MIDDLE COLORADO RIVER INTEGRATED WATER MANAGEMENT PLAN

February 2021

MIDDLE COLORADO WATERSHED COUNCIL

A Joint Project Of The Middle Colorado Watershed Council And The Mt. Sopris, Bookcliffs, And Southside Conservation Districts.

Bookcliff, Mount Sopris & South Side Conservation Districts

CONSERVATION

Our Land, Our Water, Our Heritage

Garfield - 1

PREPARED FOR

Bookcliff, Mount Sopris & South Side Conservation Districts

CONSERVATION

Our Land, Our Water, Our Heritage

Middle Colorado Watershed Council

PREPARED BY

Colorado River Engineering Incorporated

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WITH SUPPORT FROM

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DISCLAIMER

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EXECUTIVE SUMMARY

The Middle Colorado River Integrated Water Management Plan (IWMP) was conceived as a locally-driven problem-solving process to address the increased likelihood of water scarcity while working to achieve water security for all uses in the Middle Colorado River Watershed. The Middle Colorado Watershed Council (MCWC) and Mount Sopris, Bookcliff and South Side Conservation Districts (Conservation Districts) spearheaded development of the IWMP on behalf of the local communities that rely on the Middle Colorado River. Water users, water rights holders, community members and vested stakeholders all participated in the plan's development. This local input was critical for defining water needs, constraints and issues, and opportunities for optimizing land and water management within the watershed.

Values, needs, and expectations associated with rivers and water use are expanding as economies and demographics in the Middle Colorado River evolve. The Middle Colorado River and its tributaries support the communities of Glenwood Springs, New Castle, Silt, Rifle, Parachute/Battlement Mesa, and De Beque. Each of these communities rely on Colorado River water in a variety of ways. Integrated planning provided the opportunity for our communities and their various economic sectors to come together to identify the collective water needs necessary to continue to improve and grow. Key concerns that provided the initial impetus for stakeholder discussion and evaluation included:

- Population growth: Garfield County's (which encompasses most of the watershed) population was recently estimated at roughly 60,000 people. The County is expected to surpass 80,000 people somewhere between 2025 and 2030, and approach 100,000 people by 2050, according to a growth forecast from the State Demographers Office. More people will place new and changing demands on the region's water supplies.
- Aridification: This term describes a period of transition to an increasingly water scarce environment. Future predictions based on past data and current trends portend temperature-induced runoff declines of 35% or more by the end of the century. Locally, we need to figure out efficiencies and how to do more with less water.
- Colorado River interstate agreements: Water use in western Colorado is ultimately governed by the Law of the River; a collection of interstate laws and agreements apportioning the water and creating a management framework for the multi-state basin. If Colorado fails to uphold its obligations to other states, water use could be curtailed. The two agreements are the Colorado River Compact of 1922 and the Upper Colorado River Compact of 1948.
- Agricultural water shortages and aging infrastructure: The south side of the Colorado River already faces chronic shortages in available water to irrigate crops and raise livestock. As water becomes scarcer, the agricultural water gap is likely to extend to all regions of the Middle Colorado River. Rising temperatures will drive increased plant water needs, increasing agricultural demand as supply shrinks.
- Impaired waterways: Native fish populations have declined in the watershed due to habitat and flow limitations. Non-native, invasive vegetation increasingly dominates waterways, reducing riparian species preferred by native wildlife. Water quality issues have been identified in various locations but require further study into pollutant sources and remediation solutions.

- Demands for recreational uses: As our local communities undergo economic diversification, all appear to be turning to the stream and river corridors as prime opportunities for recreational development. Sufficient flows at key times of year along with environmentally-sensitive developed river access will be in demand as this sector of use increases.
- Public lands: Beetle kill, forest fires, road fragmentation, and aridification are intersecting to impact the health of forest and rangelands in the watershed's headwaters.

IWMP Mission Statement:

To improve security for all water uses in the Middle Colorado River by understanding and protecting existing uses, meeting shortages, and promoting healthy riverine ecosystems and agriculture in the face of increased future demand and climate uncertainty.

IWMP Goals:

- Foster a collaborative approach to water management through shared stewardship.
- Protect existing water uses and secure future water supplies.
- Maintain, or enhance where appropriate, healthy watersheds, rivers and streams.
- Enhance and promote responsible recreational use of local streams and rivers.
- Promote, preserve and protect agriculture.
- Increase resiliency in the regional water supply.
- Promote a resilient and diverse economy.
- Plan to adaptively meet impacts of a changing climate.

This Executive Summary was compiled for use by watershed stakeholders as a quick reference guide for carrying out planned activities that further the mission and goals of the Middle Colorado River Integrated Water Management Plan. It contains written descriptions for each of the Projects, Initiatives, and Studies identified through the planning process, collectively referred to as "Actions".

Information summarized herein is expanded upon in much greater detail in the main document. The full report contains:

- Background on the need for and logistics involved with the planning process;
- Detailed physical characterizations of the watershed;
- Descriptions of existing and future planned water uses, gaps and needs, and risks;
- Additional background on the development of recommended Actions; and
- Technical appendices and IWMP work products and tools.

Stakeholders, through a formalized consensus process, selected a total of 55 Actions to present in the IWMP (Table 1). Some Actions apply to a specific geographic location in the watershed while others are more generalized and can apply to the watershed as a whole.

Table 1. List of identified planning Actions organized by topic area.

Code	Topic	Description
AQ1	Aquatic Biota	Reconfigure Barriers for Fish Passage
AQ2	Aquatic Biota	Install Fish Screens
AQ3	Aquatic Biota	Roan Creek Barrier
AQ4	Aquatic Biota	Process Based Restoration in Rifle Creek Basin
AQ5	Aquatic Biota	Educational Signage About Illegal Transport of Aquatic Species
AQ6	Aquatic Biota	Collaborative Post Fire Watershed Management
AQ7	