative 3 discussed in Section 4.3 of this report.

- Preferred Alternative 3, Option 2 consists of two different individual drop structures spaced approximately 200 feet apart from crest to toe of each structure, followed by a constructed riffle structure. This option replaces the most downstream drop structure in Alternative 3 with a constructed riffle to provide a potential cost saving to the Project.

The following sections provide a summary of project objective design considerations applicable to both preferred alternative options, unless otherwise noted. See Appendix D for conceptual level design drawings and conceptual renderings of Preferred Alternative 3: Options 1 and 2.

6.1 Delivery of Water to Wines Ditch No. 1

As recommended in the Basis of Design Report (Appendix A) the Project requires maintained delivery of 5.81 cfs to the Wines Ditch headgate under low flow conditions. In an effort to better inform the hydraulic design of Preferred Alternative 3: Options 1 and 2, a calibrated existing conditions Hydraulic Engineering Center – River Analysis System (HEC-RAS) model was developed to determine model boundary conditions for use with a proposed conditions HEC-RAS model developed for each preferred alternative option. See Appendix E for a more technical summary of the calibration process for the existing conditions HEC-RAS model.

Using the boundary conditions developed for the existing conditions HEC-RAS model and the proposed grading for Preferred Alternative 3: Options 1 and 2, proposed conditions HEC-RAS models were developed to evaluate the depth of water entering the side channel under a low flow condition of 100 cfs for each option. Based on the results of the proposed conditions HEC-RAS models approximately 2 feet of water will be present at the entrance to the side channel when there is 100 cfs in the river. Based on the conceptual design for the headgate side channel this will facilitate the ability to deliver approximately 20 cfs to the headgate under low flow conditions.

The following provides a summary of additional considerations for delivery of water to Wines Ditch No. 1 associated with Preferred Alternative 3: Options 1 and 2:

- A sluice gate will be installed at the location of the existing headgate to facilitate sluicing of any material which builds up in the side channel back to the river. This sluice gate can also be used to manage the amount of water being delivered to the headgate and return any excess water to the river.

- An instream structure to promote scour immediately upstream of the location where the side channel enters the river should be considered as part of the final design phase. Existing conditions survey data was not available in this area for the conceptual design phase of this Project, and additional survey data will need to be collected as part of the final design phase.

6.2 Fish Barrier Hydraulic Analysis

As recommended in the Basis of Design Report (Appendix A) the Project requires maintained fish barrier function and performance under a range of flow conditions from 100 to 5,000 cfs. Using the boundary conditions developed for the existing conditions HEC-RAS model and the proposed grading for Preferred Alternative 3: Options 1 and 2, proposed conditions HEC-RAS models were developed to evaluate flow velocities at each barrier structure for flows ranging from 100 to 5,000 cfs for each option. Table 1 and Table 2 provide a summary of the estimated velocities at each fish barrier structure under this range of flow conditions for Preferred Alternative 3: Options 1 and 2, respectively. See Appendix F for a summary of HEC-RAS model output for Preferred Alternative 3: Options 1 and 2.

As discussed in the Project Basis of Design Report, the minimum velocity required to inhibit passage of non-native white sucker fish is a function of barrier length. Each proposed barrier for Preferred Alternative 3: Option 1 is approximately 30 feet long. As shown in Table 1, the channel velocity through each barrier ranges from 4.97 ft/s to 12.91 ft/s depending on low or high flow conditions, respectively. According to Gardunio (2014), the minimum velocity required to inhibit passage of the white sucker for a barrier length of 30 feet is approximately 3.3 ft/s.

The upstream and middle barrier for Preferred Alternative 3: Option 2 are approximately 30 feet long and the downstream riffle structure is approximately 133 feet long. As shown in Table 2, the channel velocity for the upstream and middle barrier ranges from 4.97 ft/s to 12.91 ft/s depending on low or high flow conditions, respectively. For the downstream riffle structure, the channel velocity ranges from 5.06 ft/s to 11.28 ft/s depending on low or high flow conditions, respectively.

According to Gardunio (2014), the minimum velocity required to inhibit passage of the white sucker for a barrier length of 30 feet and 133 feet are approximately 3.3 ft/s and 1.5 ft/s, respectively.

Therefore, at this conceptual design level, both Preferred Alternative 3: Options 1 and 2 meet the fish barrier performance criteria established in the Project Basis of Design Report.

6.3 Optional Fish Passage Considerations

As recommended in the Basis of Design Report (Appendix A) the Project needs to consider options for fish passage in the event that white suckers are determined to not be as big of a threat as perceived. Preferred Alternative 3: Option 1 incorporates fish passage structures into each fish barrier structure which can be opened or closed using a stop log structure built into the crest of the barrier. Each fish passage structure consists of a series of step-pool structures which allows for fish to rest in one pool and then burst through approximately 10 feet of channel until entering the next resting pool. The crest of the stop log structure will be located approximately 3 feet from bottom of each passage channel. This provides a vertical barrier greater than the maximum jumping height of the white sucker (approximately 2 feet) under low flow conditions (see Appendix A).

During the peak migration season from April through June flows are expected to be on average approximately 1,000 cfs or less (see Appendix A). Under a 1,000 cfs flow condition the velocity through the channel portion of the passage structure is expected to be 8 ft/s or less.

The native sucker population have sustained swimming speeds of approximately 10 ft/s for 15 feet (Haro, 2004). Therefore, in the event fish passage structures are opened, native fish should be able to migrate through these structures during average or below average annual flow conditions.

CPW has recommended that these fish passage structures be further refined during the next phase of the project in an attempt to limit flow velocities in the passage to between 2 and 3 ft/s for as many flow conditions as possible. Flow velocities in this range would maximize the potential for fish passage in the future.

CPW has also recommended, that if constructible, the fish passage structure incorporate a small sorting pool at the crest of each drop structure to facilitate manual sorting of fish. Construction costs associated with this recommendation are considered in the *Contingency* line item for the conceptual level cost estimates presented in Section 7.0 of this report.

6.4 Stream Restoration Considerations

A bankfull analysis was performed to develop a recommended typical design channel cross-section for stream restoration purposes. The bankfull discharge is considered the channel forming flow of a riverine system which develops the overall channel geometry for a river. The bankfull discharge estimated for this Project was based upon stream gage data and an analysis of existing channel cross-sections extrapolated from the site survey data. See Appendix G or a technical summary documenting this bankfull analysis.

The typical conceptual design channel cross-section, as shown in Appendix G, utilizes a staged channel approach. Stage 1 is a 22-foot-wide, 1.5-foot-deep low flow channel expected to contain all flow less than approximately 100 cfs. This low flow channel is considered wide enough to allow for a watercraft to safely navigate through the reach under low flow conditions. Stage 2 is a 61-foot-wide, 3-foot-deep channel bankfull channel expected to contain all flow less than approximately 1,000 cfs. Stage 3 of the channel is activated for all flow conditions above approximately 1,000 cfs and is effectively the Dolores River floodplain through the Project area. For flow in excess of the bankfull flow, water will spill out onto a floodplain bench. The minimum width of this floodplain bench will be 10 feet, while some areas may be a wide as 30 feet between the upstream and middle drop structure.

The typical cross section also incorporates a combination of hard armored and natural bank stabilization techniques. The bankfull channel banks will be stabilized with seeded soil wraps and staked with native willow. The low flow channel banks will be stabilized using a soil-riprap mix and staked with native willow. The concern with a more natural bank stabilization approach below the bankfull water surface elevation is the potential for boaters to become tangled in any sort of erosion control or coirwrap material installed there as part of the revegetation process. All disturbed areas outside the bankfull channel will also be revegetated.

6.5 Boater Passage Considerations

The following provides a summary of boater passage considerations associated with Preferred Alternative 3: Options 1 and 2:

- One recommendation from the Project Team included construction of a portage trail on the river right side between the top bank of the river and the side channel. Based on the proposed grading developed for Preferred Alternative 3: Options 1 and 2, installation of a portage trail at this location is not feasible because there is not enough space between the edge of the river and the side channel near the middle drop structure. As a result, this portage trail has been relocated east of the side channel, and not in between the river and the side channel (see Appendix C and Appendix D which illustrate the changed location). It is recommended, that as part of the final design phase, signage be installed in this area to discourage boaters from entering or disturbing BLM's restoration area. Construction costs associated with this recommendation are considered in the *Contingency* line item for the conceptual level cost estimates presented in Section 7.0 of this report.

- Fish passage channels are located on the river left side of the channel to help prevent conflict with a boater attempting to escape the river.

- Signal boulders are located at the crest of each barrier structure.

- The minimum channel width is 22 feet wide, which will enable watercraft to navigate each structure under low flow conditions.

- The location of the entrance to the most upstream drop structure has been located to meet the thalweg of the natural channel, resulting in a curved structure. Based on the Project Team's experience, curvature in drop structures can result in more unpredictable and adverse hydraulics through and downstream of the structure. It is recommended that the alignment of this structure be straightened during the final design process.

6.6 Rehabilitation of Wines Ditch No. 1

As discussed in the Project Basis of Design Report, one objective of the Project is to decrease sedimentation in the Wines Ditch No. 1 from stormwater interception in order to maintain ditch carrying-capacity to convey diverted water. Currently, there is approximately 2,700 linear feet of Wines Ditch No. 1 which is impacted by small stormwater tributary inflows. During rainfall events, these tributaries deliver large volumes of sediment to and destabilize the ditch. This reduces the carrying capacity of the ditch, resulting in the need for constant maintenance and reconstruction of the ditch in these locations during the irrigation season.

In November 2017, WWE toured this 2,700-foot segment of the ditch and documented specific locations where tributary inflows are entering and delivering sediment to the ditch. Appendix H provides a figure showing the location of each tributary crossing the ditch, and representative photos of the ditch at these crossings.

The following provides a summary of design considerations for rehabilitation of Wines Ditch No. 1 associated with Preferred Alternative 3: Options 1 and 2:

- Existing deposited sediment will be excavated and removed from the 2,700 foot ditch segment in need of rehabilitation. At each tributary crossing, the ditch will be reconstructed and stabilized.

- At each tributary crossing, stormwater runoff will be directed underneath the Wines Ditch No. 1 via a reinforced concrete pipe. Pipe headwall and wingwall structures will be located on the upstream and downstream side of each crossing. Trash tracks will also be installed on the upstream pipe entrance.

- Energy dissipation will be installed at the reinforced concrete pipe outlet of each tributary crossing.

- Existing conditions survey data was not available in this area for the conceptual design phase of this Project. Additional survey data will need to be collected at each tributary crossing as part of the final design phase.

Construction costs for rehabilitation of the Wines Ditch No.1 have been included as part of conceptual level construction cost estimates for Preferred Alternative 3: Options 1 and 2 (see *Wines Ditch No. 1 Rehabilitation* line item in Table 3 and Table 4).

7.0 PREFERRED ALTERNATIVE 3: OPTIONS 1 AND 2 CONCEPTUAL LEVEL COST ESTIMATES

7.1 Preferred Alternative 3: Option 1

Table 3 provides a summary of WWE’s conceptual opinion of probable construction and final engineering design, permitting, and construction services costs for Preferred Alternative 3: Option 1.

Based on WWE’s conceptual level design, the expected construction cost for Preferred Alternative 3: Option 1 is approximately $3,580,000. This estimate includes considerations for post-construction maintenance of revegetation and modifications to the structures in the event unfavorable hydraulic conditions develop.

Based on WWE’s conceptual level design and permitting evaluation to date, the expected final engineering design, permitting, and construction services costs for Preferred Alternative 3: Option 1 is approximately $366,000.

7.2 Preferred Alternative 3: Option 2

Table 4 provides a summary of WWE’s conceptual opinion of probable construction and final engineering design, permitting, and construction services costs for Preferred Alternative 3: Option 2.

Based on WWE’s conceptual level design, the expected construction cost for Preferred Alternative 3: Option 2 is approximately $3,440,000. This estimate includes considerations for post-construction maintenance of revegetation and modifications to the structures in the event unfavorable hydraulic conditions develop.

Based on WWE’s conceptual level design and permitting evaluation to date, the expected final engineering design, permitting, and construction services costs for Preferred Alternative 3: Option 2 is approximately $366,000.

Preferred Alternative 3: Option 2 appears to meet the critical structure performance and function requirements set forth in the Project Basis of Design Report and at this conceptual design level, is expected to provide some degree of construction cost savings when compared with Preferred Alternative 3: Option 1. **Therefore, the Project Team has selected Preferred Alternative 3: Option 2 as the final recommend alternative at this stage in the Project.**

8.0 CONCLUSION AND FINAL RECOMMENDATIONS

The Wines Ditch No. 1 Diversion Structure, constructed “in or around” 1900, is a rock weir structure located in Mesa County, Colorado on the Dolores River, and is need of maintenance and repair to facilitate continued delivery of pre-compact water rights to the Wines Ditch No. 1. Through a collaborative effort, the Project Team identified, evaluated, and developed a recommend preferred conceptual design alternative for replacement of the existing diversion structure. Through this collaborative effort, Preferred Alternative 3: Option 2 was selected by the Project Team and is anticipated to meet the primary performance and function requirements of the structure outlined in the Project Basis of Design Report.

8.1 Recommendations and Considerations for Final Design Phase

The Project Team has identified the following additional recommendations and considerations for the final design phase of the project. Please note that the incorporation of these recommendations during the final design phase are not expected to increase the conceptual level construction cost estimate for Preferred Alternative 3: Option 2, and are generally accounted for in the construction contingency line item as applicable:

- Additional topographic survey data needs to be collected upstream and downstream of the project area.
- Additional topographic survey data needs to be collected along the Wines Ditch No. 1 at each recommended tributary crossing improvement location. Please note additional locations may be identified by the ditch operator during this process.
- An instream structure to promote scour immediately upstream of the location where the Wines Ditch No. 1 side channel enters the river should be considered as part of the final design phase.
- Eliminate the curvature in the most upstream drop structure during the final design phase.
- If possible, additional water depth data should be collected upstream and downstream of the structure during the 2018 spring runoff season to fill the data gaps discussed in Appendix E.
- Install signage along the portage trail to discourage boaters from entering or disturbing BLM restoration area on this side of the river.
- Perform a hydraulic analysis to assess the potential risk for non-native fish species to by-pass fish barriers during a large flood event and make adjustments to barrier locations and geometry as necessary.
- Further refine the design of fish passage structures in an attempt to limit flow velocities in the passages to between 2 and 3 ft/s for flow conditions less than 1,000 cfs.
- Consider incorporating a small sorting pool in each fish passage structure at the crest of each drop structure to facilitate manual sorting of fish.
- Finalize the bankfull analysis and associated typical design cross-section geometry based on additional geomorphic data available for the Dolores River.

- Finalize overall channel grading to maximize the balance of earthwork cut-fill volumes with consideration for imported material.
- Work with BLM to identify existing vegetated areas which can harvested to provide livestakes and brushlayering for the construction phase of the Project.

9.0 REFERENCES

American Whitewater Association (AWA), 2011. Defining Recreational Streamflow Needs in the Lower Dolores River: Integrating Specific and Overall Evaluations of Flow and Recreation Quality. American Whitewater Association, Cullowhee, NC. Available here: http://ocs.fortlewis.edu/drd/pdf/Appendix-B_ Stream-Flow-Evaluation_AW.pdf

Bureau of Land Management (BLM), 2017. Summary Letter: Comments on Wines Ditch Diversion Design Considerations. Fresques, T. Bureau of Land Management - Grand Junction Field Office. Grand Junction, CO.

Gardunio, E. I., 2014. Thesis - Jumping and Swimming Performance of Burbot and White Sucker: Implications for Barrier Design. Colorado State University, Fort Collins, CO.

Haro, A., T. Castro-Santos, J. Noreika, and M. Odeh, 2004. Swimming Performance of Upstream Migrant Fishes in Open-Channel Flow: A New Approach to Predicting Passage Through Velocity Barriers. Canadian Journal of Fisheries and Aquatic Sciences. 61:9. 1560-1601.

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Tables

Table 1
Main Channel Velocity Through Each Fish Barrier Structure - Option 1

Drop Location	Upstream Drop Barrier[1]	Middle Drop Barrier[2]	Downstream Drop Barrier[3]
Barrier Length	30	30	30
Minimum Barrier Velocity Required (ft/s)	3.3	3.3	3.3
Design Flow (cfs)	**Design Velocity (ft/s)**		
100	4.97	5.03	5.03
220	6.32	6.07	6.38
500	6.46	6.49	6.51
1000	8.08	8.03	7.89
1500	9.51	9.08	8.82
1600	10.09	9.23	8.98
2000	12.62	9.90	9.62
2500	15.77	10.64	10.24
3000	11.13	10.91	10.80
3500	11.52	11.51	11.37
4000	11.91	12.49	11.94
4500	12.27	12.70	12.42
5000	12.57	12.91	12.84

1-Evalauted at Proposed Conditions Cross Section 7+41
2-Evalauted at Proposed Conditions Cross Section 4+87
3-Evalauted at Proposed Conditions Cross Section 2+32

Table 2
Main Channel Velocity Through Each Fish Barrier Structure - Option 2

Drop Location	Upstream Drop Barrier[1]	Middle Drop Barrier[2]	Downstream Riffle Barrier[3]
Barrier Length	30	30	133
Minimum Barrier Velocity Required (ft/s)	3.3	3.3	1.5
Design Flow (cfs)	**Design Velocity (ft/s)**		
100	4.97	5.03	5.06
220	6.32	6.07	6.33
500	6.46	6.49	6.07
1000	8.08	8.03	7.36
1500	9.51	9.08	8.17
1600	10.09	9.23	8.42
2000	12.62	9.90	9.04
2500	15.77	10.64	9.79
3000	11.13	10.91	10.52
3500	11.52	11.51	11.12
4000	11.91	12.49	11.35
4500	12.27	12.70	11.27
5000	12.57	12.91	11.28

1-Evalauted at Proposed Conditions Cross Section 7+41
2-Evalauted at Proposed Conditions Cross Section 4+87
3-Evalauted at Proposed Conditions Cross Section 3+52

Table 3
Conceptual Opinion of Probable Cost for Wines Ditch Diversion Rehabilitation
Preferred Alternative 3: Option 1

Pre-Construction Engineering Design, and Permitting Services Estimate					
Environmental Permitting	$ 70,000	LS	6	1	$ 70,000
Engineering Fees for Construction Plans, Contract Documents and Technical Specifications	$ 120,000	LS		1	$ 120,000
Coordination with Project Stakeholders and Reporting Costs	$ 30,000	LS		1	$ 30,000
Engineering Services During Bidding	$ 16,000	LS	7	1	$ 16,000
Pre-Construction Engineering Design and Permitting Services Total					**$ 236,000**
Estimated Construction Costs					
Description	**Cost per Unit**	**Unit**	**Reference**	**Quantity (±)**	**Cost**
Mobilization / Demobilization					
15% of Construction and Permitting Costs	$ 321,000	LS	1	1	$ 321,000
Permits					
Stormwater Permit Compliance (5% of Construction Costs)	$ 93,000	LS		1	$ 93,000
Dewatering / Water Control Permit Compliance	$ 60,000	LS	2	1	$ 60,000
Earthwork					
Harvest Large Diameter Rock Material From Existing Structure	$ 35	CY	3	1800	$ 63,000
Onsite Excavation	$ 10	CY	2	5000	$ 50,000
Onsite Fill	$ 5	CY	2	3500	$ 17,500
Excavate and Install Side Channel to Headgate	$ 30	LF	2	400	$ 12,000
Portage Trail	$ 10	SY	2	360	$ 3,600
Excavate and Install Side Tributary	$ 150	LF	2	300	$ 45,000
In-Channel Structures					
Grouted Drop and Fish Barrier Structure	$ 500	SY	2	1800	$ 900,000
Grouted Boulder Wall at Toe of Drop	$ 350	LF	2	250	$ 87,500
Riprap Approach to First Structure	$ 100	CY	2	200	$ 20,000
Fish Passage Structures	$ 100	LF	2	300	$ 30,000
Hard Armored Toe Bank Stabilization	$ 350	LF	2	100	$ 35,000
Boulder Sill	$ 200	LF	2	100	$ 20,000
Signal Boulders	$ 750	EA	2	6	$ 4,500
Boulder Clusters (3 Boulders Each Cluster)	$ 2,250	EA	2	7	$ 15,800
Stream Restoration					
Soil Riprap	$ 100	CY	2	2000	$ 200,000
Upland Seeding	$ 2,000	AC	2	1.5	$ 3,000
Erosion Control Blanket	$ 8	SY	2	6700	$ 53,600
Koirwrap Soil Lifts	$ 100	LF	2	2200	$ 220,000
Brushlayering	$ 40	LF	2	1100	$ 44,000
Harvest and Willow Livestaking	$ 5	EA	2	2200	$ 11,000
Miscellaneous					
Sluice Gate	$ 5,000	EA	2	1	$ 5,000
Reinforced Concrete Pipe Return to River	$ 80	LF	2	75	$ 6,000
Flash Board Structure on Fish Passage Structures	$ 3,000	EA	4	3	$ 9,000
Wines Ditch No. 1 Rehabilitation					
Excavate, Remove and Haul Fill Material From Ditch	$ 15	CY	2	3750	$ 56,300
Install Culverts and Appurtenances at Tributary Crossings	$ 15,000	LS	2	5	$ 75,000
Construction Subtotal					$ 2,500,000
30% Contingency					$ 750,000
Construction Total					$ 3,250,000
Post Construction Modifications to Structures and Revegetation Maintenance [5]					$ 325,000
Construction Grand Total					**$ 3,575,000**
Engineering Services During Construction and Post-Construction Estimate					
Engineering Services During Construction and Coordination with Project Stakeholders	$ 100,000	LS	8	1	$ 100,000
Post-Construction Monitoring (2-year)	$ 30,000	LS		1	$ 30,000
Engineering Services During Construction and Post-Construction Total					**$ 130,000**

[1]Estimated as 15% of Total Construction Costs Due to Remote Location

[2]Estimated from Urban Drainage and Flood Control District Bid Tabs Database

[3]Final Report for CCC Ditch Diversion Structure Improvement Project, submitted to Colorado Water Trust, 2011

[4]Wright Water Engineers, Inc. Bid Tabs from Other Projects

[5] Estimated at 10% of Total Construction Costs

[6]Includes considerations for USACE 404 , Floodplain, Archeological, and NEPA

[7]Assumes 1 month bidding period

[8]Assumes 6 month construction period

Table 4

Conceptual Opinion of Probable Cost for Wines Ditch Diversion Rehabilitation

Preferred Alternative 3: Option 2

Description	Cost per Unit	Unit	Reference	Quantity (±)	Cost
Pre-Construction Engineering Design, and Permitting Services Estimate					
Environmental Permitting	$ 70,000	LS	6	1	$ 70,000
Engineering Fees for Construction Plans, Contract Documents and Technical Specifications	$ 120,000	LS		1	$ 120,000
Coordination with Project Stakeholders and Reporting Costs	$ 30,000	LS		1	$ 30,000
Engineering Services During Bidding	$ 16,000	LS	7	1	$ 16,000
Pre-Construction Engineering Design and Permitting Services Total					**$ 236,000**
Estimated Construction Costs					
Description	**Cost per Unit**	**Unit**	**Reference**	**Quantity (±)**	**Cost**
Mobilization / Demobilization					
15% of Construction and Permitting Costs	$ 307,000	LS	1	1	$ 307,000
Permits					
Stormwater Permit Compliance (5% of Construction Costs)	$ 88,000	LS		1	$ 88,000
Dewatering / Water Control Permit Compliance	$ 60,000	LS	2	1	$ 60,000
Earthwork					
Harvest Large Diameter Rock Material From Existing Structure	$ 35	CY	3	1800	$ 63,000
Onsite Excavation	$ 10	CY	2	4100	$ 41,000
Onsite Fill	$ 5	CY	2	3300	$ 16,500
Excavate and Install Side Channel to Headgate	$ 30	LF	2	400	$ 12,000
Portage Trail	$ 10	SY	2	360	$ 3,600
Excavate and Install Side Tributary	$ 150	LF	2	300	$ 45,000
In-Channel Structures					
Grouted Drop and Fish Barrier Structure	$ 500	SY	2	1200	$ 600,000
Grouted Boulder Wall at Toe of Drop	$ 350	LF	2	250	$ 87,500
Riffle Section	$ 150	CY	2	1600	$ 240,000
Riffle Toe	$ 70	LF	2	65	$ 4,600
Riffle Crest	$ 600	LF	2	81	$ 48,600
Riprap Approach to First Structure	$ 100	CY	2	200	$ 20,000
Fish Passage Structures	$ 100	LF	2	300	$ 30,000
Hard Armored Toe Bank Stabilization	$ 350	LF	2	100	$ 35,000
Boulder Sill	$ 200	LF	2	100	$ 20,000
Signal Boulders	$ 750	EA	2	6	$ 4,500
Boulder Clusters (3 Boulders Each Cluster)	$ 2,250	EA	2	7	$ 15,800
Stream Restoration					
Soil Riprap	$ 100	CY	2	2000	$ 200,000
Upland Seeding	$ 2,000	AC	2	1.5	$ 3,000
Erosion Control Blanket	$ 8	SY	2	6700	$ 53,600
Koirwrap Soil Lifts	$ 100	LF	2	1600	$ 160,000
Brushlayering	$ 40	LF	2	800	$ 32,000
Harvest and Willow Livestaking	$ 5	EA	2	2200	$ 11,000
Miscellaneous					
Sluice Gate	$ 5,000	EA	2	1	$ 5,000
Reinforced Concrete Pipe Return to River	$ 80	LF	2	75	$ 6,000
Flash Board Structure on Fish Passage Structures	$ 3,000	EA	4	3	$ 9,000
Wines Ditch No. 1 Rehabilitation					
Excavate, Remove and Haul Fill Material From Ditch	$ 15	CY	1	3750	$ 56,300
Install Culverts and Appurtenances at Tributary Crossings	$ 15,000	LS	1	5	$ 75,000
Construction Subtotal					$ 2,400,000
30% Contingency					$ 720,000
Construction Total					$ 3,120,000
Post Construction Modifications to Structures and Revegetation Maintenance[5]					$ 312,000
Construction Grand Total					**$ 3,432,000**
Engineering Services During Construction and Post-Construction Estimate					
Engineering Services During Construction and Coordination with Project Stakeholders	$ 100,000	LS	8	1	$ 100,000
Post-Construction Monitoring (2-year)	$ 30,000	LS		1	$ 30,000
Engineering Services During Construction and Post-Construction Total					**$ 130,000**

[1]Estimated as 15% of Total Construction Costs Due to Remote Location

[2]Estimated from Urban Drainage and Flood Control District Bid Tabs Database

[3]Final Report for CCC Ditch Diversion Structure Improvement Project, submitted to Colorado Water Trust, 2011

[4]Wright Water Engineers, Inc. Bid Tabs from Other Projects

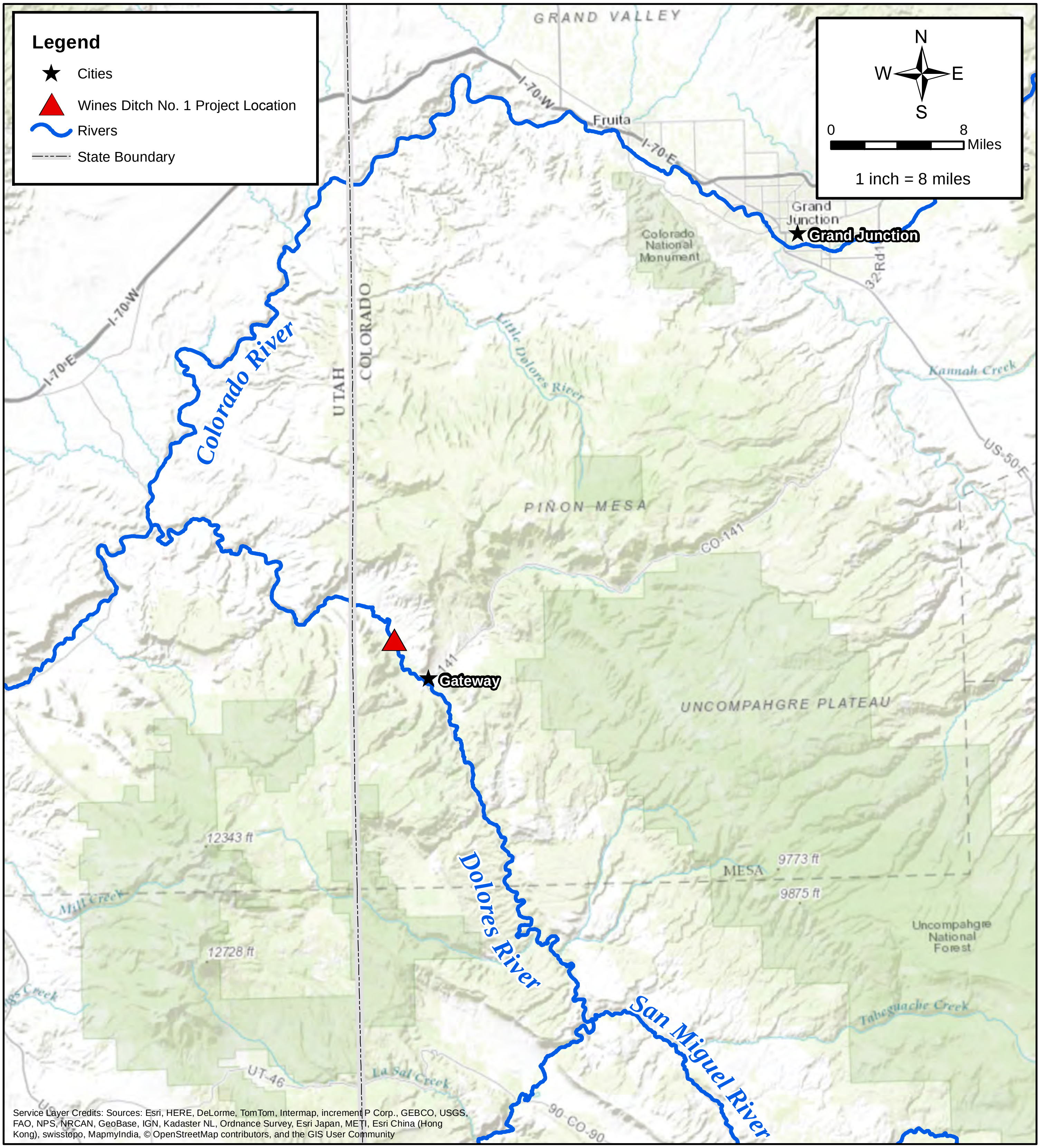
[5] Estimated at 10% of Total Construction Costs

[6]Includes considerations for USACE 404 , Floodplain, Archeological, and NEPA

[7]Assumes 1 month bidding period

[8]Assumes 6 month construction period

Figures



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USGS Topographic Quad

WWE
WRIGHT WATER ENGINEERS, INC.
1666 N. Main Ave., Suite C
Durango, CO. 81301
(970) 259-7411

MESA COUNTY, COLORADO

WINES DITCH NO. 1 PROJECT LOCATION

WESTERN SKY INVESTMENTS

TOWNSHIP 15 SOUTH, RANGE 104 WEST, SIXTH P.M.

PROJECT NO.
111-030.030

Figure
1

Appendices

Appendix A

Wines Ditch Diversion Rehabilitation Project
Basis of Design Report

Prepared for:

The Nature Conservancy
1109 Oak Drive
Durango, CO 81301

Wright Water Engineers, Inc.

August 2017

111-030-030

– BASIS OF DESIGN REPORT –

WINES DITCH NO. 1 DIVERSION STRUCTURE REHABILITATION GATEWAY, COLORADO

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WINES DITCH NO.1 DIVERSION STRUCTURE REHABILITATION
GATEWAY, COLORADO

1.0 INTRODUCTION AND PROJECT OBJECTIVES

The Wines Ditch No. 1 Diversion Structure, constructed in 1900, is a rock weir structure located in Mesa County, Colorado on the Dolores River, approximately 3.5 miles downstream of the Town of Gateway, Colorado, and approximately 4 miles upstream of the Colorado-Utah Border. The diversion is decreed for 5.8 cfs which is used to irrigate approximately 112 acres of land located on the northeast bank of the Dolores River.

The overall objectives for the Wines Ditch Diversion Structure rehabilitation project (the Project) were developed from collaboration between Wright Water Engineers, Inc. (WWE), Riverwise Engineering, Inc. (RWE), The Bureau of Land Management (BLM), Colorado Parks and Wildlife (CPW), The Nature Conservancy (TNC), American Whitewater (AW), and Western Sky Investments (operator of the Wines Ditch Diversion) (the Project Team). Based on the results of this collaboration, the Project Team has agreed that the following considerations and objectives should be critical components of the structure rehabilitation design (Project Meeting, 2017):

- Rehabilitate Wines Ditch No. 1 headgate and diversion structure to provide the ability to consistently divert and convey pre-Compact water rights by the Wines Ditch No. 1 on the Dolores River.

- Decrease sedimentation in the Wines Ditch No. 1 from stormwater interception, in order to maintain ditch carrying-capacity to convey diverted water.

- The structure should act as a fish barrier to exclude white suckers from upstream passage, particularly during high water events.

- This design should include an option for potential fish passage if future management of the fishery recommends fish passage as opposed to a barrier (BLM, 2017a). This could be in the form of a secondary fish passage channel with a manual sorting pen which could later be converted into an open fish passage channel at a later time (CPW, 2017a).

- The structure should allow for safe boater passage at various river flows.

- Address stream bank erosion below the diversion structure that may be exacerbated by the existing rock weir structure.

2.0 WINES DITCH HEADGATE CONSIDERATIONS

The existing Wines Diversion Structure coveys water to the Wines Ditch, located on the right bank (north) side of the diversion. To convey water into Wines Ditch an existing hand-operated slide gate is opened and water is conveyed to the ditch via an 18 inch pipe approximately 40 feet long. Considerations for improvements to the Wines Ditch Headgate Diversion Structure of the Project include the following:

- The headgate is located where sediment deposition regularly inundates and partially buries the headgate. As a result, the river needs to be excavated regularly during the irrigation season. The diversion design needs to incorporate a sluice gate or wasteway to facilitate cleaning of the area in front of the headgate. Alternatively, an instream structure to promote scour immediately upstream of the headgate could be considered.

- The CDSS diversion records summary for Wines Ditch No. 1 indicates that the Wines Ditch diverts water from April through October. The design will need to ensure the ability to deliver 5.8 cfs of water to the Wines Ditch during this time period under all flow conditions.

- Based on the survey information collected in 2017, the existing invert elevation of the headgate diversion is approximately 4534.25 feet. The proposed design should maintain this same invert elevation at the headgate.

- Screening on the headgate to prevent entrainment/fish from entering the ditch should be considered (Project Meeting, 2017).

- As discussed in the Project Meeting (2017), designs which would require a significant change in the historical point of diversion should be avoided.

3.0 FISH BARRIER DESIGN CONSIDERATIONS

Currently, the Wines Diversion may act as a fish barrier for non-native white suckers under moderate and low flow conditions. As a result, CPW (2017a) recommends the rehabilitation Project continue to serve as a fish barrier in order to prevent white suckers from hybridizing with native bluehead and flannelmouth suckers upstream of the diversion.

Please note this reach of the river is not considered critical habitat for round tail chub. However, if the species is found upstream of the Wines Ditch No. 1, the round tail considerations would be the same as those that we have for the bluehead sucker and flannel mouth sucker. It would not be feasible to make a fish barrier that would selectively allow round tail chub to pass, but keep white suckers out. The potential barrier would cause round tail to lose passage at the Wines Ditch unless a fish sorting channel, or some other sort of bypass, is incorporated into the barrier design. The round tail chub may have a self-sustaining population upstream of the Wines Ditch in the Dolores and San Miguel Rivers that would be able to persist without immigration from downstream of the Wines Ditch No. 1 (CPW, 2017b).

There are two primary types of fish passage barriers: 1) velocity based barriers which force fish to burst swim for unattainable distances, and 2) vertical barriers which are higher than the jumping ability of the fish. The following sections provide a summary of white sucker design criteria for each barrier type.

3.1 Velocity Barrier

A velocity barrier design that forces fish to burst swim is preferable, as these velocities force the fish to utilize anaerobic metabolism, which depletes rapidly. Gardunio (2014) provides a summary of predicted minimum barrier velocities necessary to prevent a white sucker from successfully ascending a velocity barrier with lengths ranging from 7.5 to 30 meters (24.6 feet to 98.4 feet). This information is provided in both tabular and graphical format in **Attachment A**, and should be used to inform the design of the barrier length and associated velocity under selected design flow conditions.

A velocity barrier should also consider the following design elements:

- Grout should be used for construction of a velocity fish barrier. Utilizing grout will help increase flow velocities and decrease fish refuge on the barrier (CPW, 2017a).

3.2 Vertical Barrier

A vertical barrier design prevents fish passage when constructed with a fall height greater than the jumping ability of the target species. Gardunio (2014) found that no white suckers were able to jump waterfalls over 40 cm (1.3 feet) in height, and recommends that a 70 cm (2.3 feet) high barrier be used to account for peak-performing jumpers.

A vertical barrier should also consider the following design elements:

- A shallow plunge pool less than 20 cm (0.67 feet) deep should be installed on the downstream side of the vertical barrier. A sloped apron or "splash pad" can be used immediately downstream of the barrier to keep the pool depth to a minimum (CPW, 2017a).

- Construction of a deep pool downstream of the vertical barrier to help reduce the potential for birds to predate upon native fish species. This pool should not extend to the base of the vertical barrier as it would maximize the jumping ability of the white suckers (CPW, 2017a).

3.3 Additional Barrier Design Considerations

In addition to the design criteria outlined in Sections 3.1 and 3.2, additional considerations for the fish barrier design aspect of the Project include the following:

- The primary spawning / migration season for white sucker is April through the end of June. While barrier design should inhibit white sucker passage year-round, April through the end of June is the time frame when proper functioning of the barrier is most-critical (CPW, 2017a).

- All barrier designs have some margin of buffer to account for peak-performing white sucker fish and unanticipated flow conditions (CPW, 2017a).

- BLM (2017) notes that it would be ideal to design a structure that would allow some passage of native bluehead and flannelmouth, but that it may not be feasible. CPW (2017a) confirms that it is not possible to design a barrier that would allow passage of native fish species while excluding white suckers without providing a secondary passage channel with a manual fish sorting pen. In the event white sucker are determined to not be as big of a threat as perceived, design components which allow for the passage channel to be opened at a later date to facilitate upstream passage should be considered (BLM, 2017). At least one conceptual design alternative should include a secondary passage channel with a manual fish sorting pen.

- The new structure should be designed for post McPhee reservoir flows, capable of passing flow and sediment during non-spill periods, as well as passing flow and sediment during years with releases from McPhee Reservoir.

3.4 Fish Barrier Design Parameters

Based on the information provided in Sections 3.1 to 3.3 the following design criteria for providing a vertical or velocity barrier to prevent white sucker migration and passage are presented in Table 1.

Table 1. Factors Specific to White Sucker that Dictate Barrier Design Criteria, Adapted from CPW (2017) and Gardunio (2014).

Factor	Value Range or Metric	Comments
All Barriers		
Spawning season	April 1 – June 30	While proper functioning of the barriers is most critical during April through June, designing a barrier that functions year-round is recommended (CPW, 2017a).
Secondary channel with manual sorting pen	Native Fish Passage	At least one conceptual design alternative should consider this option.
Velocity Barriers		
Minimum velocity across barrier	Varies (see comments)	Design flow velocities should exceed 90 cm/s (3 ft/s) for all expected flow conditions, however higher velocities may be necessary depending on barrier length. Confirm with information in Attachment .
Vertical Barriers		
Vertical fall height	≤ 40 cm (minimum) ≤ 70 cm (recommended)	A barrier over 70 cm is a conservative design to account for peak-performing jumpers.
Plunge pool	≥20 cm	Helps reduce probability of successful jump. Use a sloped apron or “splash pad” to minimize pool depth.
Deep pool to prevent predation of native species downstream of the barrier	4 ft	A deep pool located downstream of the barrier can help protect fish from predation. This pool should not extend to the base of barrier, as it would maximize jumping ability of white suckers.

4.0 CONSIDERATIONS FOR SAFE BOATER PASSAGE

In addition preventing non-native species from migrating upstream, the existing diversion structure presents difficulty for recreational boaters on the Dolores River during certain flow conditions. The Dolores River provides a number of high quality whitewater recreational opportunities which are flow dependent. The following information from AWA (2011) provides a range of flow conditions for when boaters are expected to be on the Lower Dolores River. This information will be used to inform diversion structure design criteria for safe boater passage under these flow conditions.

4.1 Recreational Flows on the Dolores River

AWA (2011) used a web-based approach coupled with survey responses to collect information on whitewater flows in five segments of the Lower Dolores River and organized the data to define flows that provide for certain recreational needs. Table 2 provides a summary of the median acceptable minimum, technical, standard, high, and maximum flows organized by craft-type based on the results of the survey. The Wines Ditch No. 1 Diversion Structure is located in Dolores River Segment Five – Gateway to Colorado River.

Table 2. Median Minimum, Low, Technical, Standard, High, and Maximum Flows for Dolores River Segment 5 – Gateway to Colorado River Confluence (AWA, 2011)

Minimum Flows (cfs)	Technical Flow (cfs)	Low Flow (cfs)	Standard Flow (cfs)	High Flow (cfs)	Maximum Flow (cfs)
Canoe Evaluations					
500	600	775	1,200	2,500	1,900
Kayak Evaluations					
700	900	1,000	1,500	3,500	5,000
Raft/Cataraft Evaluations					
800	900	1,000	1,800	3,500	5,000

The results presented in Table 2 suggest recreational boaters are typically in the water when flows in the Dolores River Segment 5 – Gateway to Colorado River range between 500 and 5,000 cfs. AWA (2011) also report that optimal flows for this same segment range between 1,900 and 2,700 cfs.

AWA (2011) presents a usable days analysis and found that optimal flows (greater than 1,900 cfs) have only been available in the wettest 50 percent of the years since 1991 on the Lower Dolores River. The analysis also suggested that existing whitewater boating opportunities, as well as enhancement opportunities via releases from McPhee Dam, typically occur between April and July in the Lower Dolores River.

4.2 Safe Navigational Passage and Low-Head Dams

The existing Wines Diversion structure is a boulder rubble weir without a safe navigational passage for all watercraft at all flow conditions, often requiring portages or lining. It is recommended that safe navigational passage be included in the design of the Project.

In the event a vertical fish barrier is considered, the design will need to incorporate features which prevent the creation of a low head dam and associated reverse roller. Hazards associated with low-head dams, which should be avoided as part of the Project, include the following (IDNR, 2017):

- Vertical concrete abutments that are difficult to scale if a drowning victim manages to reach it.

- Debris can become trapped in reverse roller downstream of the dam, along with a drowning victim, creating trauma hazards. The structure should include sufficient flow-through to flush debris.

- Certain reverse roller conditions downstream of the dam may cause air bubbles to mix into the water decreasing the buoyancy by one-third, which makes staying afloat more difficult.

4.3 Other Boat Passage Considerations

In addition to the criteria outlined in Sections 4.1 and 4.2, additional considerations for the boater passage design aspect of the Project include the following:

- The design should include navigational passage(s) incorporating the design considerations noted above. The passage(s) should be designed for watercraft suitable for whitewater, hydraulic features, swift currents, eddies, obstacles, and variable turbulent conditions.

- The features will not be navigable by motor driven boats or similar watercraft designed for flatwater conditions.

- The design should facilitate recreation including whitewater rafting and boating for less technical users (i.e. tubers) (BLM, 2017b).

- If possible, the proposed portage trail should be located on the south side (left bank) of the Dolores River. The area north of the right bank of the river, immediately upstream of the diversion structure, has been managed by the BLM for restoration and should not be disturbed if possible.

4.4 Boater Passage Design Parameters

Based on the information provided in Sections 4.1 to 4.3 the following design criteria for design of safe boater passage are presented in Table 3.

Table 3. Design Parameters and Considerations for Safe Boater Passage

Factor	Value Range or Metric	Comments
Recreation boating season	April through July	This is peak boater recreation season. Considerations for boater passage at low flows should also be considered.
Optimal recreational flow range	1,900 to 2,700 cfs	Peak recreational user flow range.
Recreational flow range	500 – 5,000 cfs	Boaters should be expected on the Dolores River when flows are in this range.
Portage trail	Locate bank of river	If possible, avoid right bank to minimize disturbance to BLM restoration area.
Entrapment potential	Minimize the potential for entrapment downstream of vertical barriers	Evaluate entrapment potential under design flow conditions.
Structure Spacing	200 feet	If possible, provide 200 feet of distance between barrier structures to provide enough distance for swimming boaters to escape between structures.

5.0 HYDROLOGIC ANALYSIS

USGS gage 01980000 - Dolores River near Cisco, UT, and (Cisco Gage) located approximately 17 river miles downstream of the Wines No. 1 Diversion Structure was used to evaluate expected flows at the diversion structure. The contributing watershed area upstream of the Cisco Gage and the Wines Diversion is approximately 4,570 and 4,380 square miles, respectively. The following sections provide a summary of the flood frequency analyses calculated using USACE's HEC-SSP model (Bartles *et. al*, 2016). All analyses were conducted post-McPhee Reservoir construction.

5.1 Post-McPhee Reservoir Annual Flood Frequency Analysis

Table 4 provides a summary of the HEC-SSP results for the annual peak flood frequency analysis conducted for the Cisco Gage between January 2000 and April 2017.

Table 4: Annual Peak Flood frequency analysis - all available data - USGS gage Dolores River near Cisco, UT (2000 to 2017).

Return Interval	Lower 95 % Confidence Limit	Computed Value	Upper 95 % Confidence Limit
(years)	(cfs)	(cfs)	(cfs)
500	10,254	15,980	34,200
200	8,515	12,679	24,909
100	7,334	10,541	19,363
50	6,253	8,671	14,855
20	4,954	6,550	10,192
10	4,047	5,168	7,457
5	3,173	3,939	5,270
2	1,967	2,451	3,032
1.3	1,200	1,615	2,009
1.1	767	1,141	1,478
1.0	544	882	1,189

In addition to the flood frequency analysis, an average daily flow duration curve was developed for the same time period (see Figure 1).

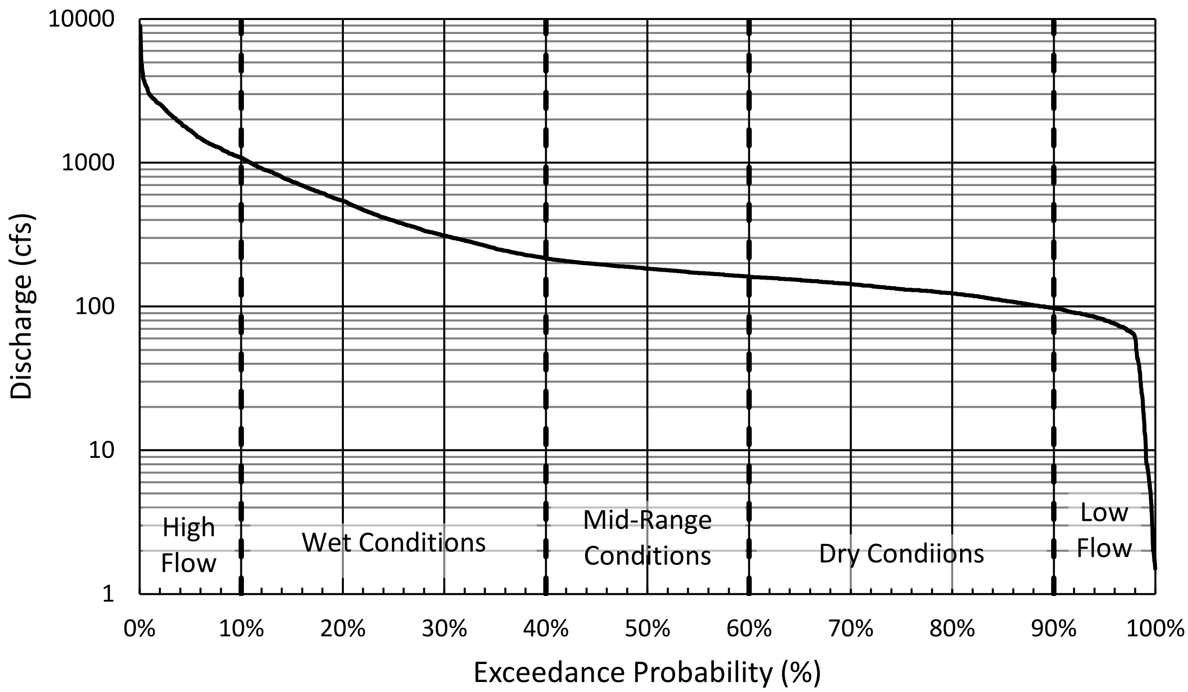

Figure 1. Average daily flow duration curve for Dolores River near Cisco, UT - All data 2000 through 2017

5.2 Post-McPhee Reservoir Seasonal Flood Frequency Analysis

Table 5 provides a summary of the HEC-SSP results for an annual peak flood frequency analysis conducted for the Cisco Gage for the months of April through June between 2000 and 2017. This analysis was performed to evaluate expected peak flows during the seasonal white sucker migration season.

Table 5: Annual Flood frequency analysis - April 1st through June 30th data - USGS gage Dolores River near Cisco, UT (2000 to 2017).

Return Interval (years)	Lower 95 % Confidence Limit (cfs)	Computed Curve (cfs)	Upper 95 % Confidence Limit (cfs)
500	7,937	12,756	28,137
200	6,943	10,830	22,538
100	6,190	9,421	18,674
50	5,435	8,054	15,131
20	4,424	6,311	10,938
10	3,640	5,035	8,138
5	2,819	3,786	5,655
2	1,584	2,116	2,843
1.3	757	1,126	1,509
1.1	327	588	854
1	148	327	525

In addition to the seasonal flood frequency analysis, a seasonal average daily flow duration curve was developed for the same time period (see Figure 2).

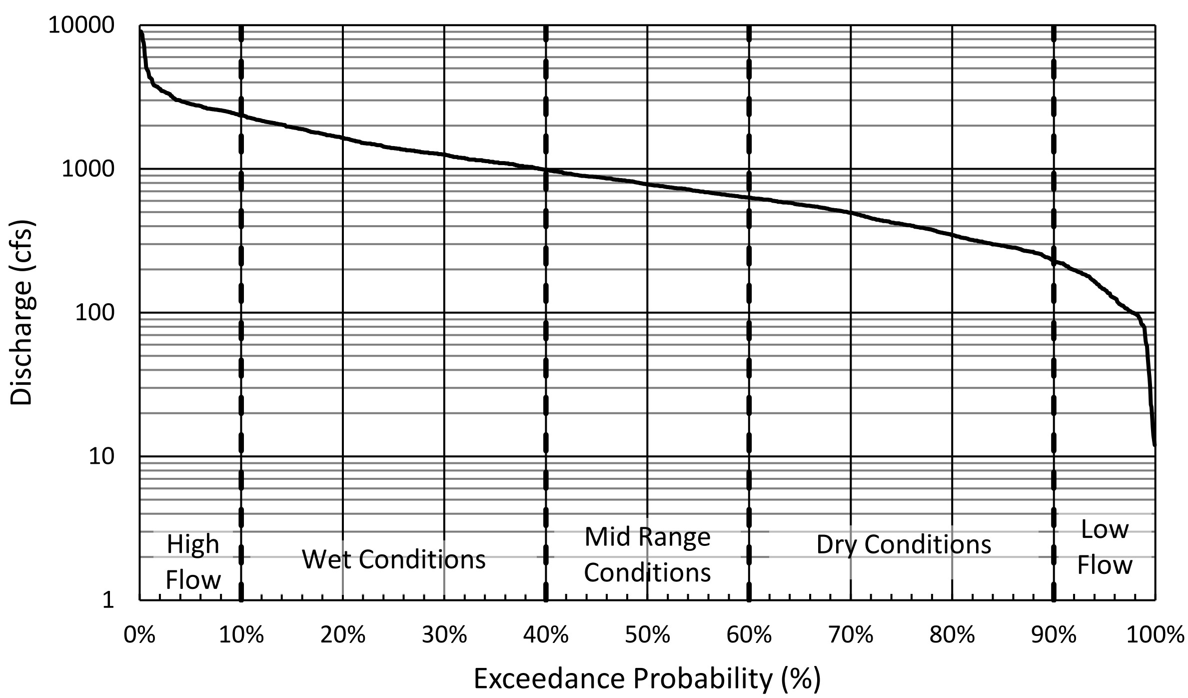

Figure 2. Average daily flow duration curve for Dolores River near Cisco, UT – April to June (2000 to 2017)

5.3 Post-McPhee Reservoir Low Flow Summary

Based on the average daily flow duration curves presented in Figure 1 and Figure 2 the expected low flow range associated with the 90 percent and 95 percent exceedance probability is between 97 cfs and 80 cfs annually and between 228 cfs and 144 cfs during the white sucker migration season.

5.4 Recommended Structure Performance for Selected Design Flows

Table 6 presents a summary of the recommended structure function and performance under select flow conditions based on the hydrologic analysis presented in Sections 5.1 through 5.3 and the information presented in Sections 3.0 and 4.0.

WWE is recommending the structure maintain fish barrier function between 100 and 5,000 cfs. The low flow value of 100 cfs is approximately equal to the 90 percent exceedance probability based on the annual average daily flow duration curve. The high flow value of 5,000 cfs is approximately equal to the calculated 10-year flood value. Additionally, this high flow value is less than the 1% exceedance probability for flow during the peak white sucker migration season.

WWE is recommending the structure maintain boater passage function between 500 and 5,000 cfs. Based on the information presented in Table 2, this is expected flow range during which boaters should be expected on the Dolores River. The structure should also provide optimum boater passage conditions between 1,900 and 2,700 cfs which are considered to be optimum boating flows on this section of the Dolores River.

For flows less than 100 cfs, the structure will need to provide sufficient flow depth at the Wines Ditch headgate to facilitate delivery of 5.8 cfs to the Wines Ditch.

Table 6. Recommended Wines Ditch Diversion Structure function and performance under a range of flow conditions.

Flow Range (cfs)	Structure Function	Discussion
5,000 – 100	Fish Barrier	For higher flows, fish barrier function should be maintained using a velocity barrier because a vertical barrier will likely become inundated during higher flow conditions. For lower flows, fish barrier function should also be maintained.
500 – 5,000	Boater Passage	This is the expected range of flows when boaters will be present on the river. Safe boater passage should be maintained under this flow range.
1,900 – 2,700	Boater Passage	This the expected optimum flow conditions for boater recreation. Under this flow range the structure should provide optimum conditions for boater passage.
<100	Delivery to Headgate	A delivery of 5.8 cfs to the Wines Ditch headgate will be maintained during low flow conditions.

Please note that the recommended design flows presented herein in may be revised as additional comments are received from Project stakeholders and other potential project constraints are evaluated during the design process.

6.0 REFERENCES

American Whitewater Association (AWA), 2011. Defining Recreational Streamflow Needs in the Lower Dolores River: Integrating Specific and Overall Evaluations of Flow and Recreation Quality. American Whitewater Association, Cullowhee, NC.

Bartles, M., G. Brunner, M. Gleming, B. Faber, and J. Slaughter, 2016. HEC-SSP Statistical Software Package Version 2.1. US Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, 609 Second Street, Davis, CA.

Bureau of Land Management (BLM), 2017a. Summary Letter: Comments on Wines Ditch Diversion Design Considerations. Fresques, T. Bureau of Land Management - Grand Junction Field Office. Grand Junction, CO.

Bureau of Land Management (BLM), 2017b. Summary Letter: BLM Design Consideration Comments. Hyatt K., T. Fresques. Bureau of Land Management - Grand Junction Field Office. Grand Junction, CO.

Colorado Parks and Wildlife (CPW), 2017a. Memo re: Initial Design Considerations for Wines Ditch Diversions Project. Gardunio, G., P. Jones, M. Kondratieff, and D. Graf. February 3, 2017.

Colorado Parks and Wildlife (CPW), 2017b. Personal Communication re: Wines Ditch Diversion Rehabilitation – Draft Basis of Design Report. June 6, 2017.

Gardunio, E. I., 2014. Thesis - Jumping and Swimming Performance of Burbot and White Sucker: Implications for Barrier Design. Colorado State University, Fort Collins, CO.

Iowa Department of Natural Resources (IDNR), 2017. Low Head Dams. Available here: http://www.iowadnr.gov/Things-to-Do/Canoeing-Kayaking/Low-Head-Dams. IDNR, Des Moines, IA.

Project Meeting, 2017. Project Kickoff Meeting Summary – Wines Ditch Project. Hawkins, C. TNC Colorado Field Office - 1109 Oak Drive Durango, CO 81301.

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Attachment A

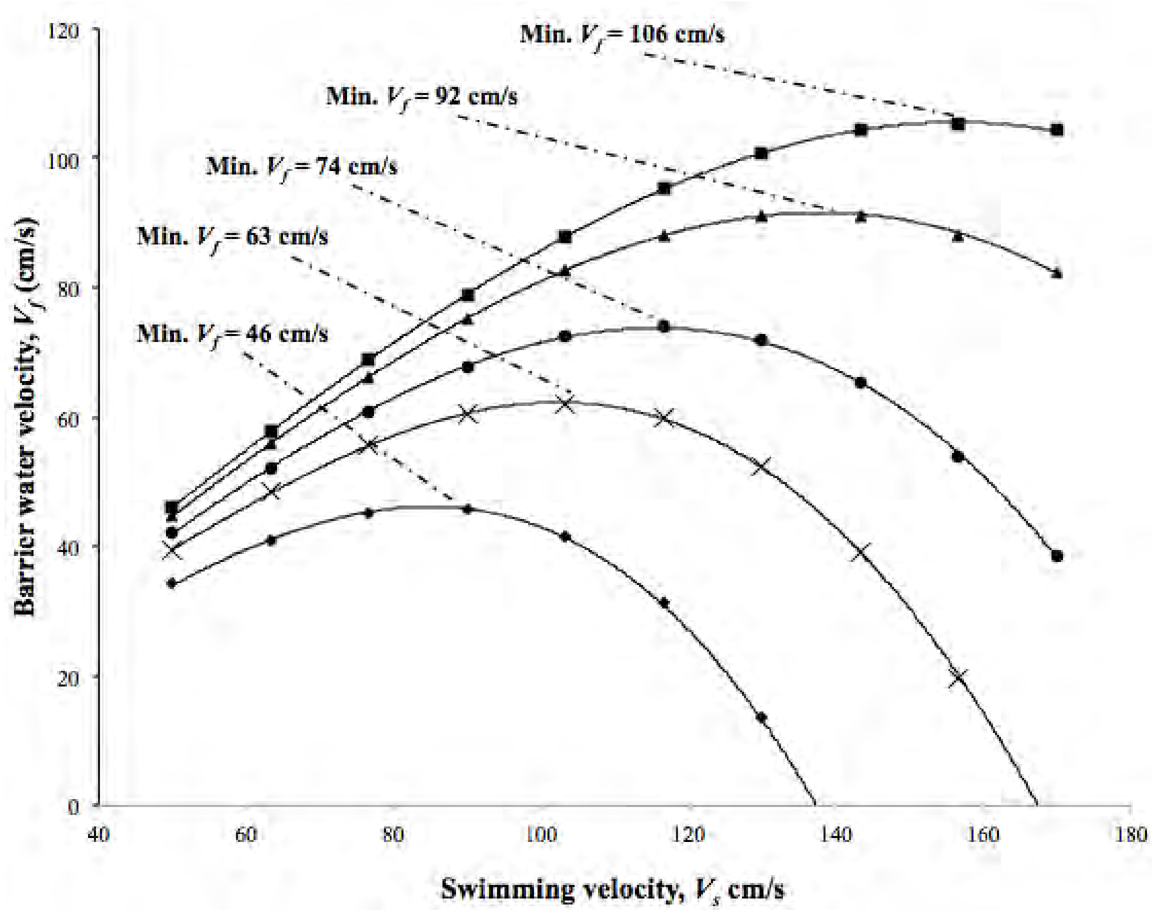

Figure 2.10: Predicted minimum barrier velocities (V_f) necessary to prevent a 400-mm white sucker from successfully ascending velocity barriers of lengths of 7.5 – 30 m. These predictions are based upon plots of fishway water velocity (V_f; cm/s) versus swimming speed (V_s; cm/s) developed using Peake‟s equation and the upper 99% prediction interval from a regression plot from fixed velocity trials for a 400-mm TL white sucker. Fixed values of V_s were used at barrier lengths (*d*; m) of 7.5 m (□) 10 m (▲), 15 m (●), 20 m(X), and 30 m(◆)).

APPENDIX H

Predicted mean, 95 and 99%-confidence intervals for fish barrier lengths (d; m) and velocities ($V_{f\text{-}x}$; cm/s) that will prevent passage of white sucker of a given length (TL; mm) calculated using Peake"s equation with data from AICc averaged logistic regression model for failure time in fixed velocity swimming flume trials. Parameter values of V= 100-160 cm/s, TL= 300-570 mm, T=6°C (minimum) were used, and all other parameters were dropped. Bold values represent optimal design criteria to withstand attempts from white suckers using an optimal positive groundspeed.

d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$
5	100	50	44	44	44	5	200	50	45	45	45	5	300	50	46	46	46	5	400	50	47	47	47
5	100	63	54	55	55	5	200	63	56	57	57	5	300	63	58	58	58	5	400	63	59	59	59
5	100	77	64	65	65	5	200	77	67	67	67	5	300	77	69	69	69	5	400	77	70	71	71
5	100	90	72	74	74	5	200	90	76	77	77	5	300	90	79	79	80	5	400	90	81	82	82
5	100	103	77	81	82	5	200	103	83	85	86	5	300	103	87	89	89	5	400	103	91	91	92
5	100	117	**80**	86	88	5	200	117	87	92	93	5	300	117	94	96	97	5	400	117	98	100	101
5	100	130	77	89	92	5	200	130	**88**	96	98	5	300	130	**97**	102	104	5	400	130	104	107	108
5	100	143	68	**91**	95	5	200	143	84	99	102	5	300	143	96	106	108	5	400	143	**106**	113	114
5	100	157	49	90	97	5	200	157	71	**99**	105	5	300	157	89	**108**	112	5	400	157	104	116	119
5	100	170	16	88	99	5	200	170	48	98	106	5	300	170	74	108	114	5	400	170	94	117	122
7.5	100	50	41	41	41	7.5	200	50	43	43	43	7.5	300	50	44	44	44	7.5	400	50	45	46	46
7.5	100	63	50	51	51	7.5	200	63	53	53	53	7.5	300	63	55	55	55	7.5	400	63	57	57	57
7.5	100	77	58	59	59	7.5	200	77	62	62	63	7.5	300	77	65	65	65	7.5	400	77	67	68	68
7.5	100	90	63	65	66	7.5	200	90	69	70	71	7.5	300	90	73	74	74	7.5	400	90	77	77	77
7.5	100	103	**64**	70	71	7.5	200	103	**73**	76	77	7.5	300	103	79	81	82	7.5	400	103	84	85	86
7.5	100	117	61	**71**	73	7.5	200	117	73	79	81	7.5	300	117	**82**	86	87	7.5	400	117	89	92	93
7.5	100	130	51	69	**73**	7.5	200	130	67	**79**	**82**	7.5	300	130	81	**88**	90	7.5	400	130	**91**	96	97
7.5	100	143	30	64	71	7.5	200	143	54	76	81	7.5	300	143	73	87	**91**	7.5	400	143	88	**97**	**100**
7.5	100	157	-	57	68	7.5	200	157	29	70	78	7.5	300	157	56	83	89	7.5	400	157	77	95	**100**
7.5	100	170	-	47	63	7.5	200	170	-13	62	74	7.5	300	170	26	76	86	7.5	400	170	56	90	97

APPENDIX H (cont): White sucker swimming criteria.

d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$
10	100	50	38	38	38	10	200	50	40	40	41	10	300	50	42	42	42	10	400	50	44	44	44
10	100	63	46	46	47	10	200	63	49	50	50	10	300	63	52	53	53	10	400	63	55	55	55
10	100	77	51	53	54	10	200	77	57	58	58	10	300	77	61	62	62	10	400	77	64	65	65
10	100	90	**54**	57	58	10	200	90	61	63	64	10	300	90	67	69	69	10	400	90	72	73	73
10	100	103	52	**58**	**60**	10	200	103	**62**	**67**	68	10	300	103	**71**	74	74	10	400	103	78	80	80
10	100	117	43	56	59	10	200	117	58	66	**69**	10	300	117	70	**76**	**77**	10	400	117	**80**	84	85
10	100	130	24	49	54	10	200	130	46	62	66	10	300	130	64	74	77	10	400	130	78	**85**	**86**
10	100	143	-	38	47	10	200	143	24	54	61	10	300	143	49	69	73	10	400	143	69	82	85
10	100	157	-	23	38	10	200	157	-	42	52	10	300	157	22	59	67	10	400	157	50	75	81
10	100	170	-	6	28	10	200	170	-	26	42	10	300	170	-	45	58	10	400	170	18	64	73
15	100	50	31	32	32	15	200	50	35	36	36	15	300	50	38	39	39	15	400	50	41	41	41
15	100	63	37	38	38	15	200	63	42	43	43	15	300	63	47	47	47	15	400	63	50	51	51
15	100	77	**39**	**41**	42	15	200	77	47	48	49	15	300	77	53	54	54	15	400	77	58	59	59
15	100	90	36	41	**42**	15	200	90	**47**	**50**	**51**	15	300	90	**56**	58	59	15	400	90	63	64	65
15	100	103	26	36	38	15	200	103	42	48	50	15	300	103	55	**59**	**60**	15	400	103	**65**	**68**	68
15	100	117	6	25	30	15	200	117	29	41	45	15	300	117	47	55	57	15	400	117	62	67	**69**
15	100	130	-	8	17	15	200	130	5	29	34	15	300	130	31	46	50	15	400	130	52	62	65
15	100	143	-	-	-	15	200	143	-	9	19	15	300	143	2	32	38	15	400	143	32	51	56
15	100	157	-	-	-	15	200	157	-	-	0	15	300	157	-	10	22	15	400	157	-	34	43
15	100	170	-	-	-	15	200	170	-	-	-	15	300	170	-	-	1	15	400	170	-	11	25

APPENDIX H (cont): White sucker swimming criteria.

d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$	d	TL	V_s	$V_{f\text{-}pred}$	$V_{f\text{-}95}$	$V_{f\text{-}99}$
20	100	50	25	26	26	20	200	50	30	31	31	20	300	50	34	35	35	20	400	50	38	38	38
20	100	63	**28**	**29**	30	20	200	63	35	36	37	20	300	63	41	42	42	20	400	63	46	46	46
20	100	77	26	29	**30**	20	200	77	**37**	**39**	**39**	20	300	77	**45**	46	47	20	400	77	52	52	53
20	100	90	17	24	26	20	200	90	33	37	38	20	300	90	45	**47**	**48**	20	400	90	**54**	**56**	56
20	100	103	-	13	17	20	200	103	21	30	32	20	300	103	39	44	46	20	400	103	52	56	**57**
20	100	117	-	-	1	20	200	117	-	16	21	20	300	117	24	35	38	20	400	117	44	51	52
20	100	130	-	-	-	20	200	130	-	-	2	20	300	130	-	19	24	20	400	130	26	39	43
20	100	143	-	-	-	20	200	143	-	-	-	20	300	143	-	-	4	20	400	143	-	20	27
20	100	157	-	-	-	20	200	157	-	-	-	20	300	157	-	-	-	20	400	157	-	-	4
20	100	170	-	-	-	20	200	170	-	-	-	20	300	170	-	-	-	20	400	170	-	-	-
30	100	50	13	14	14	30	200	50	20	21	22	30	300	50	27	27	27	30	400	50	32	32	32
30	100	63	10	13	13	30	200	63	**21**	**23**	**23**	30	300	63	**30**	31	31	30	400	63	37	38	38
30	100	77	0	6	7	30	200	77	16	20	21	30	300	77	29	**31**	**32**	30	400	77	**39**	**40**	**41**
30	100	90	-	-	-	30	200	90	4	10	12	30	300	90	22	26	27	30	400	90	36	39	40
30	100	103	-	-	-	30	200	103	-	-	-	30	300	103	6	14	17	30	400	103	27	32	33
30	100	117	-	-	-	30	200	117	-	-	-	30	300	117	-	-	-	30	400	117	7	17	20
30	100	130	-	-	-	30	200	130	-	-	-	30	300	130	-	-	-	30	400	130	-	-	-
30	100	143	-	-	-	30	200	143	-	-	-	30	300	143	-	-	-	30	400	143	-	-	-
30	100	157	-	-	-	30	200	157	-	-	-	30	300	157	-	-	-	30	400	157	-	-	-
30	100	170	-	-	-	30	200	170	-	-	-	30	300	170	-	-	-	30	400	170	-	-	-

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August 14, 2017

Via Email: w.travis.morse@usace.army.mil

Travis Morse
U.S. Army Corps of Engineers
400 Rood Avenue, Room 224
Grand Junction, Colorado 81501

Re: Status of Wines Ditch No. 1 Diversion Rehabilitation as Exempt Under Clean Water Act Section 404(f) – Army Action No. SPK-2017-00507

Dear Travis:

Wright Water Engineers, Inc. (WWE) is sending you this letter on behalf of the Wines Ditch No. 1 (Wines Ditch) Diversion Structure Rehabilitation (Project) proponents. Project proponents include Western Sky Investments, The Nature Conservancy, American Whitewater, Colorado Parks and Wildlife, and the Bureau of Land Management. The purpose of this letter is to articulate WWE's understanding of the Project's status as exempt under Clean Water Act Section 404(f) and confirm that this is consistent with your expectations. Although we have spent time discussing the Project and the Wines Ditch history over the phone and during a May 30, 2017 meeting at your Grand Junction office, we are including a summary of these topics for your information and filing purposes.

WINES DITCH HISTORY

The Wines Ditch diversion structure was constructed in 1900 and consists of a rock weir located on the Dolores River roughly 3.5 miles downstream of the Town of Gateway. The existing diversion structure is decreed to divert 5.81 cubic feet per second (cfs) of water from the Dolores River for application to approximately 111.62 acres of farm land located to the northeast of the river.

PROJECT NEED AND DESCRIPTION

The primary purpose of the Wines Ditch diversion structure is to allow the Ditch to receive 5.81 cfs of Dolores River water. Given the design and construction of the current diversion structure, that purpose is often unfulfilled—the Wines Ditch headgate is regularly inundated with sediment which compromises the diversion rate. Additionally, the diversion structure routinely requires in-stream maintenance to replace material that is washed downstream by high flow events and to remove debris that has accumulated on the upstream side of the structure.

The primary purpose of the Project is to promote the Wines Ditch diversion structure's ability to physically divert the full decreed rate from the Dolores River with minimal ongoing maintenance. All of the diverted water is used to support ongoing and normal farming activities that have been occurring for over 110 years.

During early phases of the Project planning process, ancillary objectives were identified that, if met, would promote aquatic resource function and confer recreational access benefits. These additional objectives and their design considerations include:

1. Invasive Fish Barrier: Currently, the Wines Ditch diversion structure provides benefits to the upstream Dolores River by preventing upriver passage of the invasive white sucker. This barrier is promoting the integrity of populations of native bluehead and flannel mouth suckers, which reside upstream and are susceptible to hybridization with the white sucker. While the existing diversion structure provides this benefit during low- and medium-flow conditions, WWE is working with Project proponents to develop a diversion structure design that will meet this ancillary objective over a range of flow conditions.

2. Recreational Boat Passage: Currently, the Wines Ditch diversion structure presents a difficulty of passage for recreational boaters under certain flow conditions. Consequently, an ancillary objective of the Project is to incorporate safe recreational boating passage through this reach of the Dolores River under the flows most commonly used for boating. WWE is working with the Project proponents to develop a Project design that will promote attainment of this objective over a range of flow conditions.

PROJECT CONFORMANCE TO CLEAN WATER ACT SECTION 404(f) EXEMPT ACTIVITIES

Based on our conversations and understanding of Clean Water Act Section 404(f), the Project will consist of the discharge of fill material into waters of the U.S. but will not require authorization from the U.S. Army Corps of Engineers (USACE) because it qualifies as exempt under Section 404(f). This conclusion is based on the following:

- The Project appears to conform to Section 404(f) part 1 (i.e. exempt activities) in two locations:
    - "b. for the purpose of maintenance…of currently serviceable structures such as...dams…"
    - "c. for the purpose of construction or maintenance of farm or stock ponds or irrigation ditches…"
- Wines Ditch and its associated irrigated land have been in operation for over 100 years and conform to USACE's definitions and explanations for normal farming operations.
- The Project does not pass either of the two tests for the Recapture Provision:
    - The Project does not represent a "new" use of waters of the U.S.

      OR

- The Project does not result in a reduction in reach or impairment of flow of waters of the U.S.

Based on the above, the Project appears to be exempt under Section 404(f) and does not appear to be recaptured under Section 404 regulations.

CONCLUSION

WWE and the Project proponents greatly appreciate your input and guidance to-date. Based on our conversations and understanding of Clean Water Act Section 404, the Project does not appear to require authorization from USACE because it is an exempt activity. If you have any questions regarding this assessment, please do not hesitate to contact me.

Sincerely,

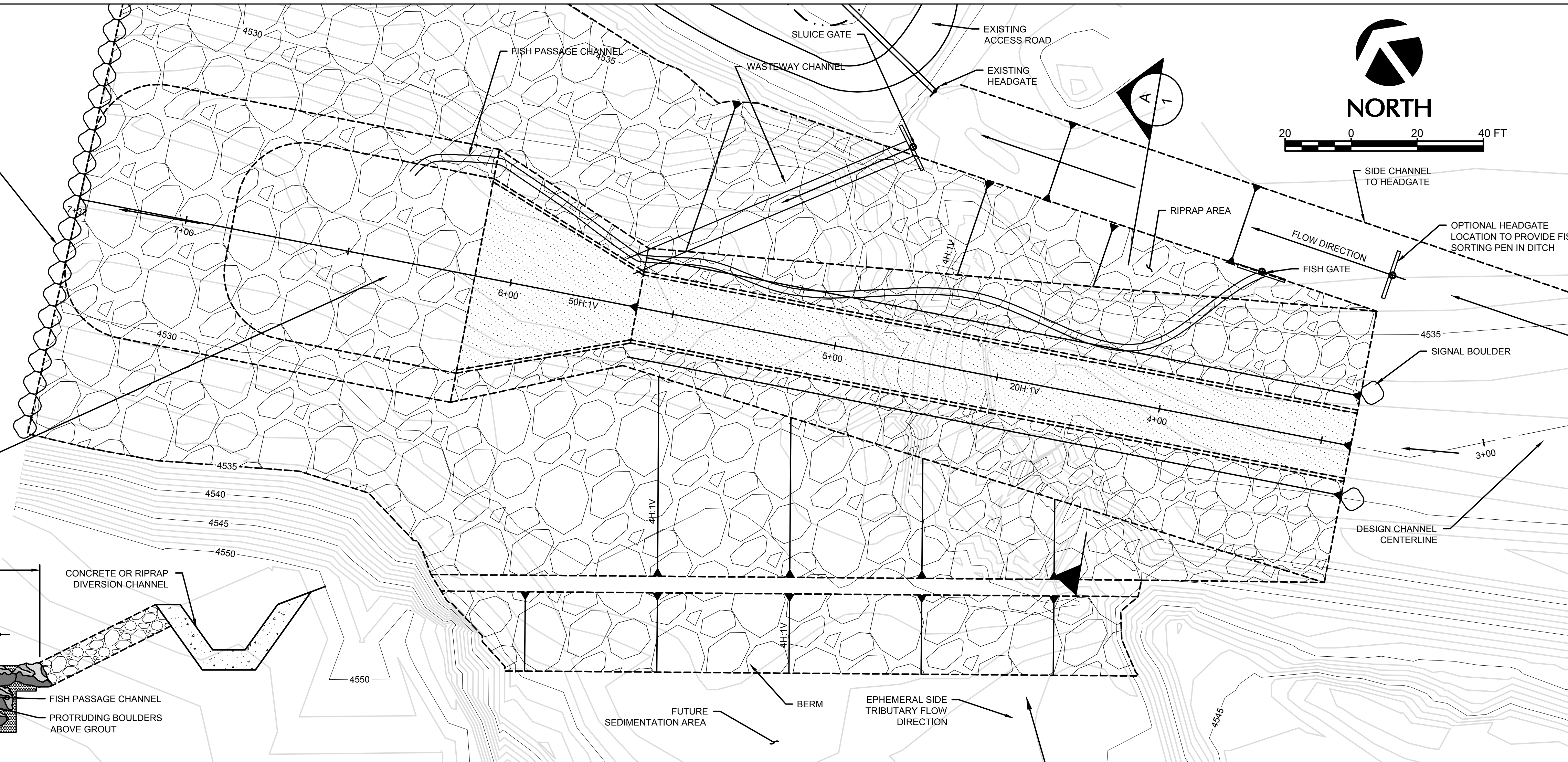
WRIGHT WATER ENGINEERS, INC.

By ______________________________
Peter R. Foster
Vice President

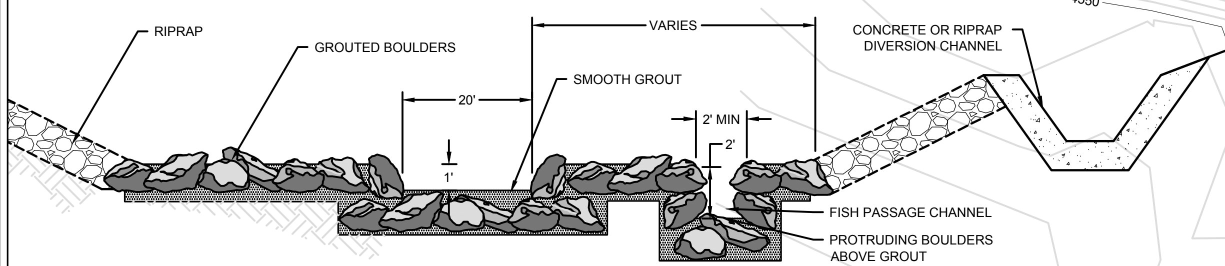
Appendix C

CONCEPTS ONLY
NOT FOR CONSTRUCTION

DRAFT
WORK IN PROGRESS



CHANNEL PLAN - STA 3+00 TO 7+00



A
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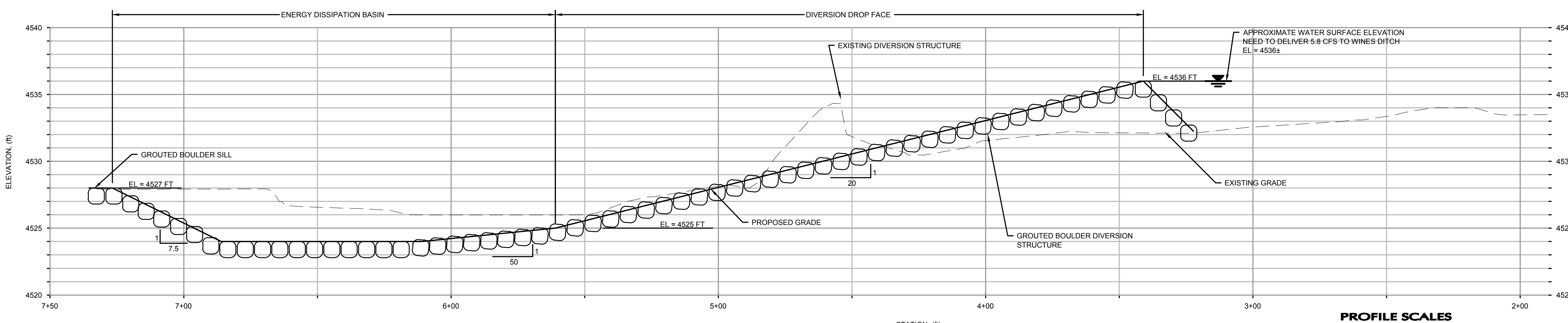
TYPICAL DIVERSION STRUCTURE SECTION
NTS



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CHANNEL PROFILE - STA 3+00 TO 7+00

WWE
WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
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THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

ALTERNATIVE 1 - SINGLE STRUCTURE

JOB NO. 111-030.030
REVISION NO. —
SHEET NO. 01

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CONCEPTS ONLY
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CONSTRUCTION

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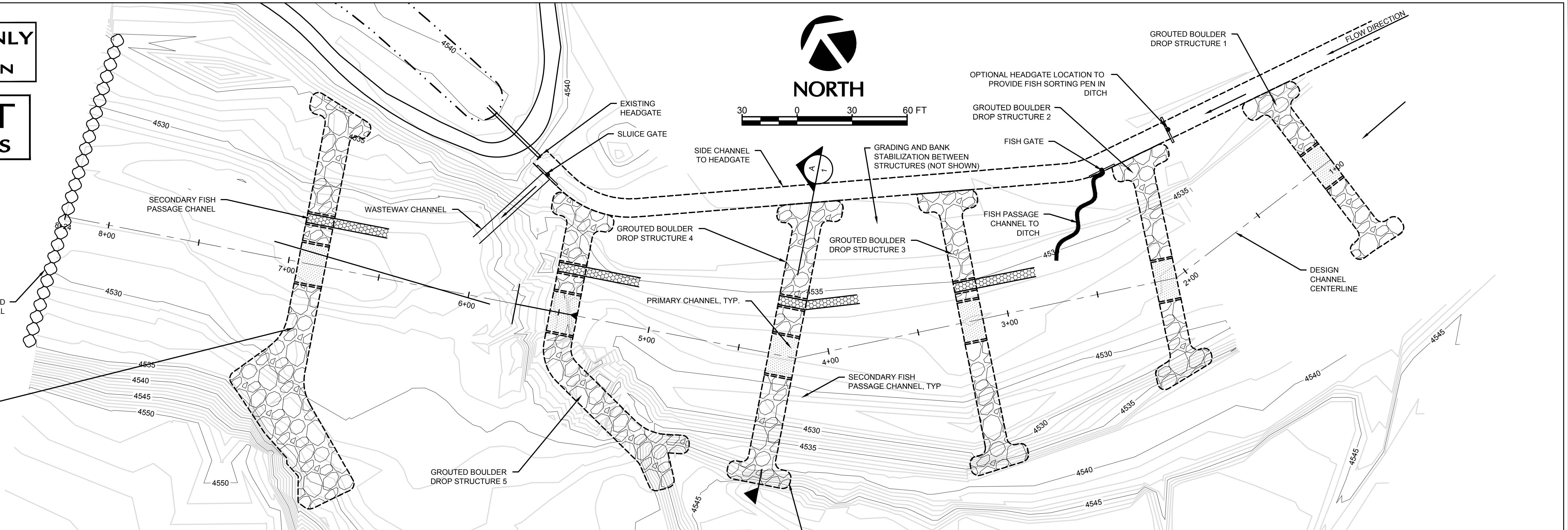
IN PROGRESS



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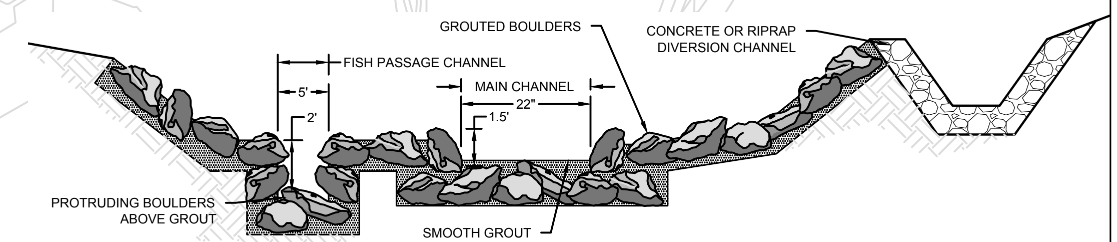

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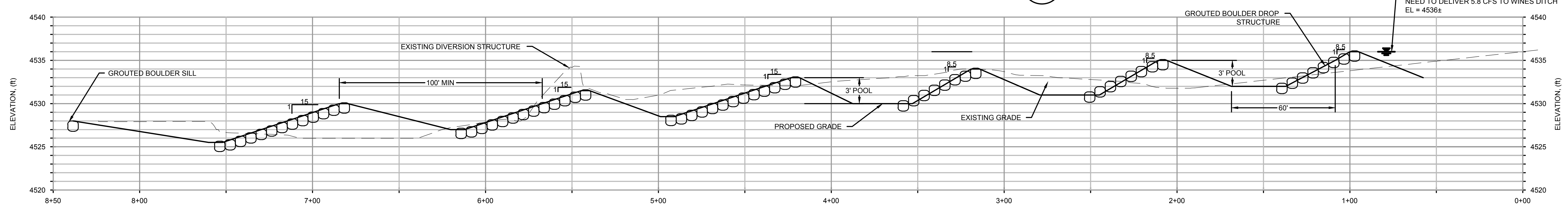

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HORIZONTAL
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VERTICAL

CHANNEL PROFILE - STA 0+00 TO 8+50

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WWE
WRIGHT WATER ENGINEERS, INC.
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DENVER, CO 80211
(303)480-1700 FAX(303)480-1020

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THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

ALTERNATIVE 2 - MULTIPLE STRUCTURES

JOB NO. 111-030.030
REVISION NO. —
SHEET NO. 02

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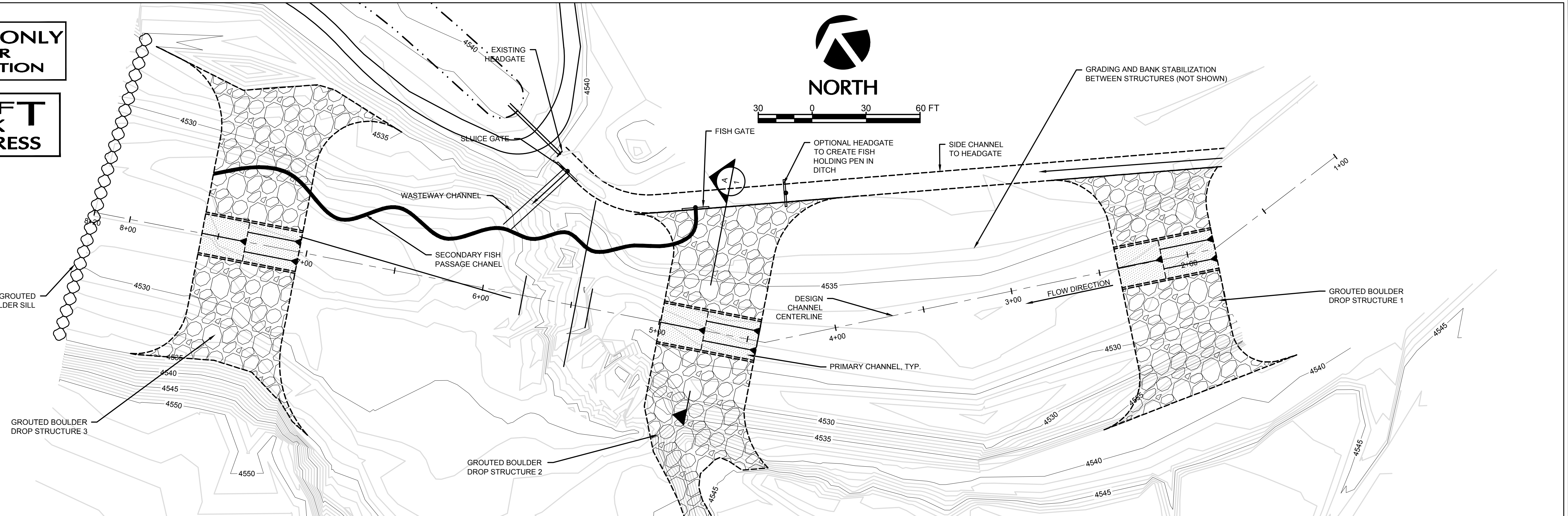

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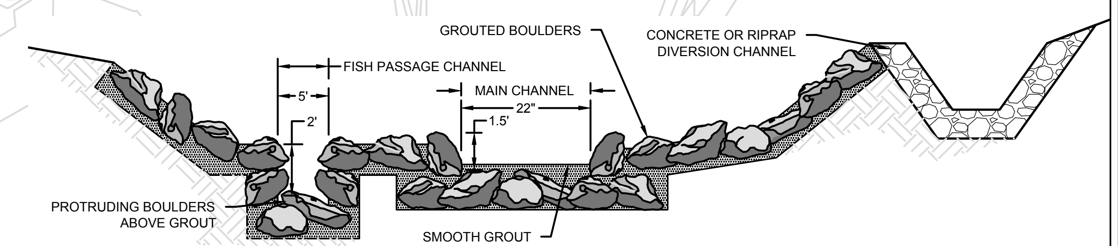

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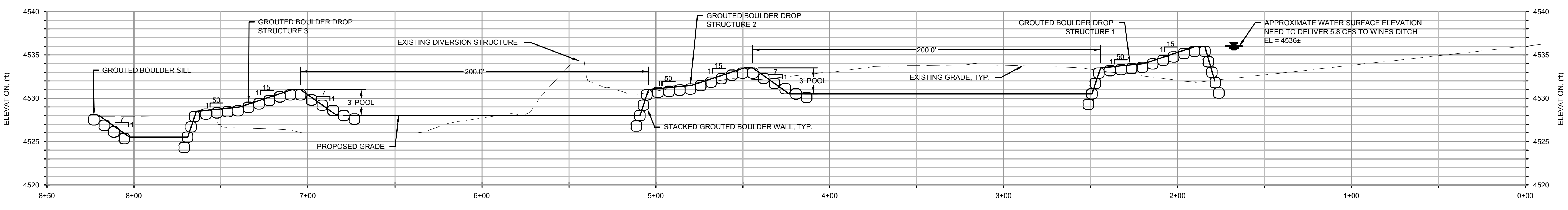

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CHANNEL PROFILE - STA 0+00 TO 8+50

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(303)480-1700 FAX(303)480-1020

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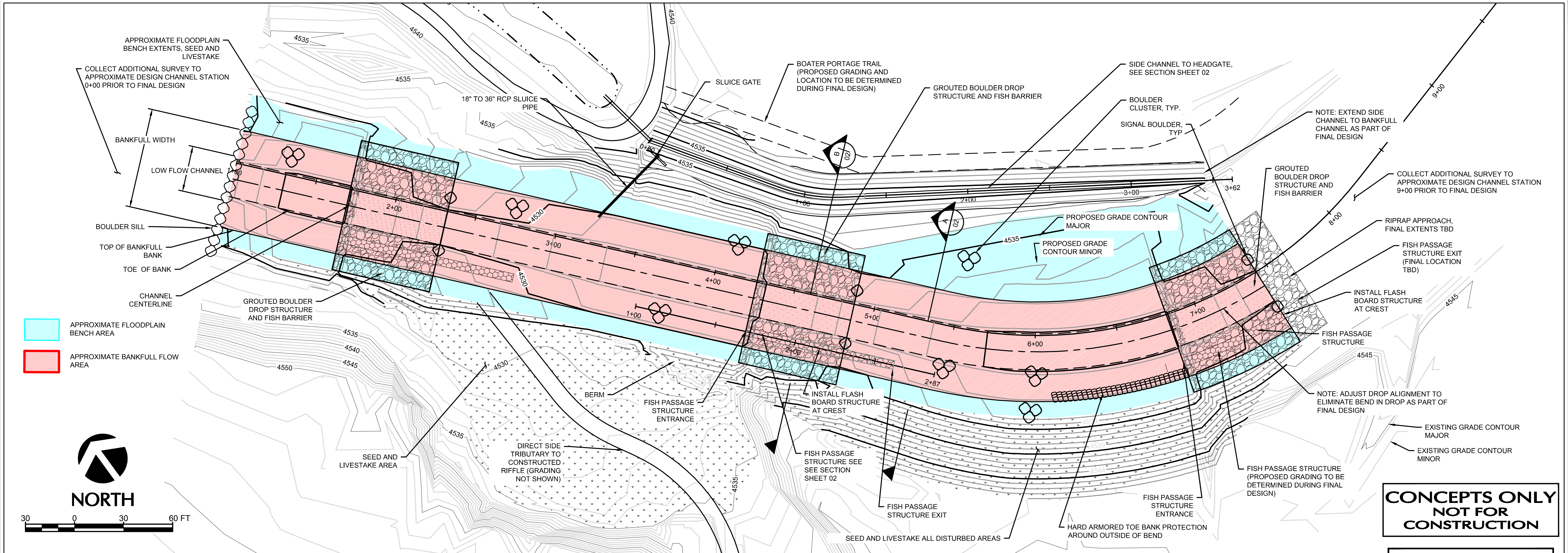
03 Alternative 3 - MULTIPLE STURUCTURES.dwg		

THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

ALTERNATIVE 3 - MULTIPLE STRUCTURES

JOB NO. 111-030.030
REVISION NO. —
SHEET NO. 03

Appendix D



CONCEPTS ONLY
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CONSTRUCTION

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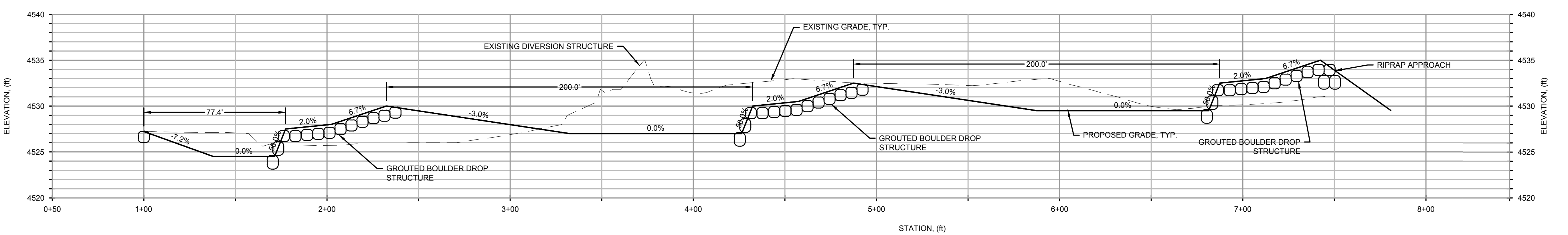
CHANNEL PLAN - STA 1+00 TO 9+00



PROFILE SCALES

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CHANNEL PROFILE - STA 0+00 TO 8+50

WWE WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
(303)480-1700 FAX(303)480-1020

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THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

PREFERRED ALTERNATIVE OPTION 1

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REVISION NO. —

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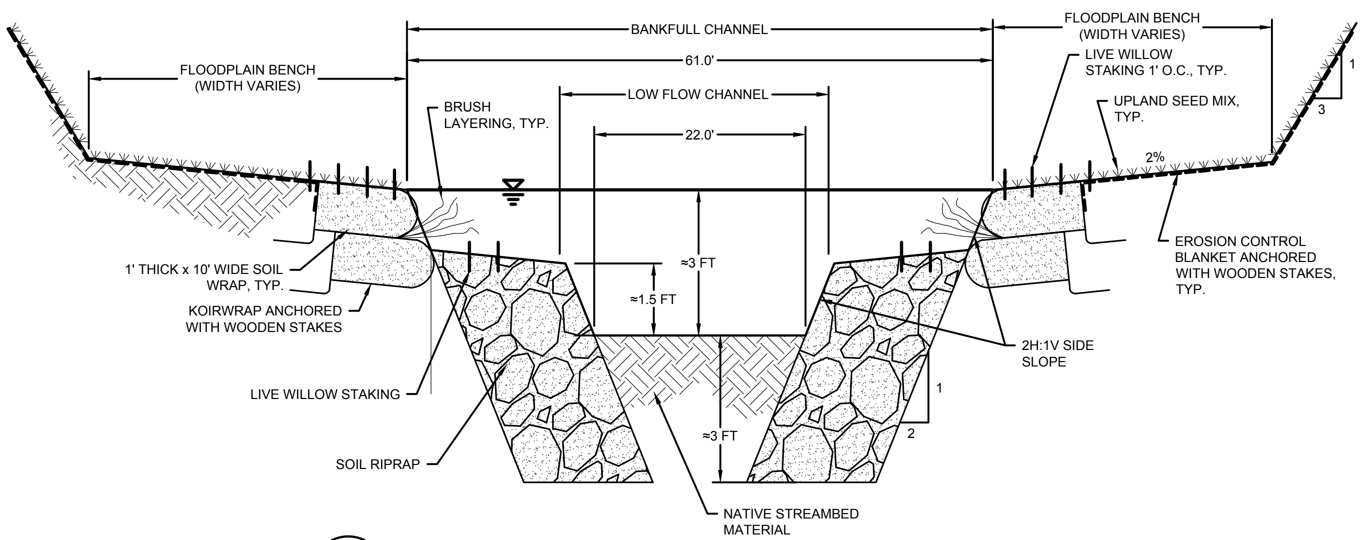

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TYPICAL CHANNEL CROSS SECTION

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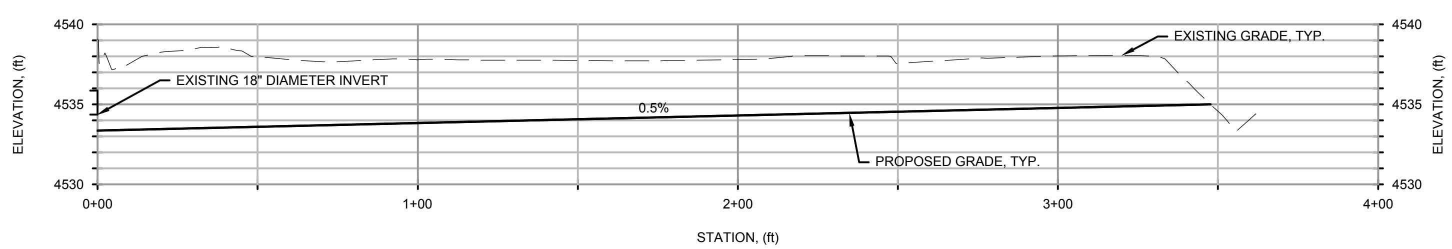

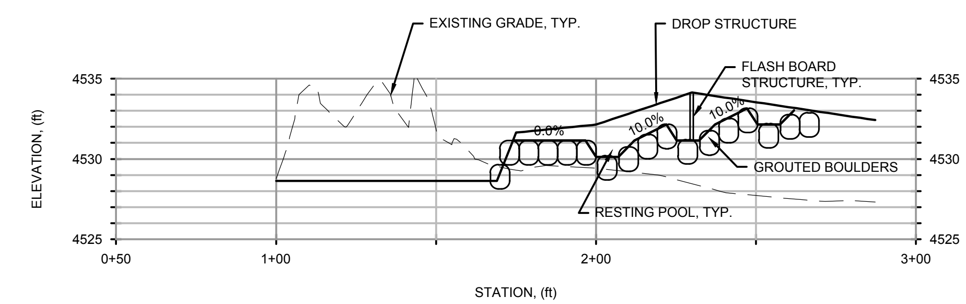

SIDE CHANNEL TO HEADGATE PROFILE - STA 1+00 TO 4+00

FISH PASSAGE PROFILE

PROFILE SCALES

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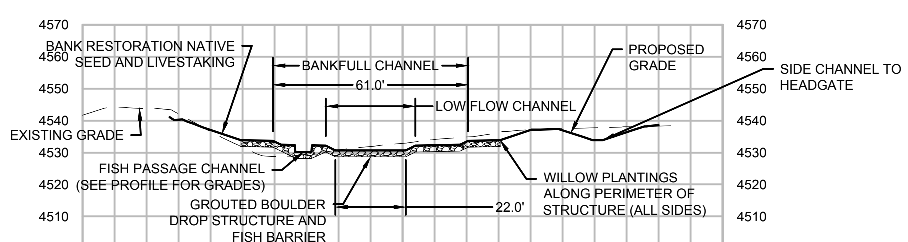
VERTICAL



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DROP STRUCTURE SECTION

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SECTION SCALES

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VERTICAL

CONCEPTS ONLY
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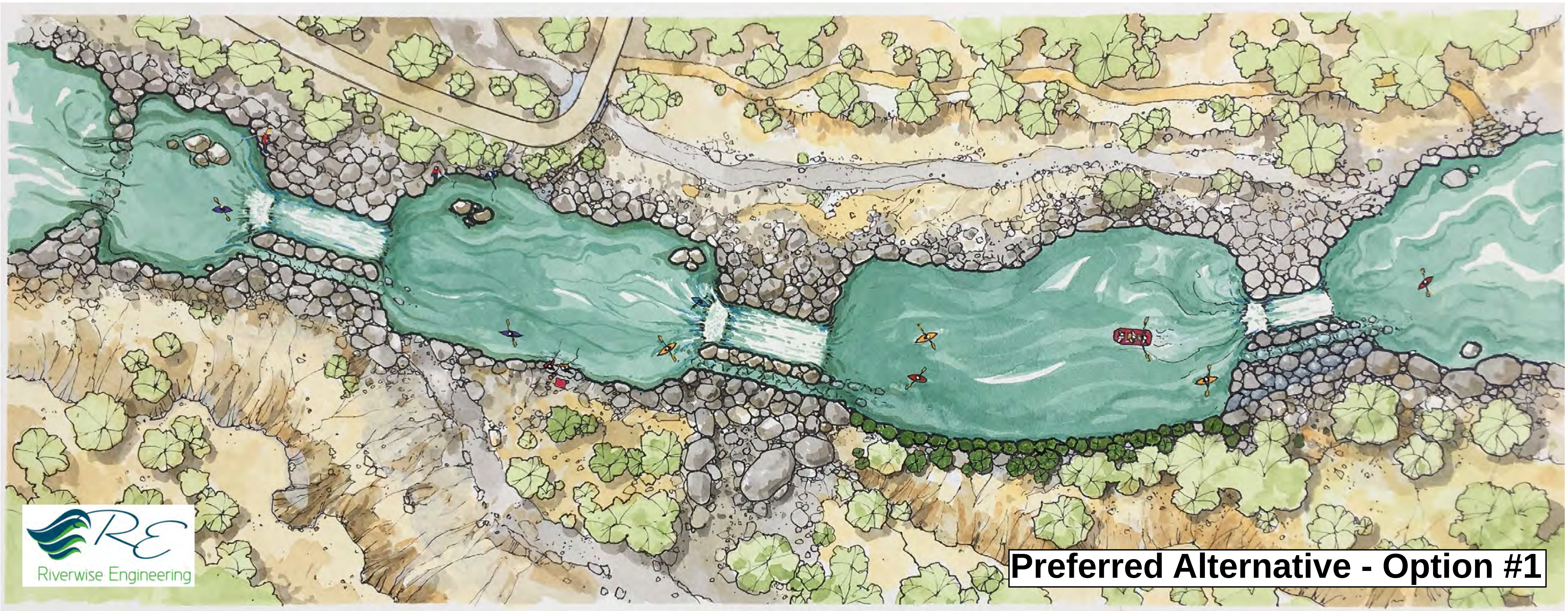
THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

PREFERRED ALTERNATIVE OPTION 1 - SECTIONS AND PROFILES

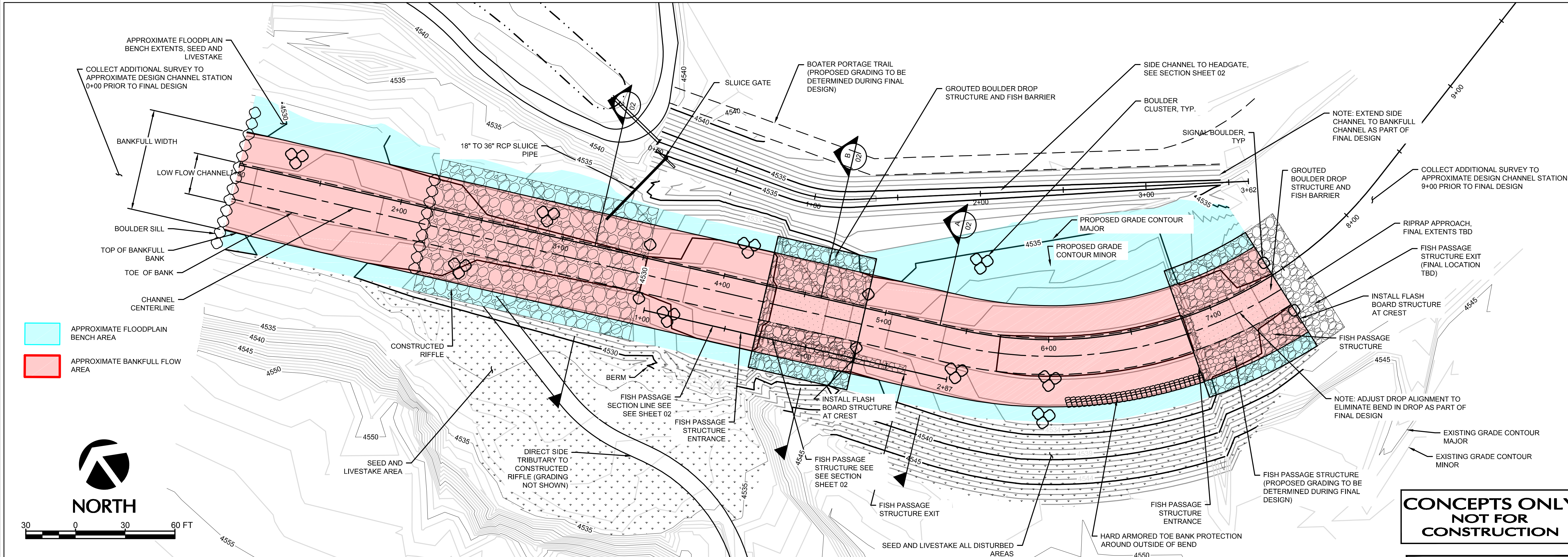
JOB NO. 111-030.030

REVISION NO. —

SHEET NO. 02



Riverwise Engineering
Preferred Alternative - Option #1



CONCEPTS ONLY
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DRAFT WORK IN PROGRESS

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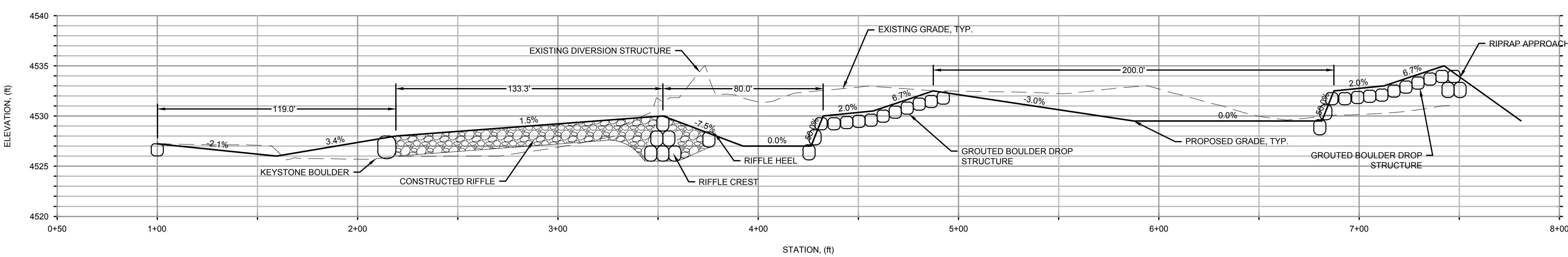

CHANNEL PROFILE - STA 0+00 TO 8+50

PROFILE SCALES

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HORIZONTAL

6 0 6 12 FT
VERTICAL

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WRIGHT WATER ENGINEERS, INC.
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DENVER, CO 80211
(303)480-1700 FAX(303)480-1020

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THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

PREFERRED ALTERNATIVE OPTION 2

JOB NO. 111-030.030
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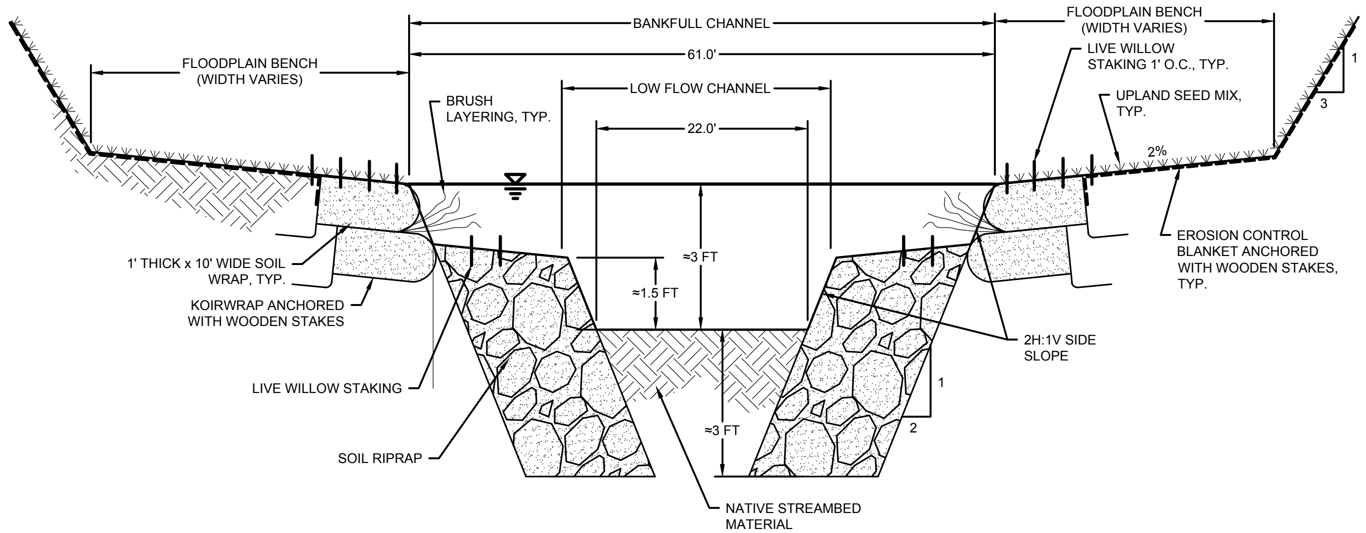

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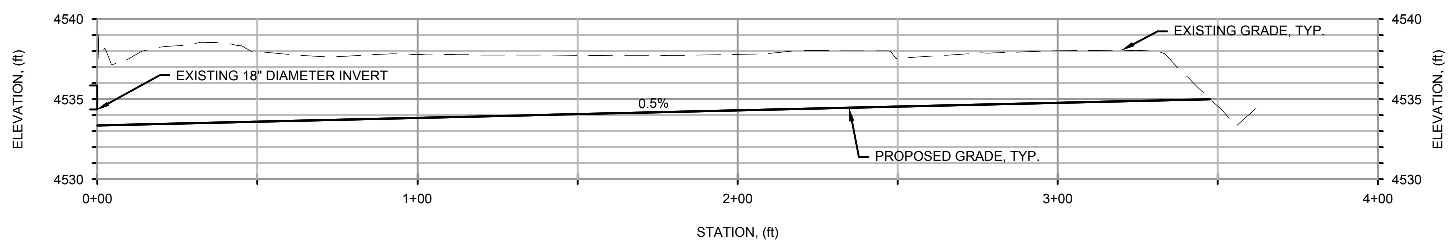
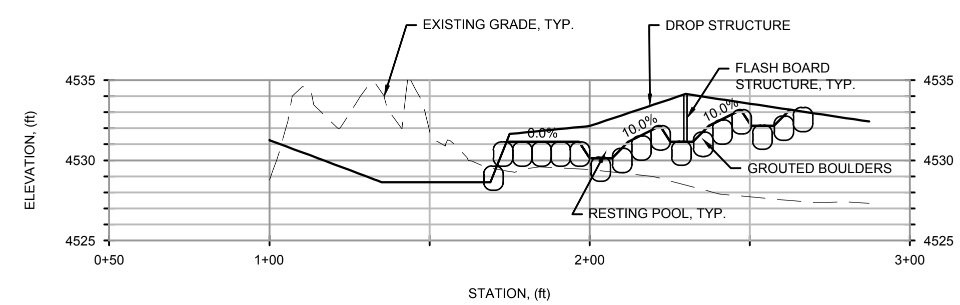


SIDE CHANNEL TO HEADGATE PROFILE - STA 0+00 TO 4+00



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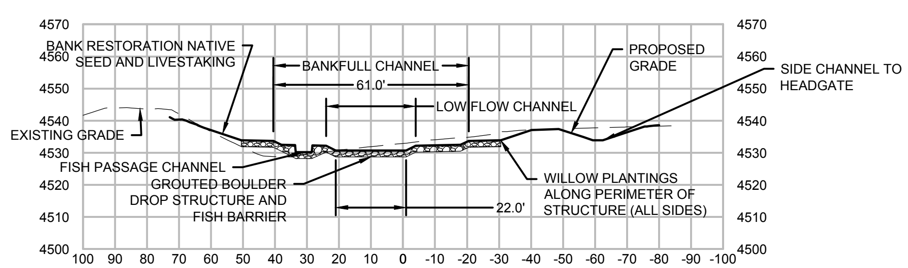

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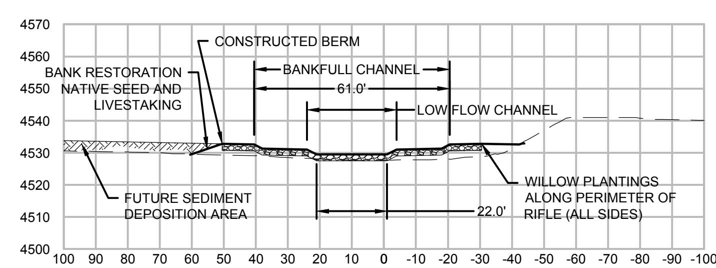

C
02
CONSTRUCTED RIFFLE SECTION
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SECTION SCALES

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HORIZONTAL

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VERTICAL

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WORK
IN PROGRESS**

WWE
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DENVER, CO 80211
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THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

PREFERRED ALTERNATIVE OPTION 2 - SECTIONS AND PROFILES

JOB NO. 111-030.030
REVISION NO. —
SHEET NO. 02

Riverwise Engineering
Preferred Alternative - Option #2

Appendix E

MEMORANDUM

To: Wines Ditch No.1 Rehabilitation Project
File #111-030.030

From: Hayes Lenhart, P.E. Wright Water Engineers, Inc. and
Shane Sigel, P.E. Riverwise Engineering, LLC

Date: July 20, 2017 – Finalized August, 2017

Re: Wines Ditch No. 1 Diversion Rehabilitation Project – Existing Conditions HEC-RAS Model Development and Calibration

Wright Water Engineers, Inc. (WWE) and Riverwise Engineering, LLC (Riverwise) prepared this technical memorandum to document the development of a calibrated existing conditions Hydraulic Engineering Center – River Analysis System (HEC-RAS) model for the Wines Ditch No. 1 Diversion Rehabilitation Project (the Project).

1.0 EXISTING CONDITIONS HEC-RAS MODEL DEVELOPMENT

In an effort to better inform the hydraulic design of future conceptual design approaches for the Project, a calibrated existing conditions Hydraulic Engineering Center – River Analysis System (HEC-RAS) model was developed using survey data collected in March of 2017 by Rolland Consulting Engineers, LLC. (2017 Rolland Survey), and level logger data collected by the Bureau of Land Management (BLM).

Two level loggers were installed by the BLM on March 22, 2017; one logger was installed downstream of the existing diversion structure (LL1) and the other logger was installed immediately upstream of the existing diversion structure (LL2). Each level logger location was surveyed and incorporated into the 2017 site survey data. Level logger data were collected from late March through early June in an attempt to monitor the rising and falling limb of streamflow in the Dolores River during spring runoff. Water surface elevation data collected by each logger was correlated to the streamflow data reported from USGS gage 01980000 - Dolores River near Cisco, UT (Cisco Gage) located approximately 17 miles downstream of the Wines Ditch No. 1 diversion structure. Attached Figure 1 provides a graphical depiction of the existing conditions HEC-RAS model cross-section locations, level logger locations, and selected water surface profiles.

Please note that during the level logger data quality control evaluation, it was found that the logger upstream of the diversion was malfunctioning and the data could not be used (LL2). Therefore, only the data collected downstream of the gage was used for model calibration. Additionally, the data collected at the downstream level logger (LL1) was found to be accurate for streamflow ranging between 900 cfs and 2500 cfs only.

Table 1 provides a summary of the calibrated existing conditions model under a low-flow condition of 220 cfs. A flow of 220 cfs was used for low-flow calibration of the model because this was the streamflow reported at the Cisco Gage during the day of the 2017 Rolland Survey. Using the surveyed edge of water line, a water surface elevation was estimated at each cross section for calibration purposes.

The primary calibration factor for the existing conditions model was selecting an appropriate manning's "n" value for the river at each channel cross-section. Table 2 provides a summary of the calibrated manning's "n" values for each channel cross-section.

1.1 HEC-RAS Boundary Conditions

As recommended in the Project Basis of Design Report (WWE, 2017) the Project requires maintained function and performance under a range of flow conditions from 100 to 5000 cfs. In order to estimate HEC-RAS model boundary conditions under this range of flow conditions for use with the conceptual design alternatives evaluation, the following process was implemented:

- Level logger data collected at the downstream cross-section were used to correlate a known water surface elevation to a specific streamflow. Known downstream water surface elevations were applicable for a range of 220 cfs to 2500 cfs.

- For modeling flows greater than 2500 cfs and less than 220 cfs, a normal depth slope calculation was used for the boundary condition. In order to estimate the downstream normal depth slope, iterations of normal depth slope were input into the downstream cross-section and the modeled downstream water surface elevation was compared to known water elevations for flows ranging between 220 and 2500 cfs. The normal depth slope was adjusted to minimize the amount of error observed when comparing the modeled downstream water surface elevation to known water surface elevations. Based on the results of this analysis, a normal depth slope of 0.0045 was calculated for use as a downstream boundary condition for flows outside the range of 220 cfs to 2500 cfs.

Table 3 provides a summary of the boundary conditions developed for the existing conditions model. These boundary conditions will be used to assess the hydraulic performance of conceptual design approaches developed for the Project.

2.0 REFERENCES

WWE, 2017. Basis of Design Report Wines Ditch No. 1 Diversion Structure Rehabilitation Gateway, Colorado. Prepared for The Nature Conservancy. August 2017. Wright Water Engineers, Inc. 1666 N. Main Avenue Suite C. Durango, CO 81301.

Attachment(s)/Enclosure(s)

Table 1. **Wines Ditch Existing Conditions HEC-RAS Model Calibration Summary for 220 cfs**

Table 2. **Wines Ditch Existing Conditions HEC-RAS Model – Calibrated Manning's "n" Values**

Table 3. **Wines Ditch Existing Conditions HEC-RAS Model – Calibrated Boundary Conditions**

Figure 1. **Existing Water Surface Profiles**

P:\111-030 Nature Conservancy\030 Wines Ditch\Alternatives Analysis Report\Appendix F - HEC-RAS Memorandum\Wines Ditch - HEC-RAS Calibration Summary.docx

Table 1
Wines Ditch Existing Conditions HEC-RAS Model Calibration Summary for 220 cfs

Cross-Section Number	HEC-RAS Cross-Section	Water Surface Elevation		Difference	Notes / Comments
		Modeled	Recorded		
		(ft)	(ft)	(ft)	
EC-9	1200.58	4535.11	4535.10	0.01	Upstream Cross-Section
EC-8	842.65	4535.04	4533.50	1.54	Water surface calibration in this area varies due to the hig irregularity associated with the existing rock diversion structure.
EC-7	837.97	4534.69	4533.50	1.19	
EC-6	795.29	4529.88	4530.11	-0.23	
EC-5	774.21	4529.83	4530.19	-0.36	
EC-4	733.94	4529.78	4530.00	-0.22	
EC-3	717.34	4529.77	4529.80	-0.03	
EC-2	692.84	4529.75	4529.70	0.05	
EC-1	573.94	4529.6	4529.60	0.00	Downstream Cross-Section

Table 2

Wines Ditch Existing Conditions HEC-RAS Model - Calibrated Manning's "n" Values

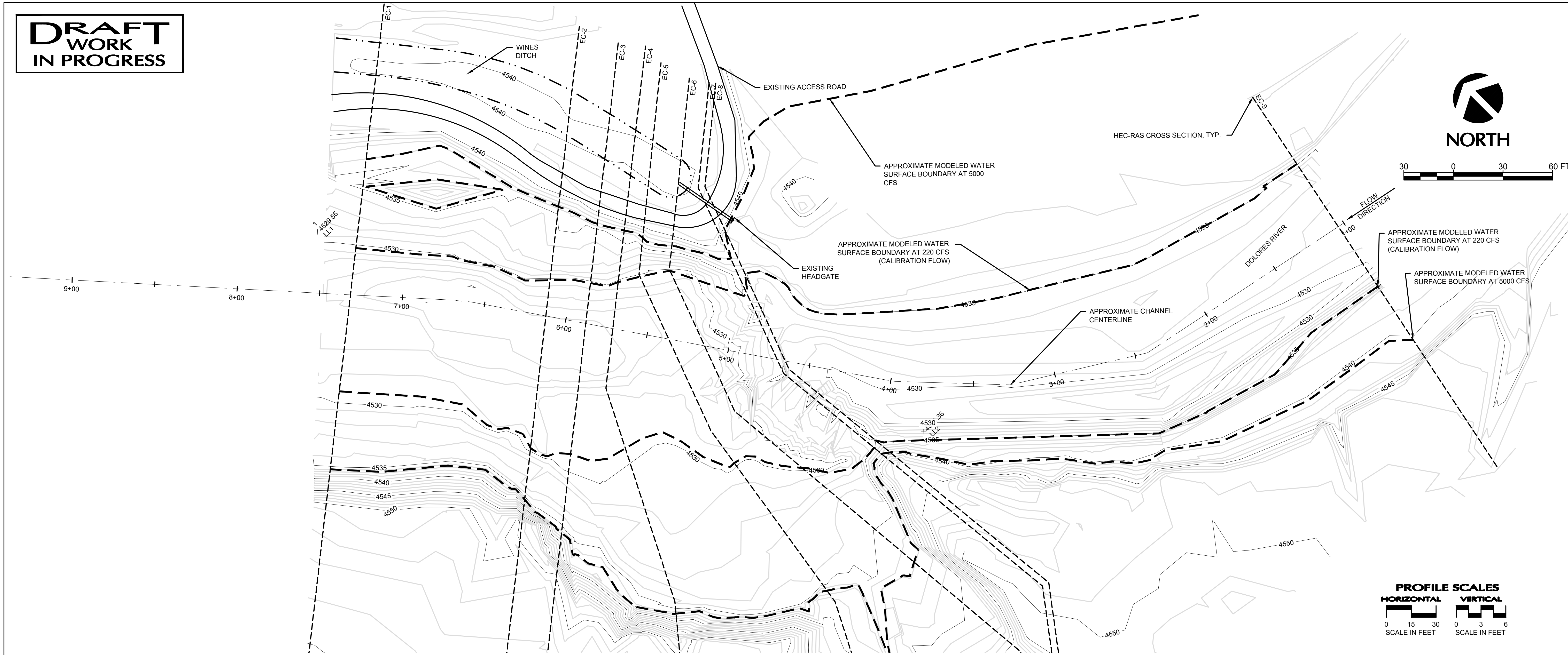
Cross-Section Number	HEC-RAS Cross Section	Manning's "n" Main Channel	Manning's "n" Left Overbank	Manning's "n" Right Overbank	Notes / Comments
EC-9	1200.58	0.03	0.1	0.1	The streambed in the area upstream of the diversion structure is comprised of a silty/sand material. This value is considered representative of these conditions.
EC-8	842.65	0.07	0.1	0.1	The streambed in this area includes the exsitng diversion structure and the channel area downstream of the diversion. Throught the years of the diversion's reconstruction, rock has mobilized downstream of the diversion resulting in a greater manning's n-value downstream.
EC-7	837.97	0.07	0.1	0.1	
EC-6	795.29	0.07	0.1	0.1	
EC-5	774.21	0.07	0.075	0.1	
EC-4	733.94	0.07	0.075	0.1	
EC-3	717.34	0.07	0.075	0.1	
EC-2	692.84	0.07	0.075	0.1	
EC-1	573.94	0.07	0.075	0.1	

Table 3

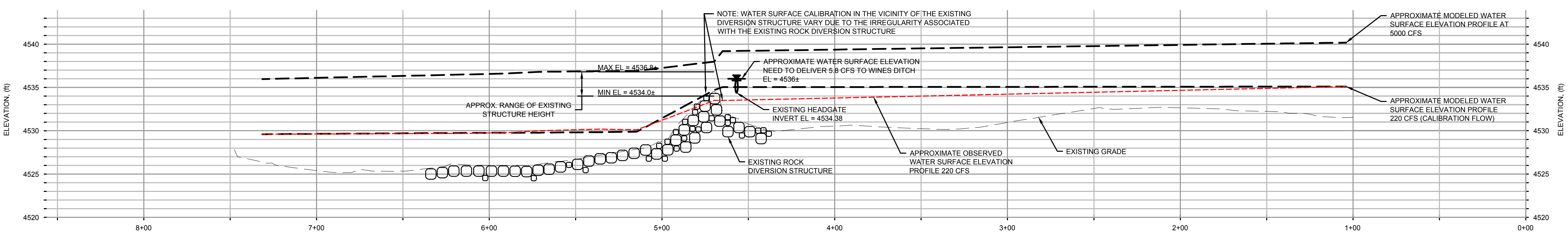
Wines Ditch Existing Conditions HEC-RAS Model - Calibrated Boundary Conditions

Design Flow (cfs)	Downstream Boundary Condition (HEC-RAS Model Cross Section EC-1`	Notes / Comments
100	Normal Depth Slope = 0.0045	Calculated normal depth slope to minimize error between known water surface elevations and modeled water surface elevations
220	Known Water Surface Elevation = 4529.60	Known water surface elevations are based on level logger data collected near existing conditions HEC-RAS Model Cross Section EC-1.
1000	Known Water Surface Elevation = 4531.28	
1500	Known Water Surface Elevation = 4531.68	
1600	Known Water Surface Elevation = 4531.80	
2000	Known Water Surface Elevation = 4532.53	
2500	Known Water Surface Elevation = 4532.88	
3000	Normal Depth Slope = 0.0045	Calculated normal depth slope to minimize error between known water surface elevations and modeled water surface elevations.
3500	Normal Depth Slope = 0.0045	
4000	Normal Depth Slope = 0.0045	
5000	Normal Depth Slope = 0.0045	

DRAFT
WORK
IN PROGRESS



CHANNEL PLAN - STA 1+00 TO 7+50



CHANNEL PROFILE - STA 1+00 TO 7+50

WWE
WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
(303)480-1700 FAX(303)480-1020

NO.	BY	DATE	DESCRIPTION	COMMENTS
1	-	-	-	-
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		DATE
DESIGN	HAL	MM/DD/YY
DETAIL	HAL	MM/DD/YY
CHECK	PRF	MM/DD/YY
APPROVAL		
SCALE	SHOWN	
1 WATER SURFACE PROFILES.dwg		

THE NATURE CONSERVANCY WINES DITCH REHABILITATION PROJECT

EXISTING WATER SURFACE PROFILES

JOB NO. 111-030.030
REVISION NO. —
SHEET NO. 1

Plot Date/Time: 07/24/2017, 03:08:18 PM; P:\111-030 NATURE CONSERVANCY\030 WINES DITCH\CAD\01_CAD\B_WWE-DWGS\1 WATER SURFACE PROFILES.DWG-1 WATER SURFACE PROFILES

Appendix F

HEC-RAS Plan: WINES_PC_OP1 River: DOLORES Reach: DESIGN-CENTERLIN

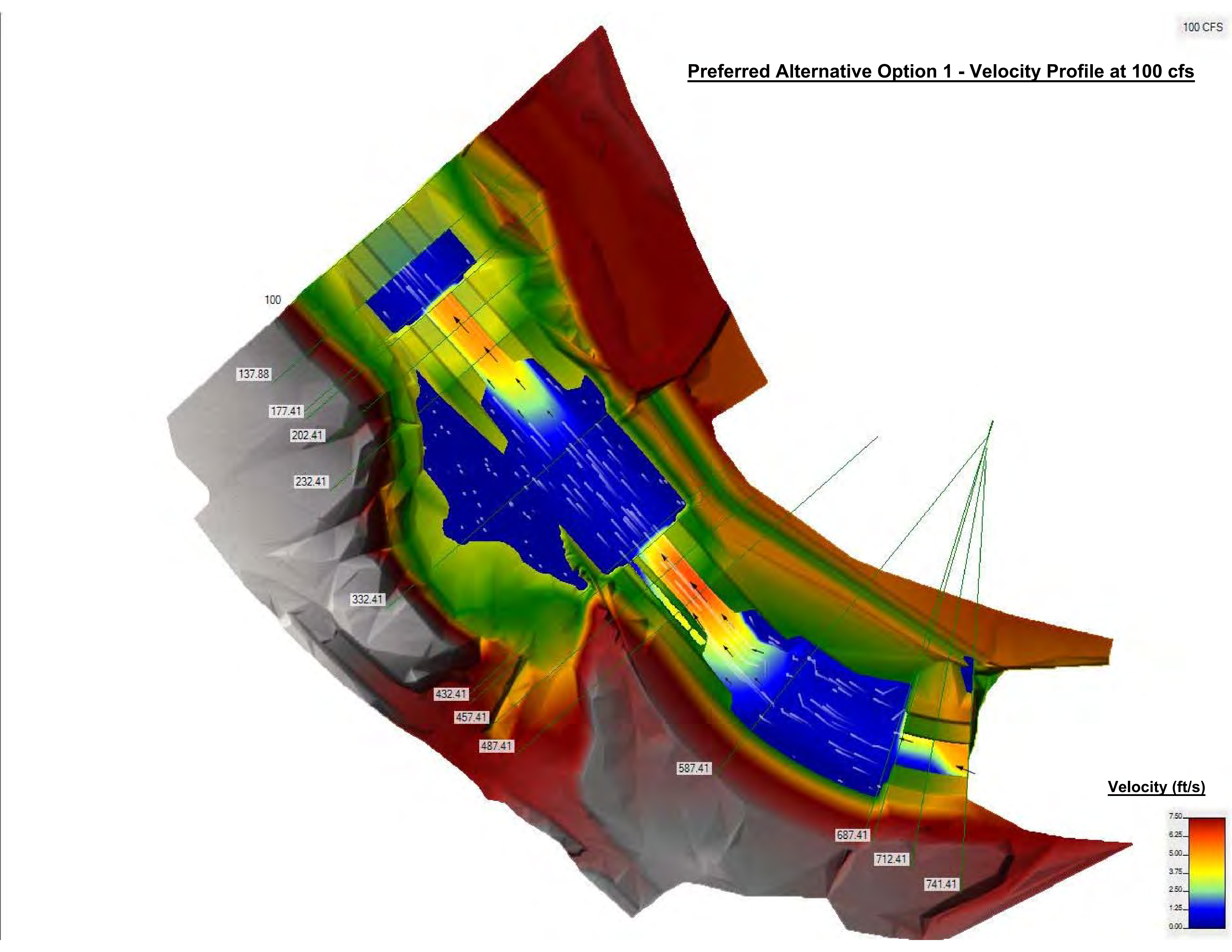
Preferred Alternative Option 1 - Proposed Conditions HEC-RAS Model Output

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DESIGN-CENTERLIN	741.41	100 CFS	100.00	4534.93	4535.78	4535.78	4536.17	0.002652	4.97	20.12	52.64	0.98
DESIGN-CENTERLIN	741.41	220 CFS	220.00	4534.93	4536.34	4536.34	4536.96	0.002362	6.32	34.79	59.90	0.99
DESIGN-CENTERLIN	741.41	500 CFS	500.00	4534.93	4537.21	4537.21	4537.86	0.002179	6.46	77.37	98.19	0.99
DESIGN-CENTERLIN	741.41	1000 CFS	1000.00	4534.93	4537.99	4537.99	4539.00	0.002834	8.08	123.78	110.55	1.00
DESIGN-CENTERLIN	741.41	1500 CFS	1500.00	4534.93	4538.21	4538.21	4539.44	0.003690	9.51	268.91	131.63	1.12
DESIGN-CENTERLIN	741.41	1600 CFS	1600.00	4534.93	4538.22	4538.22	4539.61	0.004142	10.09	270.52	132.18	1.18
DESIGN-CENTERLIN	741.41	2000 CFS	2000.00	4534.93	4538.22	4538.22	4540.38	0.006472	12.62	270.52	132.18	1.48
DESIGN-CENTERLIN	741.41	2500 CFS	2500.00	4534.93	4538.22	4538.22	4541.60	0.010112	15.77	270.52	132.18	1.85
DESIGN-CENTERLIN	741.41	3000 CFS	3000.00	4534.93	4539.76	4539.76	4541.43	0.003346	11.13	526.99	202.34	1.01
DESIGN-CENTERLIN	741.41	3500 CFS	3500.00	4534.93	4540.20	4540.20	4541.96	0.003233	11.52	620.58	225.84	0.99
DESIGN-CENTERLIN	741.41	4000 CFS	4000.00	4534.93	4540.59	4540.59	4542.45	0.003175	11.91	712.08	245.82	0.98
DESIGN-CENTERLIN	741.41	4500 CFS	4500.00	4534.93	4540.95	4540.95	4542.90	0.003120	12.27	805.55	265.28	0.97
DESIGN-CENTERLIN	712.41	100 CFS	100.00	4533.00	4533.85	4533.85	4534.23	0.002629	4.96	20.17	25.40	0.98
DESIGN-CENTERLIN	712.41	220 CFS	220.00	4533.00	4534.41	4534.41	4535.02	0.002328	6.29	34.96	27.63	0.99
DESIGN-CENTERLIN	712.41	500 CFS	500.00	4533.00	4535.26	4535.26	4535.92	0.002216	6.51	76.76	63.86	1.00
DESIGN-CENTERLIN	712.41	1000 CFS	1000.00	4533.00	4536.05	4536.05	4537.07	0.002854	8.10	123.40	73.67	1.00
DESIGN-CENTERLIN	712.41	1500 CFS	1500.00	4533.00	4536.77	4536.77	4537.96	0.002763	8.82	210.00	136.59	0.94
DESIGN-CENTERLIN	712.41	1600 CFS	1600.00	4533.00	4536.89	4536.89	4538.12	0.002758	8.96	226.93	137.37	0.93
DESIGN-CENTERLIN	712.41	2000 CFS	2000.00	4533.00	4537.41	4537.31	4538.71	0.002604	9.32	298.33	140.62	0.89
DESIGN-CENTERLIN	712.41	2500 CFS	2500.00	4533.00	4538.19	4537.81	4539.42	0.002111	9.22	409.68	145.53	0.80
DESIGN-CENTERLIN	712.41	3000 CFS	3000.00	4533.00	4538.60	4538.24	4540.04	0.002266	10.00	471.72	160.13	0.82
DESIGN-CENTERLIN	712.41	3500 CFS	3500.00	4533.00	4539.11	4538.56	4540.65	0.002188	10.38	560.74	183.19	0.81
DESIGN-CENTERLIN	712.41	4000 CFS	4000.00	4533.00	4539.68	4539.01	4541.24	0.002018	10.52	671.53	208.35	0.78
DESIGN-CENTERLIN	712.41	4500 CFS	4500.00	4533.00	4540.21	4539.38	4541.79	0.001886	10.67	787.70	231.83	0.76
DESIGN-CENTERLIN	687.41	100 CFS	100.00	4532.50	4533.33	4533.33	4533.73	0.002826	5.07	19.71	25.33	1.01
DESIGN-CENTERLIN	687.41	220 CFS	220.00	4532.50	4533.89	4533.89	4534.52	0.002414	6.37	34.54	27.57	1.00
DESIGN-CENTERLIN	687.41	500 CFS	500.00	4532.50	4534.84	4534.76	4535.43	0.001947	6.15	81.30	61.83	0.92
DESIGN-CENTERLIN	687.41	1000 CFS	1000.00	4532.50	4535.98	4535.56	4536.67	0.001701	6.65	158.18	100.20	0.75
DESIGN-CENTERLIN	687.41	1500 CFS	1500.00	4532.50	4536.88	4536.24	4537.67	0.001573	7.22	251.23	134.89	0.69
DESIGN-CENTERLIN	687.41	1600 CFS	1600.00	4532.50	4537.04	4536.36	4537.85	0.001554	7.32	270.69	140.47	0.69
DESIGN-CENTERLIN	687.41	2000 CFS	2000.00	4532.50	4537.68	4536.83	4538.52	0.001397	7.50	390.72	154.74	0.65
DESIGN-CENTERLIN	687.41	2500 CFS	2500.00	4532.50	4538.39	4537.35	4539.28	0.001312	7.85	501.34	164.60	0.63
DESIGN-CENTERLIN	687.41	3000 CFS	3000.00	4532.50	4538.83	4537.82	4539.88	0.001429	8.56	578.00	184.27	0.66
DESIGN-CENTERLIN	687.41	3500 CFS	3500.00	4532.50	4539.35	4538.22	4540.49	0.001424	8.98	680.38	207.65	0.66
DESIGN-CENTERLIN	687.41	4000 CFS	4000.00	4532.50	4539.90	4538.50	4541.09	0.001367	9.24	801.53	232.30	0.64
DESIGN-CENTERLIN	687.41	4500 CFS	4500.00	4532.50	4540.41	4538.93	4541.65	0.001321	9.47	926.39	255.22	0.64
DESIGN-CENTERLIN	681.41	100 CFS	100.00	4529.50	4533.40	4530.34	4533.40	0.000033	0.56	193.43	89.08	0.06
DESIGN-CENTERLIN	681.41	220 CFS	220.00	4529.50	4534.14	4530.90	4534.16	0.000071	0.97	262.88	98.05	0.09
DESIGN-CENTERLIN	681.41	500 CFS	500.00	4529.50	4535.22	4531.75	4535.26	0.000147	1.66	375.72	117.13	0.14
DESIGN-CENTERLIN	681.41	1000 CFS	1000.00	4529.50	4536.39	4532.56	4536.49	0.000269	2.60	514.01	138.56	0.19
DESIGN-CENTERLIN	681.41	1500 CFS	1500.00	4529.50	4537.32	4533.25	4537.48	0.000358	3.31	635.60	155.58	0.22
DESIGN-CENTERLIN	681.41	1600 CFS	1600.00	4529.50	4537.49	4533.34	4537.65	0.000368	3.42	690.70	158.57	0.23
DESIGN-CENTERLIN	681.41	2000 CFS	2000.00	4529.50	4538.12	4533.77	4538.32	0.000417	3.85	791.39	162.39	0.25
DESIGN-CENTERLIN	681.41	2500 CFS	2500.00	4529.50	4538.82	4534.31	4539.08	0.000478	4.37	914.12	189.72	0.27
DESIGN-CENTERLIN	681.41	3000 CFS	3000.00	4529.50	4539.33	4534.78	4539.66	0.000556	4.91	1015.66	212.51	0.29
DESIGN-CENTERLIN	681.41	3500 CFS	3500.00	4529.50	4539.87	4535.21	4540.26	0.000605	5.33	1138.63	237.19	0.31
DESIGN-CENTERLIN	681.41	4000 CFS	4000.00	4529.50	4540.43	4535.57	4540.86	0.000635	5.68	1276.75	262.16	0.32
DESIGN-CENTERLIN	681.41	4500 CFS	4500.00	4529.50	4540.94	4536.00	4541.41	0.000655	5.96	1416.60	276.08	0.33
DESIGN-CENTERLIN	587.41	100 CFS	100.00	4529.50	4533.40	4530.34	4533.40	0.000033	0.56	191.83	85.02	0.06
DESIGN-CENTERLIN	587.41	220 CFS	220.00	4529.50	4534.13	4530.90	4534.15	0.000072	0.98	257.11	93.37	0.09
DESIGN-CENTERLIN	587.41	500 CFS	500.00	4529.50	4535.21	4531.75	4535.25	0.000151	1.68	365.43	116.37	0.14
DESIGN-CENTERLIN	587.41	1000 CFS	1000.00	4529.50	4536.36	4532.56	4536.46	0.000277	2.64	500.95	140.06	0.19
DESIGN-CENTERLIN	587.41	1500 CFS	1500.00	4529.50	4537.28	4533.25	4537.44	0.000370	3.36	622.36	158.87	0.23
DESIGN-CENTERLIN	587.41	1600 CFS	1600.00	4529.50	4537.44	4533.36	4537.62	0.000386	3.49	645.33	162.23	0.23
DESIGN-CENTERLIN	587.41	2000 CFS	2000.00	4529.50	4538.07	4533.79	4538.28	0.000430	3.89	785.34	169.16	0.25
DESIGN-CENTERLIN	587.41	2500 CFS	2500.00	4529.50	4538.77	4534.29	4539.04	0.000490	4.41	914.33	199.81	0.27
DESIGN-CENTERLIN	587.41	3000 CFS	3000.00	4529.50	4539.27	4534.76	4539.60	0.000568	4.94	1019.28	221.64	0.29
DESIGN-CENTERLIN	587.41	3500 CFS	3500.00	4529.50	4539.81	4535.22	4540.20	0.000616	5.36	1146.45	245.50	0.31
DESIGN-CENTERLIN	587.41	4000 CFS	4000.00	4529.50	4540.36	4535.59	4540.80	0.000644	5.69	1288.58	269.69	0.32
DESIGN-CENTERLIN	587.41	4500 CFS	4500.00	4529.50	4540.88	4536.03	4541.35	0.000661	5.97	1431.73	280.98	0.33
DESIGN-CENTERLIN	487.41	100 CFS	100.00	4531.14	4532.96	4532.96	4533.35	0.009231	5.03	19.89	29.19	1.07
DESIGN-CENTERLIN	487.41	220 CFS	220.00	4531.14	4533.50	4533.50	4534.07	0.005197	6.07	36.23	31.46	1.00
DESIGN-CENTERLIN	487.41	500 CFS	500.00	4531.14	4534.49	4534.49	4535.15	0.003043	6.49	77.02	62.76	0.98
DESIGN-CENTERLIN	487.41	1000 CFS	1000.00	4531.14	4535.30	4535.30	4536.31	0.003477	8.03	124.47	71.04	0.98
DESIGN-CENTERLIN	487.41	1500 CFS	1500.00	4531.14	4535.97	4535.97	4537.25	0.003561	9.08	172.05	99.97	0.97
DESIGN-CENTERLIN	487.41	1600 CFS	1600.00	4531.14	4536.10	4536.10	4537.42	0.003530	9.23	183.22	102.92	0.97
DESIGN-CENTERLIN	487.41	2000 CFS	2000.00	4531.14	4536.55	4536.55	4538.06	0.003538	9.90	224.25	113.19	0.96
DESIGN-CENTERLIN	487.41	2500 CFS	2500.00	4531.14	4537.05	4537.05	4538.79	0.003555	10.64	274.16	124.69	0.96
DESIGN-CENTERLIN	487.41	3000 CFS	3000.00	4531.14	4537.57	4537.57	4539.34	0.003274	10.91	381.22	139.60	0.93
DESIGN-CENTERLIN	487.41	3500 CFS	3500.00	4531.14	4537.98	4537.98	4539.92	0.003311	11.51	438.08	142.68	0.93
DESIGN-CENTERLIN	487.41	4000 CFS	4000.00	4531.14	4538.20	4538.20	4540.48	0.003710	12.49	470.16	146.30	0.99
DESIGN-CENTERLIN	487.41	4500 CFS	4500.00	4531.14	4538.69	4538.69	4541.03	0.003462	12.70	546.79	168.79	0.96
DESIGN-CENTERLIN	457.41	100 CFS	100.00	4530.14	4531.17	4531.17	4531.53	0.004677	4.78	20.92	29.89	1.01
DESIGN-CENTERLIN	457.41	220 CFS	220.00	4530.14	4531.83	4531.68	4532.27	0.002431	5.30	41.54	32.66	0.83

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DESIGN-CENTERLIN	457.41	500 CFS	500.00	4530.14	4532.60	4532.57	4533.24	0.002667	6.44	77.68	57.27	0.97
DESIGN-CENTERLIN	457.41	1000 CFS	1000.00	4530.14	4533.62	4533.40	4534.43	0.002440	7.24	138.49	69.73	0.85
DESIGN-CENTERLIN	457.41	1500 CFS	1500.00	4530.14	4534.33	4534.05	4535.37	0.002526	8.22	196.44	90.29	0.84
DESIGN-CENTERLIN	457.41	1600 CFS	1600.00	4530.14	4534.45	4534.18	4535.54	0.002552	8.41	206.82	91.77	0.84
DESIGN-CENTERLIN	457.41	2000 CFS	2000.00	4530.14	4534.90	4534.62	4536.18	0.002652	9.13	245.95	97.26	0.85
DESIGN-CENTERLIN	457.41	2500 CFS	2500.00	4530.14	4535.35	4535.13	4536.90	0.002867	10.07	286.58	102.78	0.89
DESIGN-CENTERLIN	457.41	3000 CFS	3000.00	4530.14	4535.74	4535.61	4537.57	0.003112	10.98	321.71	107.42	0.92
DESIGN-CENTERLIN	457.41	3500 CFS	3500.00	4530.14	4536.07	4536.06	4538.21	0.003373	11.87	352.84	123.02	0.96
DESIGN-CENTERLIN	457.41	4000 CFS	4000.00	4530.14	4536.42	4536.42	4538.81	0.003509	12.58	386.72	135.97	0.99
DESIGN-CENTERLIN	457.41	4500 CFS	4500.00	4530.14	4536.86	4536.86	4539.39	0.003397	12.96	430.60	151.01	0.97
DESIGN-CENTERLIN	432.41	100 CFS	100.00	4530.00	4531.14	4530.84	4531.34	0.000988	3.61	27.73	31.57	0.68
DESIGN-CENTERLIN	432.41	220 CFS	220.00	4530.00	4531.97	4531.43	4532.16	0.000717	3.53	62.24	56.74	0.60
DESIGN-CENTERLIN	432.41	500 CFS	500.00	4530.00	4532.78	4532.23	4533.10	0.000987	4.55	109.98	60.01	0.59
DESIGN-CENTERLIN	432.41	1000 CFS	1000.00	4530.00	4533.77	4533.03	4534.30	0.001237	5.85	183.74	92.41	0.62
DESIGN-CENTERLIN	432.41	1500 CFS	1500.00	4530.00	4534.50	4533.69	4535.23	0.001410	6.89	247.09	122.37	0.65
DESIGN-CENTERLIN	432.41	1600 CFS	1600.00	4530.00	4534.63	4533.80	4535.40	0.001445	7.09	258.23	145.48	0.65
DESIGN-CENTERLIN	432.41	2000 CFS	2000.00	4530.00	4535.09	4534.24	4536.03	0.001580	7.84	300.86	175.69	0.68
DESIGN-CENTERLIN	432.41	2500 CFS	2500.00	4530.00	4535.58	4534.74	4536.73	0.001737	8.69	350.36	189.18	0.71
DESIGN-CENTERLIN	432.41	3000 CFS	3000.00	4530.00	4536.01	4535.25	4537.37	0.001889	9.49	394.51	198.95	0.75
DESIGN-CENTERLIN	432.41	3500 CFS	3500.00	4530.00	4536.40	4535.71	4537.97	0.002031	10.22	435.08	205.27	0.77
DESIGN-CENTERLIN	432.41	4000 CFS	4000.00	4530.00	4537.05	4536.12	4538.41	0.001649	9.79	703.21	213.27	0.70
DESIGN-CENTERLIN	432.41	4500 CFS	4500.00	4530.00	4537.52	4536.53	4538.89	0.001583	9.99	845.84	220.63	0.69
DESIGN-CENTERLIN	426.41	100 CFS	100.00	4527.00	4531.28	4527.84	4531.28	0.000021	0.50	223.33	84.71	0.05
DESIGN-CENTERLIN	426.41	220 CFS	220.00	4527.00	4532.09	4528.40	4532.10	0.000048	0.86	293.90	94.49	0.08
DESIGN-CENTERLIN	426.41	500 CFS	500.00	4527.00	4532.98	4529.25	4533.02	0.000125	1.59	374.71	109.88	0.13
DESIGN-CENTERLIN	426.41	1000 CFS	1000.00	4527.00	4534.07	4530.06	4534.17	0.000252	2.57	479.93	130.60	0.18
DESIGN-CENTERLIN	426.41	1500 CFS	1500.00	4527.00	4534.89	4530.74	4535.06	0.000364	3.37	563.78	183.67	0.23
DESIGN-CENTERLIN	426.41	1600 CFS	1600.00	4527.00	4535.04	4530.86	4535.22	0.000385	3.51	578.74	188.36	0.23
DESIGN-CENTERLIN	426.41	2000 CFS	2000.00	4527.00	4535.57	4531.25	4535.81	0.000465	4.05	635.28	198.88	0.26
DESIGN-CENTERLIN	426.41	2500 CFS	2500.00	4527.00	4536.18	4531.77	4536.46	0.000516	4.50	878.04	207.64	0.28
DESIGN-CENTERLIN	426.41	3000 CFS	3000.00	4527.00	4536.72	4532.25	4537.06	0.000581	4.97	980.49	213.26	0.30
DESIGN-CENTERLIN	426.41	3500 CFS	3500.00	4527.00	4537.21	4532.67	4537.61	0.000637	5.41	1076.34	218.12	0.31
DESIGN-CENTERLIN	426.41	4000 CFS	4000.00	4527.00	4537.69	4533.08	4538.13	0.000677	5.76	1227.50	222.08	0.33
DESIGN-CENTERLIN	426.41	4500 CFS	4500.00	4527.00	4538.13	4533.49	4538.62	0.000717	6.11	1326.26	225.26	0.34
DESIGN-CENTERLIN	332.41	100 CFS	100.00	4527.00	4531.28		4531.28	0.000020	0.48	284.31	157.28	0.05
DESIGN-CENTERLIN	332.41	220 CFS	220.00	4527.00	4532.09		4532.10	0.000041	0.80	423.15	183.01	0.07
DESIGN-CENTERLIN	332.41	500 CFS	500.00	4527.00	4532.98		4533.00	0.000100	1.42	592.41	196.45	0.11
DESIGN-CENTERLIN	332.41	1000 CFS	1000.00	4527.00	4534.07		4534.14	0.000184	2.20	813.41	205.57	0.16
DESIGN-CENTERLIN	332.41	1500 CFS	1500.00	4527.00	4534.91		4535.01	0.000250	2.80	987.90	210.06	0.19
DESIGN-CENTERLIN	332.41	1600 CFS	1600.00	4527.00	4535.06		4535.16	0.000263	2.91	1018.82	210.70	0.19
DESIGN-CENTERLIN	332.41	2000 CFS	2000.00	4527.00	4535.61		4535.75	0.000307	3.30	1136.16	213.11	0.21
DESIGN-CENTERLIN	332.41	2500 CFS	2500.00	4527.00	4536.22		4536.39	0.000357	3.75	1266.29	215.73	0.23
DESIGN-CENTERLIN	332.41	3000 CFS	3000.00	4527.00	4536.77		4536.97	0.000403	4.16	1384.92	218.13	0.25
DESIGN-CENTERLIN	332.41	3500 CFS	3500.00	4527.00	4537.27		4537.51	0.000443	4.53	1495.95	220.39	0.26
DESIGN-CENTERLIN	332.41	4000 CFS	4000.00	4527.00	4537.75		4538.02	0.000479	4.87	1601.60	222.54	0.28
DESIGN-CENTERLIN	332.41	4500 CFS	4500.00	4527.00	4538.20		4538.51	0.000512	5.19	1702.02	224.56	0.29
DESIGN-CENTERLIN	232.41	100 CFS	100.00	4530.00	4530.84	4530.84	4531.23	0.002749	5.03	19.89	25.36	1.00
DESIGN-CENTERLIN	232.41	220 CFS	220.00	4530.00	4531.39	4531.39	4532.02	0.002426	6.38	34.49	27.57	1.01
DESIGN-CENTERLIN	232.41	500 CFS	500.00	4530.00	4532.26	4532.26	4532.91	0.002219	6.51	83.29	81.15	1.00
DESIGN-CENTERLIN	232.41	1000 CFS	1000.00	4530.00	4533.05	4533.05	4534.00	0.002702	7.89	158.78	109.91	0.98
DESIGN-CENTERLIN	232.41	1500 CFS	1500.00	4530.00	4533.69	4533.69	4534.84	0.002830	8.82	243.46	145.51	0.95
DESIGN-CENTERLIN	232.41	1600 CFS	1600.00	4530.00	4533.80	4533.80	4534.99	0.002840	8.98	260.27	148.83	0.95
DESIGN-CENTERLIN	232.41	2000 CFS	2000.00	4530.00	4534.21	4534.21	4535.55	0.002920	9.62	323.83	165.45	0.95
DESIGN-CENTERLIN	232.41	2500 CFS	2500.00	4530.00	4534.69	4534.69	4536.18	0.002930	10.24	406.38	176.45	0.94
DESIGN-CENTERLIN	232.41	3000 CFS	3000.00	4530.00	4535.11	4535.11	4536.74	0.002947	10.80	482.15	179.31	0.94
DESIGN-CENTERLIN	232.41	3500 CFS	3500.00	4530.00	4535.49	4535.49	4537.27	0.002997	11.37	549.83	181.13	0.95
DESIGN-CENTERLIN	232.41	4000 CFS	4000.00	4530.00	4535.82	4535.82	4537.76	0.003079	11.94	610.30	182.55	0.96
DESIGN-CENTERLIN	232.41	4500 CFS	4500.00	4530.00	4536.15	4536.15	4538.23	0.003112	12.42	671.13	183.82	0.97
DESIGN-CENTERLIN	202.41	100 CFS	100.00	4528.00	4528.84	4528.84	4529.23	0.002787	5.05	19.80	25.35	1.01
DESIGN-CENTERLIN	202.41	220 CFS	220.00	4528.00	4529.39	4529.39	4530.02	0.002449	6.40	34.38	27.55	1.01
DESIGN-CENTERLIN	202.41	500 CFS	500.00	4528.00	4530.69		4531.06	0.001146	4.91	101.85	59.64	0.66
DESIGN-CENTERLIN	202.41	1000 CFS	1000.00	4528.00	4531.14	4531.04	4532.07	0.002555	7.76	129.38	72.95	0.94
DESIGN-CENTERLIN	202.41	1500 CFS	1500.00	4528.00	4531.73	4531.73	4532.98	0.002929	9.03	188.82	112.90	0.97
DESIGN-CENTERLIN	202.41	1600 CFS	1600.00	4528.00	4531.84	4531.84	4533.15	0.002953	9.21	201.99	114.69	0.97
DESIGN-CENTERLIN	202.41	2000 CFS	2000.00	4528.00	4532.49	4532.29	4533.77	0.002488	9.21	279.67	125.16	0.87
DESIGN-CENTERLIN	202.41	2500 CFS	2500.00	4528.00	4532.88	4532.78	4534.45	0.002810	10.26	329.08	131.99	0.92
DESIGN-CENTERLIN	202.41	3000 CFS	3000.00	4528.00	4533.24	4533.24	4535.08	0.003052	11.15	377.92	138.36	0.96
DESIGN-CENTERLIN	202.41	3500 CFS	3500.00	4528.00	4533.67	4533.67	4535.67	0.003041	11.68	439.28	145.97	0.96
DESIGN-CENTERLIN	202.41	4000 CFS	4000.00	4528.00	4534.09	4534.09	4536.22	0.002997	12.11	502.41	153.30	0.95
DESIGN-CENTERLIN	202.41	4500 CFS	4500.00	4528.00	4534.43	4534.43	4536.74	0.003058	12.65	555.22	157.08	0.96
DESIGN-CENTERLIN	177.41	100 CFS	100.00	4527.50	4528.34	4528.34	4528.73	0.002804	5.06	19.76	25.34	1.01
DESIGN-CENTERLIN	177.41	220 CFS	220.00	4527.50	4529.61	4528.90	4529.77	0.000559	3.23	68.01	57.32	0.52
DESIGN-CENTERLIN	177.41	500 CFS	500.00	4527.50	4530.79	4529.75	4530.99	0.000530	3.61	141.65	86.05	0.42
DESIGN-CENTERLIN	177.41	1000 CFS	1000.00	4527.50	4531.41	4530.56	4531.90	0.001079	5.62	205.73	111.20	0.58

HEC-RAS Plan: WINES_PC_OP1 River: DOLORES Reach: DESIGN-CENTERLIN (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DESIGN-CENTERLIN	177.41	1500 CFS	1500.00	4527.50	4531.94	4531.26	4532.69	0.001471	7.03	266.02	115.98	0.67
DESIGN-CENTERLIN	177.41	1600 CFS	1600.00	4527.50	4532.07	4531.36	4532.86	0.001492	7.20	281.35	117.75	0.67
DESIGN-CENTERLIN	177.41	2000 CFS	2000.00	4527.50	4532.77	4531.82	4533.59	0.001342	7.42	367.66	130.35	0.64
DESIGN-CENTERLIN	177.41	2500 CFS	2500.00	4527.50	4533.21	4532.31	4534.23	0.001529	8.32	426.77	136.81	0.68
DESIGN-CENTERLIN	177.41	3000 CFS	3000.00	4527.50	4533.46	4532.79	4534.76	0.001864	9.42	461.22	140.34	0.75
DESIGN-CENTERLIN	177.41	3500 CFS	3500.00	4527.50	4533.94	4533.19	4535.37	0.001876	9.92	530.17	146.89	0.75
DESIGN-CENTERLIN	177.41	4000 CFS	4000.00	4527.50	4534.38	4533.62	4535.93	0.001889	10.37	596.14	150.67	0.76
DESIGN-CENTERLIN	177.41	4500 CFS	4500.00	4527.50	4534.78	4533.96	4536.45	0.001918	10.83	656.85	153.71	0.76
DESIGN-CENTERLIN	171.41	100 CFS	100.00	4524.50	4528.50	4525.34	4528.51	0.000029	0.54	201.93	87.46	0.06
DESIGN-CENTERLIN	171.41	220 CFS	220.00	4524.50	4529.72	4525.90	4529.73	0.000043	0.83	313.75	96.93	0.07
DESIGN-CENTERLIN	171.41	500 CFS	500.00	4524.50	4530.91	4526.75	4530.94	0.000092	1.44	434.45	104.82	0.11
DESIGN-CENTERLIN	171.41	1000 CFS	1000.00	4524.50	4531.69	4527.56	4531.78	0.000231	2.49	518.14	111.34	0.18
DESIGN-CENTERLIN	171.41	1500 CFS	1500.00	4524.50	4532.35	4528.25	4532.51	0.000365	3.36	594.57	120.91	0.23
DESIGN-CENTERLIN	171.41	1600 CFS	1600.00	4524.50	4532.49	4528.34	4532.67	0.000386	3.50	612.38	123.85	0.23
DESIGN-CENTERLIN	171.41	2000 CFS	2000.00	4524.50	4533.18	4528.80	4533.40	0.000434	3.95	701.69	135.91	0.25
DESIGN-CENTERLIN	171.41	2500 CFS	2500.00	4524.50	4533.71	4529.30	4534.01	0.000534	4.58	775.47	142.84	0.28
DESIGN-CENTERLIN	171.41	3000 CFS	3000.00	4524.50	4534.09	4529.77	4534.48	0.000652	5.22	831.27	147.70	0.31
DESIGN-CENTERLIN	171.41	3500 CFS	3500.00	4524.50	4534.61	4530.19	4535.07	0.000715	5.69	909.10	151.56	0.33
DESIGN-CENTERLIN	171.41	4000 CFS	4000.00	4524.50	4535.09	4530.60	4535.61	0.000774	6.12	982.39	154.59	0.35
DESIGN-CENTERLIN	171.41	4500 CFS	4500.00	4524.50	4535.53	4530.95	4536.12	0.000829	6.53	1050.81	156.43	0.36
DESIGN-CENTERLIN	137.88	100 CFS	100.00	4524.50	4528.50	4525.34	4528.51	0.000029	0.54	202.58	88.29	0.06
DESIGN-CENTERLIN	137.88	220 CFS	220.00	4524.50	4529.71	4525.91	4529.72	0.000043	0.83	314.75	97.13	0.07
DESIGN-CENTERLIN	137.88	500 CFS	500.00	4524.50	4530.91	4526.75	4530.94	0.000092	1.44	436.00	106.19	0.11
DESIGN-CENTERLIN	137.88	1000 CFS	1000.00	4524.50	4531.68	4527.56	4531.77	0.000231	2.49	520.24	113.29	0.18
DESIGN-CENTERLIN	137.88	1500 CFS	1500.00	4524.50	4532.34	4528.25	4532.50	0.000366	3.36	598.06	123.23	0.23
DESIGN-CENTERLIN	137.88	1600 CFS	1600.00	4524.50	4532.48	4528.37	4532.66	0.000387	3.50	616.10	125.61	0.23
DESIGN-CENTERLIN	137.88	2000 CFS	2000.00	4524.50	4533.17	4528.77	4533.39	0.000434	3.95	705.13	134.74	0.25
DESIGN-CENTERLIN	137.88	2500 CFS	2500.00	4524.50	4533.69	4529.30	4533.99	0.000536	4.58	777.91	142.96	0.28
DESIGN-CENTERLIN	137.88	3000 CFS	3000.00	4524.50	4534.07	4529.74	4534.46	0.000657	5.23	833.12	149.71	0.32
DESIGN-CENTERLIN	137.88	3500 CFS	3500.00	4524.50	4534.58	4530.21	4535.04	0.000724	5.71	912.08	157.00	0.33
DESIGN-CENTERLIN	137.88	4000 CFS	4000.00	4524.50	4535.06	4530.58	4535.58	0.000786	6.16	987.98	170.12	0.35
DESIGN-CENTERLIN	137.88	4500 CFS	4500.00	4524.50	4535.50	4530.98	4536.09	0.000839	6.56	1060.32	178.15	0.37
DESIGN-CENTERLIN	100	100 CFS	100.00	4527.23	4528.06	4528.06	4528.46	0.015045	5.08	19.68	25.33	1.02
DESIGN-CENTERLIN	100	220 CFS	220.00	4527.23	4529.60	4528.64	4529.71	0.001831	2.65	83.01	58.36	0.39
DESIGN-CENTERLIN	100	500 CFS	500.00	4527.23	4530.75	4529.49	4530.92	0.001323	3.27	161.67	92.08	0.36
DESIGN-CENTERLIN	100	1000 CFS	1000.00	4527.23	4531.28	4530.29	4531.71	0.002711	5.32	215.44	108.48	0.54
DESIGN-CENTERLIN	100	1500 CFS	1500.00	4527.23	4531.68	4530.96	4532.41	0.003927	6.96	260.13	114.76	0.66
DESIGN-CENTERLIN	100	1600 CFS	1600.00	4527.23	4531.80	4531.10	4532.57	0.003955	7.14	273.97	116.63	0.67
DESIGN-CENTERLIN	100	2000 CFS	2000.00	4527.23	4532.53	4531.55	4533.30	0.003163	7.24	363.58	129.33	0.62
DESIGN-CENTERLIN	100	2500 CFS	2500.00	4527.23	4532.88	4532.06	4533.88	0.003726	8.28	410.12	136.76	0.68
DESIGN-CENTERLIN	100	3000 CFS	3000.00	4527.23	4532.50	4532.50	4534.26	0.007274	10.93	360.24	128.85	0.93
DESIGN-CENTERLIN	100	3500 CFS	3500.00	4527.23	4532.93	4532.93	4534.83	0.007033	11.45	416.82	137.81	0.93
DESIGN-CENTERLIN	100	4000 CFS	4000.00	4527.23	4533.35	4533.35	4535.37	0.006725	11.86	477.08	147.35	0.93
DESIGN-CENTERLIN	100	4500 CFS	4500.00	4527.23	4533.72	4533.72	4535.87	0.006570	12.29	533.24	153.76	0.93


100 CFS
Preferred Alternative Option 1 - Velocity Profile at 100 cfs
100
137.88
177.41
202.41
232.41
332.41
432.41
457.41
487.41
587.41
687.41
712.41
741.41
Velocity (ft/s)
7.50
6.25
5.00
3.75
2.50
1.25
0.00

HEC-RAS Plan: WINES_PC_OP2 River: DOLORES Reach: DESIGN-CHANNEL-C

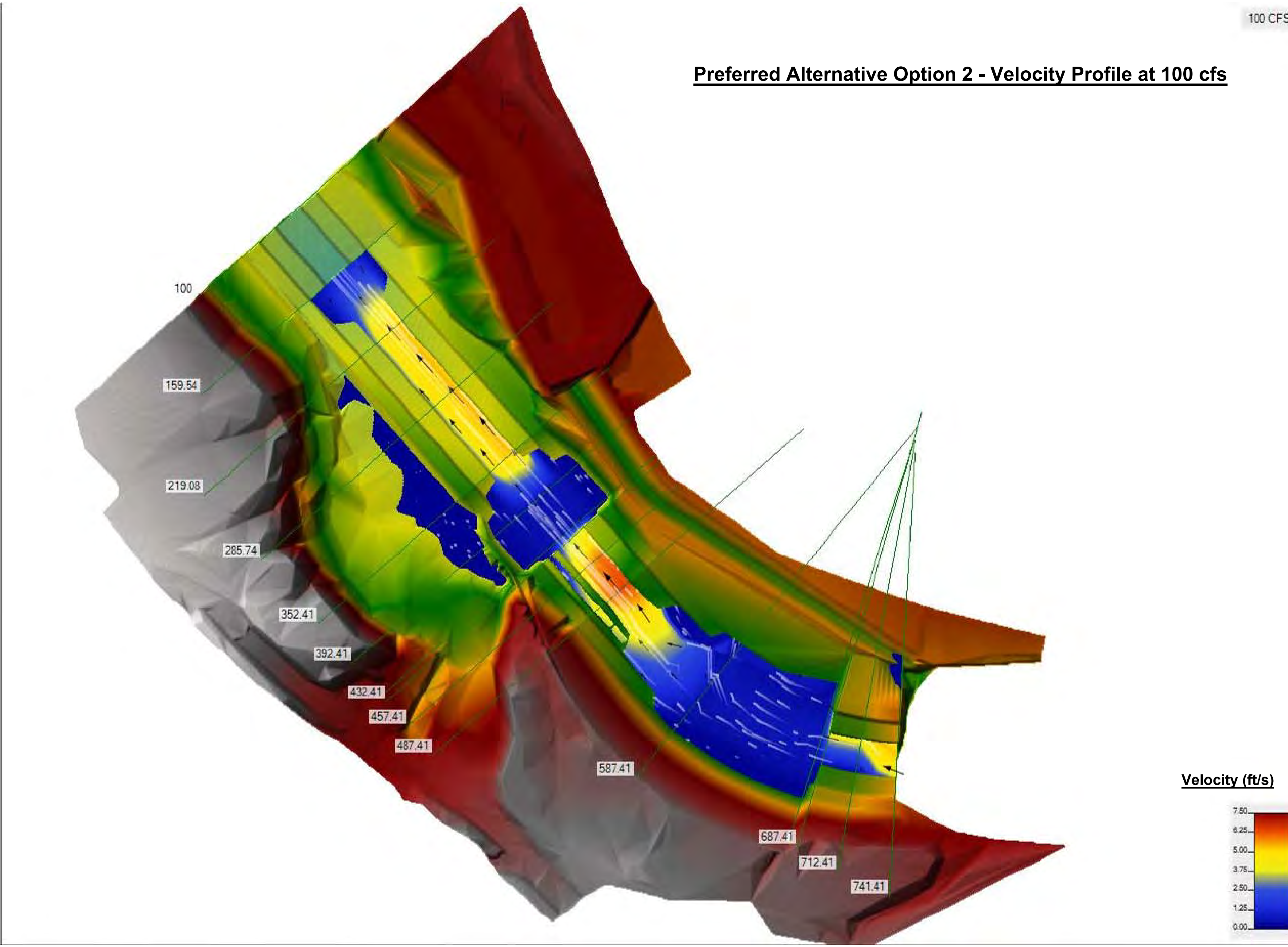
Preferred Alternative Option 2 - Proposed Conditions HEC-RAS Model Output

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DESIGN-CHANNEL-C	741.41	100 CFS	100.00	4534.93	4535.78	4535.78	4536.17	0.002652	4.97	20.12	52.64	0.98
DESIGN-CHANNEL-C	741.41	220 CFS	220.00	4534.93	4536.34	4536.34	4536.96	0.002362	6.32	34.79	59.90	0.99
DESIGN-CHANNEL-C	741.41	500 CFS	500.00	4534.93	4537.21	4537.21	4537.86	0.002179	6.46	77.37	98.19	0.99
DESIGN-CHANNEL-C	741.41	1000 CFS	1000.00	4534.93	4537.99	4537.99	4539.00	0.002834	8.08	123.78	110.55	1.00
DESIGN-CHANNEL-C	741.41	1500 CFS	1500.00	4534.93	4538.21	4538.21	4539.44	0.003690	9.51	268.91	131.63	1.12
DESIGN-CHANNEL-C	741.41	1600 CFS	1600.00	4534.93	4538.22	4538.22	4539.61	0.004142	10.09	270.52	132.18	1.18
DESIGN-CHANNEL-C	741.41	2000 CFS	2000.00	4534.93	4538.22	4538.22	4540.38	0.006472	12.62	270.52	132.18	1.48
DESIGN-CHANNEL-C	741.41	2500 CFS	2500.00	4534.93	4538.22	4538.22	4541.60	0.010112	15.77	270.52	132.18	1.85
DESIGN-CHANNEL-C	741.41	3000 CFS	3000.00	4534.93	4539.76	4539.76	4541.43	0.003346	11.13	526.99	202.34	1.01
DESIGN-CHANNEL-C	741.41	3500 CFS	3500.00	4534.93	4540.20	4540.20	4541.96	0.003233	11.52	620.58	225.84	0.99
DESIGN-CHANNEL-C	741.41	4000 CFS	4000.00	4534.93	4540.59	4540.59	4542.45	0.003175	11.91	712.08	245.82	0.98
DESIGN-CHANNEL-C	741.41	4500 CFS	4500.00	4534.93	4540.95	4540.95	4542.90	0.003120	12.27	805.55	265.28	0.97
DESIGN-CHANNEL-C	712.41	100 CFS	100.00	4533.00	4533.85	4533.85	4534.23	0.002629	4.96	20.17	25.40	0.98
DESIGN-CHANNEL-C	712.41	220 CFS	220.00	4533.00	4534.41	4534.41	4535.02	0.002328	6.29	34.96	27.63	0.99
DESIGN-CHANNEL-C	712.41	500 CFS	500.00	4533.00	4535.26	4535.26	4535.92	0.002216	6.51	76.76	63.86	1.00
DESIGN-CHANNEL-C	712.41	1000 CFS	1000.00	4533.00	4536.05	4536.05	4537.07	0.002854	8.10	123.40	73.67	1.00
DESIGN-CHANNEL-C	712.41	1500 CFS	1500.00	4533.00	4536.77	4536.77	4537.96	0.002763	8.82	210.01	136.59	0.94
DESIGN-CHANNEL-C	712.41	1600 CFS	1600.00	4533.00	4536.89	4536.89	4538.12	0.002758	8.96	226.93	137.37	0.93
DESIGN-CHANNEL-C	712.41	2000 CFS	2000.00	4533.00	4537.41	4537.32	4538.71	0.002604	9.32	298.33	140.62	0.89
DESIGN-CHANNEL-C	712.41	2500 CFS	2500.00	4533.00	4538.19	4537.78	4539.42	0.002111	9.22	409.69	145.53	0.80
DESIGN-CHANNEL-C	712.41	3000 CFS	3000.00	4533.00	4538.60	4538.24	4540.04	0.002266	10.00	471.73	160.13	0.82
DESIGN-CHANNEL-C	712.41	3500 CFS	3500.00	4533.00	4539.11	4538.56	4540.65	0.002188	10.38	560.74	183.19	0.81
DESIGN-CHANNEL-C	712.41	4000 CFS	4000.00	4533.00	4539.68	4538.98	4541.24	0.002018	10.52	671.53	208.35	0.78
DESIGN-CHANNEL-C	712.41	4500 CFS	4500.00	4533.00	4540.21	4539.36	4541.79	0.001886	10.67	787.71	231.83	0.76
DESIGN-CHANNEL-C	687.41	100 CFS	100.00	4532.50	4533.33	4533.33	4533.73	0.002826	5.07	19.71	25.33	1.01
DESIGN-CHANNEL-C	687.41	220 CFS	220.00	4532.50	4533.89	4533.89	4534.52	0.002414	6.37	34.54	27.57	1.00
DESIGN-CHANNEL-C	687.41	500 CFS	500.00	4532.50	4534.84	4534.76	4535.43	0.001947	6.15	81.30	61.83	0.92
DESIGN-CHANNEL-C	687.41	1000 CFS	1000.00	4532.50	4535.98	4535.56	4536.67	0.001701	6.65	158.18	100.20	0.75
DESIGN-CHANNEL-C	687.41	1500 CFS	1500.00	4532.50	4536.88	4536.24	4537.67	0.001573	7.22	251.23	134.89	0.69
DESIGN-CHANNEL-C	687.41	1600 CFS	1600.00	4532.50	4537.04	4536.36	4537.85	0.001554	7.32	270.69	140.47	0.69
DESIGN-CHANNEL-C	687.41	2000 CFS	2000.00	4532.50	4537.68	4536.83	4538.52	0.001397	7.50	390.72	154.74	0.65
DESIGN-CHANNEL-C	687.41	2500 CFS	2500.00	4532.50	4538.39	4537.35	4539.28	0.001312	7.85	501.34	164.60	0.63
DESIGN-CHANNEL-C	687.41	3000 CFS	3000.00	4532.50	4538.83	4537.82	4539.88	0.001429	8.56	577.99	184.27	0.66
DESIGN-CHANNEL-C	687.41	3500 CFS	3500.00	4532.50	4539.35	4538.22	4540.49	0.001424	8.98	680.38	207.65	0.66
DESIGN-CHANNEL-C	687.41	4000 CFS	4000.00	4532.50	4539.90	4538.50	4541.09	0.001367	9.24	801.53	232.30	0.64
DESIGN-CHANNEL-C	687.41	4500 CFS	4500.00	4532.50	4540.41	4538.93	4541.65	0.001321	9.47	926.39	255.22	0.64
DESIGN-CHANNEL-C	681.41	100 CFS	100.00	4529.50	4533.40	4530.34	4533.40	0.000033	0.56	193.43	89.08	0.06
DESIGN-CHANNEL-C	681.41	220 CFS	220.00	4529.50	4534.14	4530.90	4534.16	0.000071	0.97	262.88	98.05	0.09
DESIGN-CHANNEL-C	681.41	500 CFS	500.00	4529.50	4535.22	4531.75	4535.26	0.000147	1.66	375.72	117.13	0.14
DESIGN-CHANNEL-C	681.41	1000 CFS	1000.00	4529.50	4536.39	4532.56	4536.49	0.000269	2.60	514.01	138.56	0.19
DESIGN-CHANNEL-C	681.41	1500 CFS	1500.00	4529.50	4537.32	4533.25	4537.48	0.000358	3.31	635.60	155.58	0.22
DESIGN-CHANNEL-C	681.41	1600 CFS	1600.00	4529.50	4537.49	4533.34	4537.65	0.000368	3.42	690.70	158.57	0.23
DESIGN-CHANNEL-C	681.41	2000 CFS	2000.00	4529.50	4538.12	4533.77	4538.32	0.000417	3.85	791.39	162.39	0.25
DESIGN-CHANNEL-C	681.41	2500 CFS	2500.00	4529.50	4538.82	4534.31	4539.08	0.000478	4.37	914.12	189.72	0.27
DESIGN-CHANNEL-C	681.41	3000 CFS	3000.00	4529.50	4539.33	4534.78	4539.66	0.000556	4.91	1015.66	212.51	0.29
DESIGN-CHANNEL-C	681.41	3500 CFS	3500.00	4529.50	4539.87	4535.21	4540.26	0.000605	5.33	1138.63	237.19	0.31
DESIGN-CHANNEL-C	681.41	4000 CFS	4000.00	4529.50	4540.43	4535.57	4540.86	0.000635	5.68	1276.75	262.16	0.32
DESIGN-CHANNEL-C	681.41	4500 CFS	4500.00	4529.50	4540.94	4536.00	4541.41	0.000655	5.96	1416.60	276.08	0.33
DESIGN-CHANNEL-C	587.41	100 CFS	100.00	4529.50	4533.40	4530.34	4533.40	0.000033	0.56	191.83	85.02	0.06
DESIGN-CHANNEL-C	587.41	220 CFS	220.00	4529.50	4534.13	4530.90	4534.15	0.000072	0.98	257.11	93.37	0.09
DESIGN-CHANNEL-C	587.41	500 CFS	500.00	4529.50	4535.21	4531.75	4535.25	0.000151	1.68	365.43	116.37	0.14
DESIGN-CHANNEL-C	587.41	1000 CFS	1000.00	4529.50	4536.36	4532.56	4536.46	0.000277	2.64	500.95	140.06	0.19
DESIGN-CHANNEL-C	587.41	1500 CFS	1500.00	4529.50	4537.28	4533.25	4537.44	0.000370	3.36	622.36	158.87	0.23
DESIGN-CHANNEL-C	587.41	1600 CFS	1600.00	4529.50	4537.44	4533.36	4537.62	0.000386	3.49	645.33	162.23	0.23
DESIGN-CHANNEL-C	587.41	2000 CFS	2000.00	4529.50	4538.07	4533.79	4538.28	0.000430	3.89	785.34	169.16	0.25
DESIGN-CHANNEL-C	587.41	2500 CFS	2500.00	4529.50	4538.77	4534.29	4539.04	0.000490	4.41	914.24	199.79	0.27
DESIGN-CHANNEL-C	587.41	3000 CFS	3000.00	4529.50	4539.27	4534.76	4539.60	0.000568	4.94	1019.28	221.64	0.29
DESIGN-CHANNEL-C	587.41	3500 CFS	3500.00	4529.50	4539.81	4535.22	4540.20	0.000616	5.36	1146.45	245.50	0.31
DESIGN-CHANNEL-C	587.41	4000 CFS	4000.00	4529.50	4540.36	4535.59	4540.80	0.000644	5.69	1288.58	269.69	0.32
DESIGN-CHANNEL-C	587.41	4500 CFS	4500.00	4529.50	4540.88	4536.03	4541.35	0.000661	5.97	1431.73	280.98	0.33
DESIGN-CHANNEL-C	487.41	100 CFS	100.00	4531.14	4532.96	4532.96	4533.35	0.009231	5.03	19.89	29.19	1.07
DESIGN-CHANNEL-C	487.41	220 CFS	220.00	4531.14	4533.50	4533.50	4534.07	0.005197	6.07	36.23	31.46	1.00
DESIGN-CHANNEL-C	487.41	500 CFS	500.00	4531.14	4534.49	4534.49	4535.15	0.003043	6.49	77.02	62.76	0.98
DESIGN-CHANNEL-C	487.41	1000 CFS	1000.00	4531.14	4535.30	4535.30	4536.31	0.003477	8.03	124.47	71.04	0.98
DESIGN-CHANNEL-C	487.41	1500 CFS	1500.00	4531.14	4535.97	4535.97	4537.25	0.003561	9.08	172.05	99.97	0.97
DESIGN-CHANNEL-C	487.41	1600 CFS	1600.00	4531.14	4536.10	4536.10	4537.42	0.003530	9.23	183.22	102.92	0.97
DESIGN-CHANNEL-C	487.41	2000 CFS	2000.00	4531.14	4536.55	4536.55	4538.06	0.003538	9.90	224.25	113.19	0.96
DESIGN-CHANNEL-C	487.41	2500 CFS	2500.00	4531.14	4537.05	4537.05	4538.79	0.003555	10.64	274.16	124.69	0.96
DESIGN-CHANNEL-C	487.41	3000 CFS	3000.00	4531.14	4537.57	4537.57	4539.34	0.003274	10.91	381.22	139.60	0.93
DESIGN-CHANNEL-C	487.41	3500 CFS	3500.00	4531.14	4537.98	4537.98	4539.92	0.003311	11.51	438.08	142.68	0.93
DESIGN-CHANNEL-C	487.41	4000 CFS	4000.00	4531.14	4538.20	4538.20	4540.48	0.003710	12.49	470.16	146.30	0.99
DESIGN-CHANNEL-C	487.41	4500 CFS	4500.00	4531.14	4538.69	4538.69	4541.03	0.003462	12.70	546.79	168.79	0.96
DESIGN-CHANNEL-C	457.41	100 CFS	100.00	4530.14	4531.17	4531.17	4531.53	0.004677	4.78	20.92	29.89	1.01
DESIGN-CHANNEL-C	457.41	220 CFS	220.00	4530.14	4531.81	4531.68	4532.26	0.002534	5.37	40.99	32.59	0.84

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DESIGN-CHANNEL-C	457.41	500 CFS	500.00	4530.14	4532.57	4532.57	4533.24	0.002808	6.58	76.03	57.16	1.01
DESIGN-CHANNEL-C	457.41	1000 CFS	1000.00	4530.14	4533.40	4533.40	4534.40	0.003204	8.02	124.74	60.47	0.98
DESIGN-CHANNEL-C	457.41	1500 CFS	1500.00	4530.14	4534.05	4534.05	4535.33	0.003351	9.09	173.37	86.94	0.98
DESIGN-CHANNEL-C	457.41	1600 CFS	1600.00	4530.14	4534.18	4534.18	4535.50	0.003328	9.24	184.19	88.52	0.97
DESIGN-CHANNEL-C	457.41	2000 CFS	2000.00	4530.14	4534.62	4534.62	4536.15	0.003410	9.96	221.16	93.80	0.97
DESIGN-CHANNEL-C	457.41	2500 CFS	2500.00	4530.14	4535.13	4535.13	4536.88	0.003425	10.70	266.28	100.04	0.97
DESIGN-CHANNEL-C	457.41	3000 CFS	3000.00	4530.14	4535.61	4535.61	4537.56	0.003407	11.32	310.02	105.89	0.97
DESIGN-CHANNEL-C	457.41	3500 CFS	3500.00	4530.14	4536.06	4536.06	4538.21	0.003398	11.90	351.77	122.43	0.97
DESIGN-CHANNEL-C	457.41	4000 CFS	4000.00	4530.14	4536.42	4536.42	4538.81	0.003509	12.58	386.72	135.97	0.99
DESIGN-CHANNEL-C	457.41	4500 CFS	4500.00	4530.14	4536.86	4536.86	4539.39	0.003397	12.96	430.60	151.01	0.97
DESIGN-CHANNEL-C	432.41	100 CFS	100.00	4530.00	4531.14	4530.84	4531.34	0.000998	3.63	27.54	26.54	0.63
DESIGN-CHANNEL-C	432.41	220 CFS	220.00	4530.00	4531.95	4531.43	4532.15	0.000737	3.58	61.46	56.69	0.61
DESIGN-CHANNEL-C	432.41	500 CFS	500.00	4530.00	4532.64	4532.23	4533.02	0.001207	4.93	101.41	59.44	0.67
DESIGN-CHANNEL-C	432.41	1000 CFS	1000.00	4530.00	4533.29	4533.03	4534.07	0.002081	7.09	144.27	83.90	0.82
DESIGN-CHANNEL-C	432.41	1500 CFS	1500.00	4530.00	4533.69	4533.69	4534.96	0.003030	9.05	176.81	90.92	0.97
DESIGN-CHANNEL-C	432.41	1600 CFS	1600.00	4530.00	4533.80	4533.80	4535.13	0.003084	9.27	185.92	96.02	0.97
DESIGN-CHANNEL-C	432.41	2000 CFS	2000.00	4530.00	4534.24	4534.24	4535.77	0.003149	9.96	224.12	111.08	0.97
DESIGN-CHANNEL-C	432.41	2500 CFS	2500.00	4530.00	4534.74	4534.74	4536.50	0.003220	10.73	268.36	159.58	0.98
DESIGN-CHANNEL-C	432.41	3000 CFS	3000.00	4530.00	4535.25	4535.25	4537.19	0.003148	11.28	317.29	180.14	0.96
DESIGN-CHANNEL-C	432.41	3500 CFS	3500.00	4530.00	4535.71	4535.71	4537.82	0.003130	11.83	363.17	192.82	0.96
DESIGN-CHANNEL-C	432.41	4000 CFS	4000.00	4530.00	4536.12	4536.12	4538.42	0.003146	12.37	405.42	200.56	0.96
DESIGN-CHANNEL-C	432.41	4500 CFS	4500.00	4530.00	4536.53	4536.53	4538.99	0.003120	12.83	448.47	207.03	0.96
DESIGN-CHANNEL-C	426.41	100 CFS	100.00	4527.00	4531.27	4527.84	4531.28	0.000021	0.50	222.92	84.70	0.05
DESIGN-CHANNEL-C	426.41	220 CFS	220.00	4527.00	4532.08	4528.40	4532.09	0.000048	0.86	292.99	94.24	0.08
DESIGN-CHANNEL-C	426.41	500 CFS	500.00	4527.00	4532.87	4529.25	4532.91	0.000135	1.62	364.80	108.44	0.13
DESIGN-CHANNEL-C	426.41	1000 CFS	1000.00	4527.00	4533.76	4530.06	4533.87	0.000303	2.72	448.74	122.47	0.20
DESIGN-CHANNEL-C	426.41	1500 CFS	1500.00	4527.00	4534.38	4530.74	4534.57	0.000477	3.66	510.87	156.50	0.26
DESIGN-CHANNEL-C	426.41	1600 CFS	1600.00	4527.00	4534.48	4530.86	4534.70	0.000513	3.83	521.74	173.19	0.27
DESIGN-CHANNEL-C	426.41	2000 CFS	2000.00	4527.00	4534.87	4531.25	4535.17	0.000654	4.50	561.61	182.93	0.30
DESIGN-CHANNEL-C	426.41	2500 CFS	2500.00	4527.00	4535.30	4531.77	4535.70	0.000828	5.27	605.97	193.92	0.34
DESIGN-CHANNEL-C	426.41	3000 CFS	3000.00	4527.00	4535.71	4532.25	4536.19	0.000936	5.82	788.63	201.18	0.37
DESIGN-CHANNEL-C	426.41	3500 CFS	3500.00	4527.00	4536.07	4532.67	4536.64	0.001067	6.41	856.65	206.45	0.40
DESIGN-CHANNEL-C	426.41	4000 CFS	4000.00	4527.00	4536.39	4533.08	4537.07	0.001195	6.96	918.75	209.88	0.42
DESIGN-CHANNEL-C	426.41	4500 CFS	4500.00	4527.00	4536.72	4533.49	4537.48	0.001304	7.46	981.24	213.30	0.45
DESIGN-CHANNEL-C	392.41	100 CFS	100.00	4527.00	4531.27	4527.84	4531.28	0.000021	0.50	224.02	86.89	0.05
DESIGN-CHANNEL-C	392.41	220 CFS	220.00	4527.00	4532.08	4528.40	4532.09	0.000048	0.86	297.19	101.00	0.08
DESIGN-CHANNEL-C	392.41	500 CFS	500.00	4527.00	4532.87	4529.25	4532.91	0.000133	1.61	391.65	138.09	0.13
DESIGN-CHANNEL-C	392.41	1000 CFS	1000.00	4527.00	4533.75	4530.06	4533.85	0.000293	2.68	533.84	184.79	0.20
DESIGN-CHANNEL-C	392.41	1500 CFS	1500.00	4527.00	4534.38	4530.75	4534.55	0.000443	3.53	650.89	200.70	0.25
DESIGN-CHANNEL-C	392.41	1600 CFS	1600.00	4527.00	4534.48	4530.86	4534.68	0.000473	3.68	671.92	203.77	0.26
DESIGN-CHANNEL-C	392.41	2000 CFS	2000.00	4527.00	4534.88	4531.30	4535.13	0.000587	4.27	750.98	213.56	0.29
DESIGN-CHANNEL-C	392.41	2500 CFS	2500.00	4527.00	4535.32	4531.79	4535.65	0.000717	4.92	841.60	219.21	0.32
DESIGN-CHANNEL-C	392.41	3000 CFS	3000.00	4527.00	4535.73	4532.24	4536.13	0.000835	5.50	924.76	223.24	0.35
DESIGN-CHANNEL-C	392.41	3500 CFS	3500.00	4527.00	4536.10	4532.74	4536.58	0.000943	6.04	1001.94	226.94	0.37
DESIGN-CHANNEL-C	392.41	4000 CFS	4000.00	4527.00	4536.43	4533.24	4536.99	0.001049	6.54	1072.38	230.30	0.40
DESIGN-CHANNEL-C	392.41	4500 CFS	4500.00	4527.00	4536.77	4533.75	4537.40	0.001138	6.99	1143.06	233.65	0.42
DESIGN-CHANNEL-C	352.41	100 CFS	100.00	4530.00	4530.84	4530.84	4531.23	0.014838	5.06	19.76	25.34	1.01
DESIGN-CHANNEL-C	352.41	220 CFS	220.00	4530.00	4531.40	4531.40	4532.02	0.012397	6.33	34.76	27.61	0.99
DESIGN-CHANNEL-C	352.41	500 CFS	500.00	4530.00	4532.29	4532.29	4532.84	0.010238	6.07	106.15	123.97	0.92
DESIGN-CHANNEL-C	352.41	1000 CFS	1000.00	4530.00	4533.00	4533.00	4533.75	0.009121	7.36	207.74	162.78	0.92
DESIGN-CHANNEL-C	352.41	1500 CFS	1500.00	4530.00	4533.56	4533.56	4534.44	0.008094	8.17	310.53	197.70	0.90
DESIGN-CHANNEL-C	352.41	1600 CFS	1600.00	4530.00	4533.63	4533.63	4534.55	0.008301	8.42	323.89	198.91	0.92
DESIGN-CHANNEL-C	352.41	2000 CFS	2000.00	4530.00	4533.96	4533.96	4535.00	0.008163	9.04	389.10	204.79	0.93
DESIGN-CHANNEL-C	352.41	2500 CFS	2500.00	4530.00	4534.31	4534.31	4535.50	0.008216	9.79	460.13	209.72	0.95
DESIGN-CHANNEL-C	352.41	3000 CFS	3000.00	4530.00	4534.62	4534.62	4535.96	0.008420	10.52	522.14	213.83	0.98
DESIGN-CHANNEL-C	352.41	3500 CFS	3500.00	4530.00	4534.92	4534.92	4536.40	0.008444	11.12	583.85	217.88	0.99
DESIGN-CHANNEL-C	352.41	4000 CFS	4000.00	4530.00	4535.30	4535.16	4536.81	0.007790	11.35	661.87	222.89	0.97
DESIGN-CHANNEL-C	352.41	4500 CFS	4500.00	4530.00	4535.77	4535.50	4537.23	0.006672	11.27	760.73	229.12	0.91
DESIGN-CHANNEL-C	285.74	100 CFS	100.00	4529.00	4529.84	4529.84	4530.23	0.014751	5.05	19.80	25.35	1.01
DESIGN-CHANNEL-C	285.74	220 CFS	220.00	4529.00	4530.39	4530.39	4531.02	0.012803	6.40	34.39	27.55	1.01
DESIGN-CHANNEL-C	285.74	500 CFS	500.00	4529.00	4531.26	4531.26	4531.89	0.011844	6.42	86.67	86.21	0.98
DESIGN-CHANNEL-C	285.74	1000 CFS	1000.00	4529.00	4532.04	4532.04	4532.91	0.009824	7.72	166.09	119.14	0.96
DESIGN-CHANNEL-C	285.74	1500 CFS	1500.00	4529.00	4532.69	4532.69	4533.68	0.007986	8.39	267.65	176.89	0.91
DESIGN-CHANNEL-C	285.74	1600 CFS	1600.00	4529.00	4532.80	4532.80	4533.81	0.007783	8.51	287.28	179.85	0.90
DESIGN-CHANNEL-C	285.74	2000 CFS	2000.00	4529.00	4533.15	4533.15	4534.29	0.007685	9.15	351.15	183.73	0.91
DESIGN-CHANNEL-C	285.74	2500 CFS	2500.00	4529.00	4533.54	4533.54	4534.83	0.007645	9.87	423.32	187.50	0.93
DESIGN-CHANNEL-C	285.74	3000 CFS	3000.00	4529.00	4533.92	4533.88	4535.32	0.007378	10.39	496.53	191.21	0.93
DESIGN-CHANNEL-C	285.74	3500 CFS	3500.00	4529.00	4534.55	4534.20	4535.82	0.005692	10.08	617.85	196.22	0.84
DESIGN-CHANNEL-C	285.74	4000 CFS	4000.00	4529.00	4535.09		4536.32	0.004838	10.03	725.71	200.30	0.78
DESIGN-CHANNEL-C	285.74	4500 CFS	4500.00	4529.00	4535.58		4536.80	0.004325	10.08	824.82	203.44	0.75
DESIGN-CHANNEL-C	219.08	100 CFS	100.00	4528.00	4528.85	4528.85	4529.23	0.014056	4.97	20.11	25.40	0.99
DESIGN-CHANNEL-C	219.08	220 CFS	220.00	4528.00	4529.41	4529.41	4530.02	0.012256	6.31	34.89	33.80	0.99
DESIGN-CHANNEL-C	219.08	500 CFS	500.00	4528.00	4530.73	4530.27	4531.09	0.004562	4.79	104.42	80.53	0.64
DESIGN-CHANNEL-C	219.08	1000 CFS	1000.00	4528.00	4531.38	4531.06	4532.04	0.005876	6.63	184.83	110.95	0.76

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DESIGN-CHANNEL-C	219.08	1500 CFS	1500.00	4528.00	4531.96	4531.68	4532.85	0.006077	7.80	249.83	114.69	0.80
DESIGN-CHANNEL-C	219.08	1600 CFS	1600.00	4528.00	4532.10	4531.79	4533.01	0.005856	7.91	266.18	116.40	0.79
DESIGN-CHANNEL-C	219.08	2000 CFS	2000.00	4528.00	4532.82	4532.12	4533.69	0.004363	7.85	353.48	126.53	0.71
DESIGN-CHANNEL-C	219.08	2500 CFS	2500.00	4528.00	4533.28	4532.61	4534.34	0.004575	8.67	413.78	141.37	0.74
DESIGN-CHANNEL-C	219.08	3000 CFS	3000.00	4528.00	4533.60	4533.02	4534.88	0.005102	9.61	459.57	149.17	0.79
DESIGN-CHANNEL-C	219.08	3500 CFS	3500.00	4528.00	4534.12	4533.50	4535.47	0.004668	9.88	541.55	160.28	0.77
DESIGN-CHANNEL-C	219.08	4000 CFS	4000.00	4528.00	4534.59	4533.88	4536.00	0.004400	10.18	618.46	166.83	0.76
DESIGN-CHANNEL-C	219.08	4500 CFS	4500.00	4528.00	4535.04	4534.29	4536.50	0.004183	10.45	694.13	171.86	0.75
DESIGN-CHANNEL-C	159.54	100 CFS	100.00	4526.00	4528.53	4526.85	4528.55	0.000268	1.08	92.49	59.01	0.15
DESIGN-CHANNEL-C	159.54	220 CFS	220.00	4526.00	4529.72	4527.41	4529.74	0.000197	1.33	179.75	90.99	0.14
DESIGN-CHANNEL-C	159.54	500 CFS	500.00	4526.00	4530.89	4528.27	4530.96	0.000288	2.04	293.24	102.80	0.18
DESIGN-CHANNEL-C	159.54	1000 CFS	1000.00	4526.00	4531.64	4529.06	4531.81	0.000622	3.38	372.95	111.88	0.28
DESIGN-CHANNEL-C	159.54	1500 CFS	1500.00	4526.00	4532.27	4529.75	4532.55	0.000891	4.40	446.15	120.52	0.34
DESIGN-CHANNEL-C	159.54	1600 CFS	1600.00	4526.00	4532.41	4529.86	4532.71	0.000923	4.56	463.13	122.64	0.35
DESIGN-CHANNEL-C	159.54	2000 CFS	2000.00	4526.00	4533.07	4530.31	4533.44	0.000954	5.01	547.98	132.57	0.36
DESIGN-CHANNEL-C	159.54	2500 CFS	2500.00	4526.00	4533.57	4530.78	4534.04	0.001121	5.72	616.00	139.00	0.39
DESIGN-CHANNEL-C	159.54	3000 CFS	3000.00	4526.00	4533.94	4531.24	4534.53	0.001324	6.45	668.33	143.73	0.43
DESIGN-CHANNEL-C	159.54	3500 CFS	3500.00	4526.00	4534.45	4531.69	4535.13	0.001398	6.95	742.70	150.23	0.45
DESIGN-CHANNEL-C	159.54	4000 CFS	4000.00	4526.00	4534.90	4532.07	4535.66	0.001472	7.42	810.93	153.61	0.47
DESIGN-CHANNEL-C	159.54	4500 CFS	4500.00	4526.00	4535.32	4532.48	4536.17	0.001536	7.84	876.31	155.95	0.48
DESIGN-CHANNEL-C	100	100 CFS	100.00	4527.23	4528.07	4528.07	4528.46	0.014521	5.03	19.90	25.36	1.00
DESIGN-CHANNEL-C	100	220 CFS	220.00	4527.23	4529.60	4528.62	4529.71	0.001831	2.65	83.01	58.36	0.39
DESIGN-CHANNEL-C	100	500 CFS	500.00	4527.23	4530.75	4529.48	4530.92	0.001323	3.27	161.67	92.08	0.36
DESIGN-CHANNEL-C	100	1000 CFS	1000.00	4527.23	4531.28	4530.27	4531.71	0.002711	5.32	215.44	108.48	0.54
DESIGN-CHANNEL-C	100	1500 CFS	1500.00	4527.23	4531.68	4530.96	4532.41	0.003927	6.96	260.13	114.76	0.66
DESIGN-CHANNEL-C	100	1600 CFS	1600.00	4527.23	4531.80	4531.09	4532.57	0.003955	7.14	273.97	116.63	0.67
DESIGN-CHANNEL-C	100	2000 CFS	2000.00	4527.23	4532.53	4531.53	4533.30	0.003163	7.24	363.58	129.33	0.62
DESIGN-CHANNEL-C	100	2500 CFS	2500.00	4527.23	4532.88	4532.04	4533.88	0.003726	8.28	410.12	136.76	0.68
DESIGN-CHANNEL-C	100	3000 CFS	3000.00	4527.23	4532.48	4532.48	4534.26	0.007438	11.01	356.85	128.36	0.94
DESIGN-CHANNEL-C	100	3500 CFS	3500.00	4527.23	4532.85	4532.85	4534.83	0.007473	11.67	406.12	136.13	0.96
DESIGN-CHANNEL-C	100	4000 CFS	4000.00	4527.23	4533.30	4533.30	4535.37	0.006966	11.99	469.90	146.51	0.94
DESIGN-CHANNEL-C	100	4500 CFS	4500.00	4527.23	4533.67	4533.67	4535.87	0.006819	12.43	524.78	152.81	0.94

Preferred Alternative Option 2 - Velocity Profile at 100 cfs



Appendix G

WWE

MEMORANDUM

To: Wines Ditch No.1 Rehabilitation Project
File #111-030.030

From: Scott Schreiber, P.E. and Hayes Lenhart, P.E.
Wright Water Engineers, Inc.

Date: January 15, 2018

Re: Wines Ditch No. 1 Diversion Rehabilitation Project – Channel Bankfull Analysis

Wright Water Engineers, Inc. (WWE) prepared this technical memorandum to document the channel bankfull analysis developed for the Wines Ditch No. 1 Diversion Rehabilitation Project (the Project). This memorandum provides the basis for the typical conceptual design channel cross-section developed for the Project. Please note that the typical channel cross-section developed is conceptual, and refinement to this cross-section are expected as part of the final design phase of the Project.

1.0 BANKFULL ANALYSIS

The bankfull discharge is considered the channel forming flow of a riverine system which develops the overall channel geometry and typical channel cross-section for that river. This bankfull discharge is generally considered to be between the 1- and 2-year return frequency flood event, and typically occurs once a year during spring runoff. For this analysis the bankfull was evaluated as the 1.5-year event. Under stable river conditions, streamflow above the bankfull discharge will typically result in activation of the river floodplain. For the purposes of informing conceptual design alternative for the Project, both dominant and effective discharges for this Project will be assumed to equal the bankfull discharge

The estimated bankfull discharge for this Project was developed using the following data sources:

- Historical stream gage data from USGS gage 01980000 - Dolores River near Cisco, UT (Cisco Gage) located approximately 17 miles downstream of the Wines Ditch No. 1 structure. The watershed area contributing to the Wines Ditch No.1 Diversion Structure is approximately 4,380 square-miles, while the watershed area contributing to the Cisco Gage is approximately 4,570 square-miles. As a result, a contributing area ratio of 0.96 (4380 ÷ 4570 = 0.96) was applied to the Cisco Gage data to adjust streamflow data to be more representative of the Project site. Please note all streamflow data utilized was post-McPhee Reservoir construction.
- Existing conditions topographic survey data collected in March of 2017 by Rolland Consulting Engineers, LLC. (2017 Rolland Survey) was used to develop existing condition river cross-sections through the channel reach.

Wright Water Engineers, Inc., 2490 W. 26th Avenue, Ste. 100A, Denver, CO 80211
Tel. 303/480-1700; Fax. 303/480-1020, e-mail: krw@wrightwater.com

1.1 Bankfull Discharge Bulletin #17B Analysis

A statistical analysis to determine the 1.5-year return frequency flood event was performed following "Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee", (USGS, 1981) developed by US Geological Survey (USGS). This analysis provides an estimate of annual peak flood frequency hydrology for various return intervals, and are based on a Log Pearson III distribution of streamflow data. The Bulletin #17B analysis can be performed using the HEC-SSP model, developed by the US Army Corps of Engineers.

The results of the HEC-SSP analysis for the Cisco Gage indicate the bankfull discharge is between 1,000 and 1.500 cfs.

1.2 Existing Cross-Section Evaluation

An additional bankfull discharge evaluation was also completed by developing existing conditions cross-sections of the Dolores River through the project site using the 2017 Rolland Survey. This additional existing condition cross-section analysis helps to provide a more river specific basis for design of the bankfull channel geometry. Please note that the geomorphology of the Dolores River in the Project area is considered a confined alluvial valley, and bankfull indicators are difficult to determine under this type of geomorphic condition. Therefore, this information is considered cursory and is only used as a reasonableness check for channel design parameters.

Multiple cross-sections were developed from existing conditions site topography and an overall channel profile to better understand the capacity of the existing channel for various flow depths. The existing cross-sections were evaluated to determine an approximate existing bankfull channel area and provide bounds to support the development of phe proposed bankfull channel cross-section.

From the Project topography the existing slope through our project area has a range of approximately 0.6% to 1%. This slope is influenced by the existing diversion structure, but is considered best available information at the time of this analysis. Six cross-sections were evaluated upstream and downstream of the existing diversion structure. Table 1 provides a summary of the existing geometry information for the full width of the Dolores River and estimated bankfull channel characteristics.

Using the average bankfull channel parameters a bankfull discharge of approximately 700 cfs was estimated from the existing conditions cross-section evaluation. The existing channel geometry will be used to verify the reasonableness of the proposed design channel for the Project. The overall goal will be to develop a bankfull channel to meet the minimum flow requirements, while flows outside the bankfull discharge will be conveyed in the overbanks during larger flood events.

1.3 Typical Conceptual Design Channel Cross-Section

Based on the Bulletin #17B and existing channel cross-section analysis, a design bankfull value of 1,000 cfs was chosen for conceptual design purposes. Using this value, and taking into consideration requirements for minimum boater passage channel width and minimum fish barrier velocity requirements discussed in the Project Basis of Design Report (WWE, 2017), a typical conceptual design channel cross-section was developed. The proposed conceptual design channel cross-section consists of a 3-stage channel.

- Stage 1 is a 22-foot-wide and 1.5 feet deep low flow channel that is expected to contain all flow less than approximately 100 cfs. A 22-foot-wide low flow channel dimension was selected to provide enough width to facilitate navigation of watercraft during low flows.
- Stage 2 is a 61-foot-wide 3 feet deep bankfull channel that is expected to contain all flow less than approximately 1,000 cfs.
- Stage 3 is activated for all flow conditions above approximately 1,000 cfs. Stage 3 is effectively the Dolores River floodplain through the Project area. Due to the confined and narrow valley channel conditions, reconnecting the channel to its historical floodplain is not feasible, however a minimum floodplain bench width of 10 feet will be provided of both sides of the channel before beginning the bank transition to meet adjacent grade.

Figure 1 provides the conceptual design channel cross-section dimensions proposed.

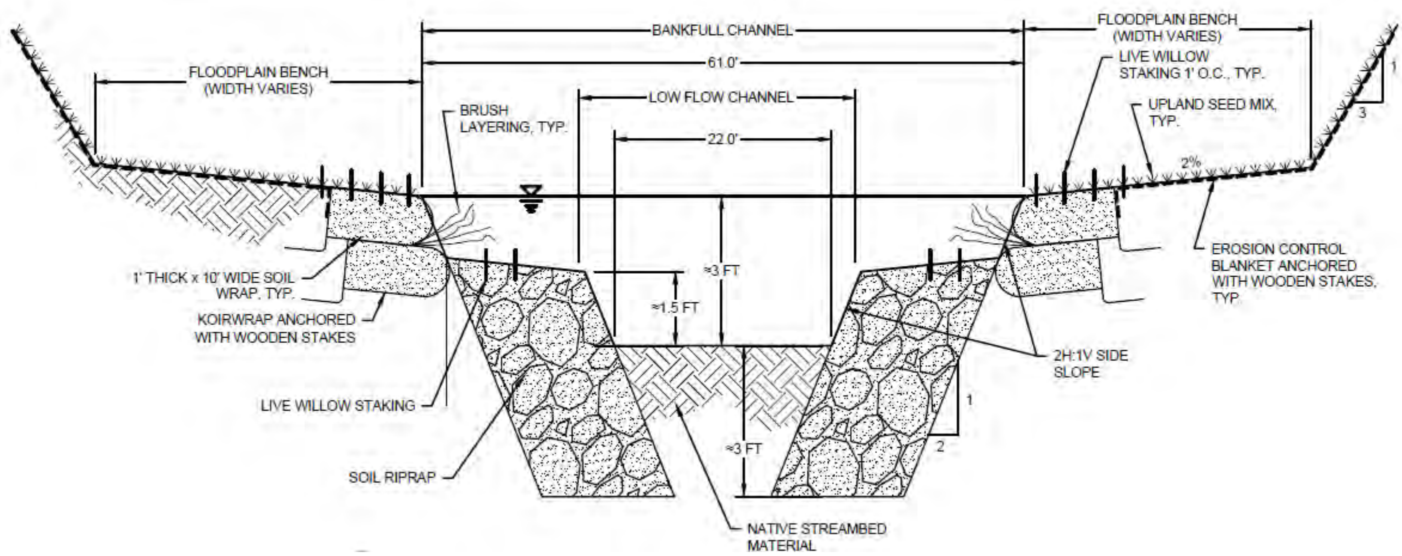


Figure 1. Typical Conceptual Design Channel Cross-Section

2.0 CONCLUSION

The bankfull analysis presented herein was developed for the purposes of developing a conceptual design channel cross-section for the Wines Ditch No. 1 Diversion Rehabilitation Project. It is expected that the typical design channel cross-section will be refined during the final design phase once additional topographical survey is collected and a more detailed hydraulic analysis and evaluation of the preferred alternative is performed.

3.0 REFERENCES

WWE, 2017. Basis of Design Report Wines Ditch No. 1 Diversion Structure Rehabilitation Gateway, Colorado. Prepared for The Nature Conservancy. August 2017. Wright Water Engineers, Inc. 1666 N. Main Avenue Suite C. Durango, CO 81301.

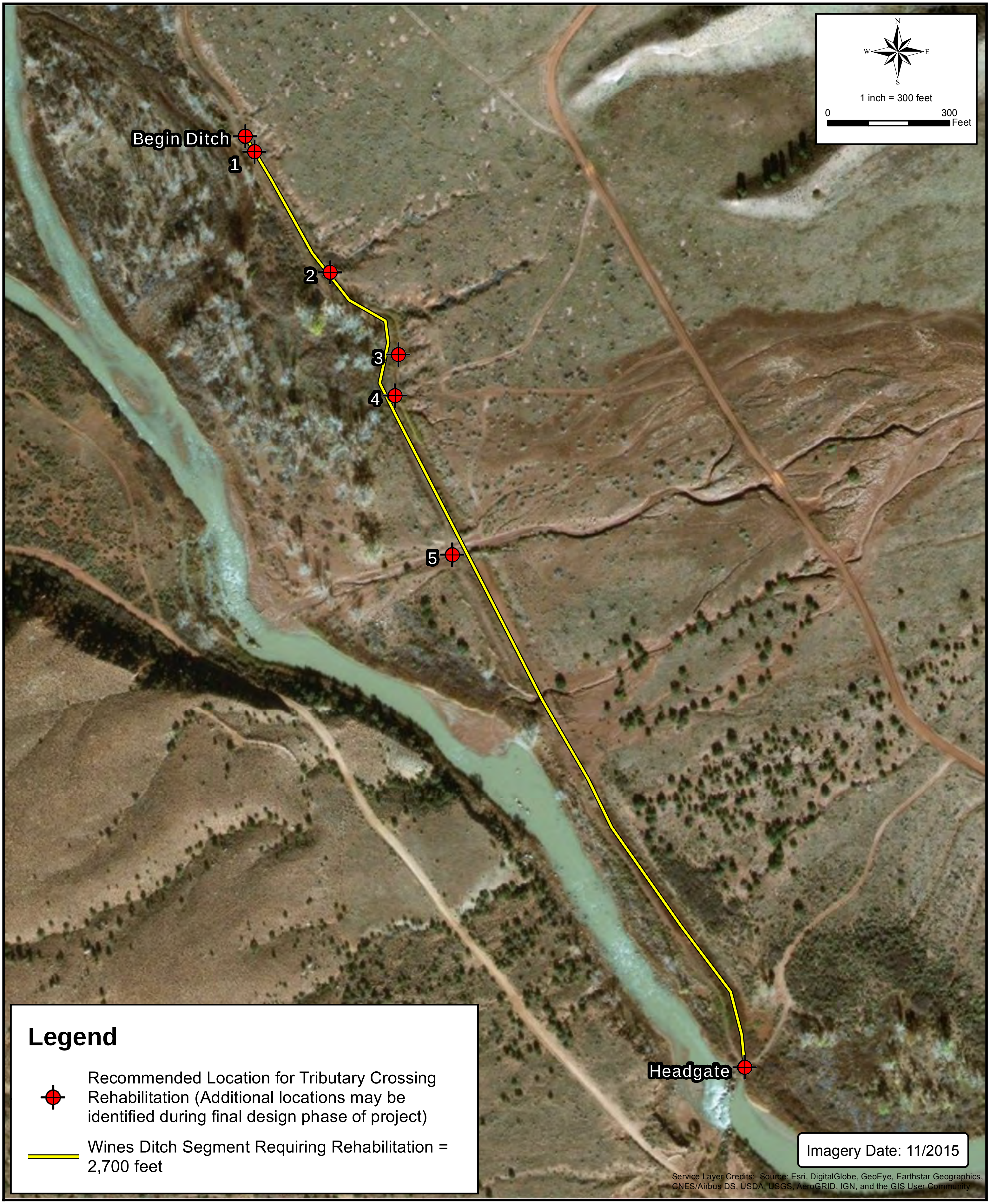
Attachment(s)/Enclosure(s)

Table 1. Existing Conditions Channel Cross-Section Geometry

Table 1
Existing Conditions Channel Cross-Section Geometry

Cross-Section Analyzed	Full Channel Width			Bankfull Channel		
	Top Width [ft]	Depth [ft]	Flow Area [ft^2]	Top Width [ft]	Depth [ft]	Flow Area [ft^2]
1	94	9	876	30	3	90
2	104	11	1117	27	3	92
3	99	9	855	24	3	75
4	86	8	694	38	3	98
5	110	7	770	No bankfull indicators could be determined from survey data.		
6	89	14	1216			
Average	**97**	**10**	**921**	**30**	**3**	**89**

Appendix H



Date: 2/19/2018 Document Path: P:\111-030 Nature Conservancy\030 Wines Ditch\Mapping\Figure 1 - Wines Ditch No. 1 Rehab Extent.mxd

User Name: TDowning

WWE
Wright Water Engineers, Inc.
1666 N. Main Ave., Ste.C
Durango, CO 81301
(970) 259-7411 ph 259-8758 fx

MESA COUNTY, CO

WINES DITCH NO. 1 - REHABILITATION EXTENT AND LOCATIONS FOR TRIBUTARY CROSSINGS

THE NATURE CONSERVANCY

PROJECT NO. 111-030.030

FIGURE 1

Representative Photos of Recommended Locations for Tributary Crossing Rehabilitation – November 14, 2017 Site Visit

Appendix I

Project Kickoff Meeting Summary
Wines Ditch Project
January 12, 2017
2:00 PM-4:00 PM

Objectives:

- Make sure that all project participants understand the project tasks, timelines, and grant deliverables to the State of Colorado
- Confirm which project partners will be working with WWE on project tasks
- Discussion of initial design considerations
- Set schedule for key full group activities (including the project site visit)

Agenda:

2:00 PM-2:30 PM Introductions and Overview of Project—Celene Hawkins

Introductions

Paul Jones, CPW
Eric Gardunio, CPW
David Graf, CPW
Matt Kondratieff, CPW
Nathan Fey, AW
Mark Hamilton, counsel for Western Sky Investments
Pete Foster, WWE
Hayes Lenhart, WWE
Celene Hawkins, TNC

Overview of Project

Celene (TNC) provided an overview of the project, including a review of the grant-funded tasks. Celene reported that the CWCB is not requiring other entities to track and report matching/in-kind funding, but that each organization providing match or in-kind on this project is responsible for ensuring that it is not reporting Wines Ditch time as a match for another grant.

The project team's discussion of the project scope of work focused on work in Task 4.

- David (CPW) confirmed that there is agreement within CPW that the threat of white sucker introgression is bigger/more important than opening up fish passage at the Wines Ditch location. CPW would like to maintain a fish barrier at the Wines Ditch location, but CPW would also like to have the designs consider options to retrofit the new structure with a holding pool where CPW could manually/physically sort fish in the future.
- Paul (CPW) mentioned that water levels on the Dolores could be high this spring, and that we will need to watch the snowpack and continue close coordination planning field work in 2017.

- Eric (CPW) raised some questions about identification of fish migration patterns in Task 4. The team clarified that the migration pattern information may be needed to inform design work on selective fish passage retrofits/designs and on the velocity barrier (boater passage). Eric and Paul agreed that there is not any highly specific migration information for the Dolores River, but that a key time frame for fish migration is a 3 to 4 month time period around peak runoff (typically April through June or July) because the movement of fish is tied to flow and temperature.
- Nathan (AW) raised a question about the use of a vertical barriers versus velocity barriers to maintain a barrier against white sucker introgression. The team confirmed that safe boater passage is a goal of the project, and we discussed the need for identifying the upper and lower range of flows in the Dolores River where we want to maintain the fish barrier and/or provide safe boater passage. Matt (CPW) noted that it may be difficult to engineer a project that balances the goals of water right protection, boater passage, and a fish barrier.

2:30 PM-3:30 PM Discussion of Initial Design Considerations--WWE

- CPW can provide WWE a response to the initial design considerations memo. Matt (CPW) and Eric (CPW) can provide an overview of information about the aquatic species of concern (white suckers). Matt (CPW), Eric (CPW), David (CPW), and Paul (CPW) will coordinate on this work.
- It is important to engage the BLM in the design considerations related to the fisheries. Team members recommended outreach to Tom Fresquez at the BLM to see if we can engage him in the fisheries side of the work on this project.
- CPW confirmed that CPW is open to the use of grout in this project.
- CPW would like to explore screening on the headgate to prevent entrainment/fish from entering the ditch.
- The team discussed a few considerations with the Wines Ditch headgate. This project will maintain historical water deliveries and safe access to the headgate. The design should prevent boaters from entering the headgate. Any design options that contemplate movement of the headgate need to be discussed with WWE and counsel for Western Sky Investments. In general, the group agreed that designs which would require a significant change in the historic point of diversion should be avoided.
- The team had a more thorough discussion of the design considerations around the Wines Ditch structure operating as a fish barrier and for recreational boater passage. The team agreed that we need to set some high and low flow rates for both the fish barrier operation and the recreational boater passage. American Whitewater has data on the minimum, maximum, and optimum levels for boating the Dolores River, and Nathan (AW) will provide that to WWE.
- Matt (CPW) recommended that WWE look at diversion structures that are already acting as barriers for white suckers (e.g., the diversion on the lower Mancos River).
- Matt (CPW) asked about design considerations for channel stabilization, bank stabilization, and riparian habitat. WWE has identified erosion on river left as a design consideration to be addressed as we evaluate alternatives that will stabilize the banks around the structure.
- Matt (CPW) asked about whether the design for recreational boater passage will focus on flow through passage or on a recreational (whitewater park style) feature. WWE will follow up with BLM and Western Sky Investments on this issue.

- Based on the discussion, WWE will issue a Basis of Design Memo in late March/early April to consolidate input from project participants (as a check-in point before moving forward on design work).

3:30 PM-4:00 PM Next steps, including scheduling of project site visit—Celene Hawkins

The project team discussed the next steps on the project.

- The project team determined that delaying the project site visit until we have some conceptual design alternatives will help maximize the benefit of time spent traveling on-site. We anticipate that the site visit will occur in July or August.
- CPW requested time to look at the survey extent request before the surveyors go on site. Nathan (AW) will also review this request. WWE is also considering the installation of a water level monitoring staff gage downstream of the diversion to help calibrate the HEC-RAS model that will be developed to help inform the conceptual design alternatives. The elevation of the stage of the staff gage would be surveyed such that stage measurements on the gage could be paired with nearby stream gage data. David (CPW) suggested that his office may have an automatic level logger WWE could install for this purpose. WWE will follow up with CPW on this prior to the survey.
- Celene (TNC) asked each of the project participants about the desired level of involvement in the technical work that will occur in between touch points/review points with the whole group. Mark Hamilton and Al Sisson will talk about this and let Celene and WWE know about Western Sky Investment's preferred involvement in specific tasks in the project scope of work.

<u>**Immediate Next Steps**</u>

- **Celene/The Nature Conservancy** will reach out to **Kevin Hyatt/BLM** to make sure that BLM is up to speed on the project and to ask about BLM fisheries involvement in the project.
- **Celene/The Nature Conservancy** will coordinate with **Al and Mark/Western Sky Investments** about that organization's preferred involvement in specific tasks.
- **Hayes/WWE sent** out the survey extent request on January 13, 2017. **CPW (David) and AW (Nathan)** will review these and give comments to WWE by January 20, 2017.
- **Celene/The Nature Conservancy** will put together a set of call notes and circulate those to all project partners. Expect this by January 20, 2017.
- **Nathan/American Whitewater** will provide data/information about minimum/optimum/maximum flows to support existing boater use on this Section of the Dolores River and any revisions or additions to the Initial Design Considerations memo. Due date to WWE—February 3, 2017.
- **Dave, Matt, Paul, Eric/CPW** will provide any revisions or additions to the Initial Design Considerations Memo. Due date to WWE—February 3, 2017.

Upcoming Work

- WWE will work on Tasks 3-5 over the next couple of months. During this time, we anticipate that there will be significant work with CPW and BLM on the fisheries work.
- In late March or early April, the project team should anticipate receiving a Basis of Design Memo from WWE. We will be in touch about scheduling a project team call (if needed at that time).

WWE

MEMORANDUM

To: Wines Ditch Diversion Rehabilitation Project Team
Via Email

From: Hayes Lenhart, P.E. and Pete Foster, P.E
Wright Water Engineers, Inc. and
Shane Sigle, P.E.
Riverwise Engineering, LLC

Date: January 6, 2017

Re: Initial Design Considerations for the Wines Ditch Diversion Rehabilitation Project

The following provides a summary of initial design considerations for the Wines Ditch Diversion Rehabilitation Project. These considerations are intended to serve as a basis for discussion during the project kickoff meeting between all project team members. Wright Water Engineers, Inc. (WWE) is anticipating that Colorado Parks and Wildlife (CPW) will be taking the lead on an evaluation of fish species populations, migration patterns, and aquatic/riparian attributes of the Dolores River, with a special emphasis on species of special concern. This evaluation by CPW will provide a basis for the diversion design alternatives that will be developed by WWE and Riverwise Engineering, LLC. A summary of initial design considerations, which will likely be expanded during our kickoff meeting, are provided as follows:

- Aquatic species of concern and their characteristics which will inform the diversion design:
  - Relevant species
  - Sustained swimming speed(s)
  - Burst swimming speed(s)
  - Jump height(s)
  - Spawning season
  - Predators and any habitat characteristics that protect them from these predators
  - Preferred habitat characteristics such as:
    - Depths
    - Velocities
    - Substrate composition
    - Cover
    - Preferred feeding zones and associated hydraulic characteristics
  - Others?
- Maximum and minimum velocities for the fish barrier
- Maximum and minimum vertical falls for the fish barrier
- Rating curve for maximum / minimum velocities and falls versus discharges
- Specific attraction flow criteria

- Specific turbulence criteria
- Seasonal migration patterns
- Grout vs. non-grout
- Void space recommendations in grouted boulders
- Bank stabilization issues and proposed remediation techniques
- Sediment transport concerns
- Public access and associated improvements
- Headgate safety concerns
- Geo-technical concerns such as bedrock outcroppings and substrate composition
- Floodplain considerations
- Dewatering techniques, and construction timing considerations
- Operational design flows and return periods for the proposed structure alternatives.

MILLER ECOLOGICAL CONSULTANTS, INC.

2404 Thoroughbred Lane
PO Box 1383
Bozeman, MT 59771-1383
(406) 577-2068

MEMORANDUM

Date: June 5, 2017

To: Hayes Lenhart, Wright Water Engineers, Inc.
From: Bill Miller
CC:
Subject: Comments on Wines Ditch No. 1 Diversion Structure Rehabilitation Project, Basis of Design Report

---

I have reviewed the subject document and have several comments and questions regarding the design. My review focused on aspects of the project regarding fish passage and prevention of upstream movement by White Sucker (*Catostomus commersoni*).

The current structure appears to be constructed from native stream bed materials and does not provide a barrier to upstream fish passage. One objective of the rehabilitation is to construct a permanent structure that serves as a fish barrier, in particular, for white sucker. The subject report provides the basis and description of the fish barrier design. The narrative and basis for the design provide sufficient detail for the evaluation of the design.

One consideration for the permanent structure should be the need to provide passage for native species. This consideration is noted in the report and listed as an option for the design. The current structure likely does not prevent upstream passage of native species. Two native species of particular concern are Flannelmouth Sucker and Bluehead Sucker. These species have swimming capabilities similar to the non-native White Sucker. As a result, any barrier to White Sucker is likely a barrier to native suckers. The native suckers have a larval drift component as part of their life history. The result may be a long term decline in native species upstream of the rehabilitated diversion structure is some selective passage component is not included.

The overall design components for the barrier including the velocity and vertical barriers seem appropriate for prevention of upstream movement by White Sucker. As noted above, the structure will also likely preclude upstream movement of native species. I recommend the design include the option of a selective fish passage for native fish passage. The design flow range of 100 cfs to 5000 cfs seems appropriate based on the hydrologic analysis and the seasonal movement of the White Sucker.

The other native species of concern in the Dolores River is Roundtail Chub. Has consideration been given to the need for this species to move upstream and downstream of the diversion structure? I know the species is present in the river but do not know if there are substantial populations in proximity to the diversion structure location. I recommend that CPW be consulted to confirm whether Roundtail Chub should be addressed in the design.

MEMORANDUM

To: Celene Hawkins
The Nature Conservancy
Colorado Field Office
1109 Oak Drive,
Durango, CO 81301
Via email celene.hawkins@TNC.org

From: Hayes Lenhart, P.E. and Pete Foster, P.E
Wright Water Engineers, Inc.

Date: September 6, 2017 – Revised November 29, 2017

Re: Wines Diversion – August 22, 2017 Project Stakeholder Meeting Notes

On August 22, 2017 a project stakeholder meeting was held for the Wines Diversion Rehabilitation Project at the project location in Gateway, Colorado. The primary representative(s) for each project stakeholder group in attendance at the meeting were:

Attendee	Representing
Celene Hawkins	The Nature Conservancy (TNC)
David Graf	Colorado Parks and Wildlife (CPW)
Eric Gardunio	
Nathan Fey	American Whitewater Association (AWA)
Mark Hamilton	Property Owner
William Caile	
Kevin Hyatt	Bureau of Land Management (BLM)
Hayes Lenhart	Wright Water Engineers, Inc. (WWE)
Pete Foster	

Prior to the site visit, WWE provided copies of three conceptual design alternatives to the project stakeholders. During the site visit the group discussed each conceptual design alternative in detail, and discussed the pros and cons of each alternative presented. These notes are organized by an initial discussion of items relevant to all alternatives, followed by a discussion of each conceptual design alternative and associated summary of the group discussion which occurred for each alternative.

General Items Related to All Structures

The BLM is currently working to define the Pre-Federal Land Policy and Management Act of 1976 (Pre-FLPMA) footprint of the historical Wines Diversion Structure.

From a boating perspective this stretch of the Dolores River, which has put-in and take-out locations near Gateway and Stateline, contains at least one Class 4 rapid suggesting that most of the boaters who run this stretch of river are more experienced. As a result, alternatives which could cause hydraulic conditions that require a more experienced boater should not be discounted.

The area around the project location is predominantly natural wilderness area and the aesthetics of the structure should be an important consideration given the setting.

Conceptual Design Alternative 1 – Single Structure

WWE discussed the overall approach for conceptual Alternative 1. It consists of a single continuous drop structure with an overall drop height of approximately 9 feet. This approach minimizes the proposed structures footprint and provides the most robust fish barrier, however it is the least preferred option from a boater safety perspective and would be the most difficult option to provide optional fish passage features as part of the design or in the future. The specific pros, cons, and other considerations for this alternative discussed by the group were as follows:

Pros

- Minimizes the length of the side channel needed to deliver water upstream of the diversion to the wines ditch headgate (less than 200 feet).
- The group agreed that this is likely the least expensive alternative when compared to the other two alternatives.
- The group agreed that this alternative is likely easier to construct when compared to the other two alternatives.
- This has the smallest overall structural footprint when compared to the other alternatives.
- This alternative is the most robust fish barrier.

Cons

- Most difficult alternative to incorporate fish passage during the design and construction phases or in the future.
- Most difficult to modify post construction in the event changes need to be made to control hydraulics at the toe of the drop.
- This alternative has a low to moderate level of boater navigability. Most boaters will likely portage this structure. Will generally require scouting because of the structures horizon line.
- At higher flows a larger and more chaotic hydraulic at the toe of the structure will likely form, resulting in a higher potential for boaters to “swim” and get caught in the hydraulic.
- In the event a boat flips on the structure there is a higher potential for injury to a person in the water when compared to the other alternatives.
- Not an aesthetically pleasing structure.
- Integrating the existing side tributary will be more difficult, and will likely require additional grading and construction activities after the structure has been installed to minimize the potential for the tributary to undermine or destabilize the structure.
- There is a potential for debris accumulation at the top of the drop which may inhibit boater passage and require portaging.

Other General Considerations / Recommendations if Alternative 1 is Selected

- A stakeholder suggested the potential need for a scaled physical model of this drop structure be constructed and tested in a laboratory to evaluate the safety of the hydraulic at the toe of the structure under varying flow conditions.

Alternative 2 – Multiple Structures (Seven Structures)

WWE discussed the overall approach for conceptual Alternative 2. It consists of seven different individual drop structure spaced approximately 100 feet apart from crest to toe of each structure. Four of the structures have overall drop heights of 1 foot and three of the structures have drop heights of approximately 1.5 feet, for a total overall drop height of approximately 9 feet. This approach is the most boater friendly and would be the best approach to facilitate fish passage in the future, however it has the largest footprint and is the least robust fish barrier. The specific pros, cons, and other considerations for this alternative discussed by the group were as follows:

Pros

- Fish bypass can be easily incorporated during the design and construction phases or in the future.
- It is the best alternative from a boater safety and fish passage perspective.
- This is more aesthetically pleasing when compared to Alternative 1.
- Easiest to modify post construction in the event changes need to be made to control hydraulics at the toe of one or more of the drops.
- Integration of the side tributary is less concerning since the tributary will enter between two drop structures.

Cons

- Largest footprint of all the alternatives.
- The group agreed that this is likely the most expensive alternative when compared to the other two alternatives.
- The group agreed that this alternative is likely more difficult to construct when compared to the other two alternatives.
- Longest portage route.
- Maximizes the length of the side channel needed to deliver water upstream of the diversion to the wines ditch headgate (Approximately 500 feet).
- Least robust fish barrier.
- In the event a large sediment load is delivered via the side tributary the two most downstream drops structures could become ineffective fish barriers.

Other General Considerations / Recommendations if Alternative 2 is Selected

- CPW recommends the two most upstream drop structures be combined into a single drop to provide a more robust fish barrier.
- A portage trail, approximately 10 feet wide, should be incorporated onto the river right side between the top bank of the structure and the side channel which will facilitate delivery of water to the Wines Ditch headgate. This will also help minimize the potential for boaters traverse across the side channel delivering water to the headgate and into the BLM's restoration area on this side of the river.
- Escape routes should be considered for each drop structure. If a boater does "swim," they will likely head towards the right bank and onto the previously discussed portage trail. Moving fish passage structures to the left side of the primary channel should be considered to prevent conflict with a boater attempting to escape.
- Restoring and stabilizing the stream in-between each proposed drop structure will need to be considered.
- Installation of J-hooks on the side tributary should be considered to divert water away from the second most downstream drop structure.
- The group agreed that using the diversion side channel in combination with fish screens a means of controlling fish passage was a good approach.

Alternative 3 – Multiple Structures (Three Structures)

WWE discussed the overall approach for conceptual Alternative 3. It consists of three different individual drop structures spaced approximately 200 feet apart from crest to toe of each structure. Each structure has a drop of approximately 3 feet for an overall drop height of approximately 9 feet. This alternative is intended to serve as the "middle ground" between Alternatives 1 and 2. The specific pros, cons, and other considerations for this alternative discussed by the group were as follows:

Pros

- This alternative would provide a higher quality experience for boaters from a recreational perspective when compared to Alternative 1, while Alternative 2 would have the highest quality whitewater out of the three Alternatives considered.
- This alternative would likely provide a more robust fish barrier for a wider range of flow conditions when compared with Alternative 2.
- Strikes a middle ground with respect to construction costs and constructability when compared with the other alternatives.
- Provides a structure footprint that is more likely to fit within a smaller Pre-FLPMA footprint.
- Strikes a middle ground with respect to length of the side channel needed to deliver water upstream of the diversion to the wines ditch headgate when compared with the other alternatives.
- Integration of the side tributary is less concerning since the tributary will enter between two drop structures.
- Higher potential for integration of an operational fish passage structure when compared with Alternative 1.

Cons

- In the event a large sediment load is delivered via the side tributary the most downstream drop structure could become an ineffective fish barrier.
- There is a higher concern for eddies and erosional features to develop at the left and right embankments the structures when compared to Alternative 2.
- Due to the larger structure drop heights associated with Alternative 3, there is a higher likelihood for necessary follow-up maintenance to address unforeseen adverse hydraulic conditions after construction. It is recommended that the project budget include considerations for maintenance after construction to address any adverse hydraulic conditions that develop.

Other General Considerations / Recommendations if Alternative 3 is Selected

- Due to the larger drop height of these structures, a minimum distance of 200 feet between the downstream toe and upstream crest of each structure is recommended to allow a reasonable amount of distance for a boater who "swims" to escape.
- A portage trail, approximately 10 feet wide, should be incorporated onto the river right side between the top bank of the structure and the side channel which will facilitate delivery of water to the Wines Ditch headgate. This will also help minimize the potential for boaters traverse across the side channel delivering water to the headgate and into the BLM's restoration area on this side of the river.
- Escape routes should be considered for each drop structure. If a boater does "swim," they will likely head towards the right bank and onto the previously discussed portage trail. Moving fish passage structures to the left side of the primary channel should be considered to prevent conflict with a boater attempting to escape.
- Restoring and stabilizing the stream in-between each proposed drop structure will need to be considered.
- Installation of J-hooks on the side tributary should be considered to divert water away from the middle drop structure.
- The group agreed that using the diversion side channel in combination with fish screens a means of controlling fish passage was a good approach.

Preferred Alternative Discussion

In general the group agreed that Alternative 3 is the preferred alternative. It is the most balanced approach to meet the overall project objectives of creating a more boater friendly structure and is most likely to achieve the fish barrier requirements with options for fish passage in the future.

The BLM is in the process of finalizing their opinion on the historical structure footprint, which will likely guide the decision for which alternative will be selected.

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MEMORANDUM

Date: February 26, 2018

To: Hayes Lenhart, WWE
From: William J. Miller, PhD, Miller Ecological Consultants, Inc
CC:
Subject: Comments on Draft Wines Ditch Diversion Alternatives Report

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Thanks for the opportunity to review and comment on the subject report. The report is well written and provides the logic for each alternative. I only have one comment on the report. All of my previous comments have been addressed in this revised draft. The incorporation of the option for a future fish passage responds to my comment from the earlier draft. I think it is a good addition to the design. I suggest considering moving the downstream entrance to the fish passage closer to the low flow section of Drop Structure 3 in Alternative 3. The current location may be too far from attraction flow more near the center of the channel and fish may not easily find the passage entrance.

The velocity criteria and drop heights all seem to preclude fish passage based on the best available data. As with all these structures and designs, fish sometimes find the right combination of velocity and depth to move upstream. The proposed design is an improvement over the current nearly unrestricted passage that occurs at the diversion.

Please contact me if you have question regarding my comments.

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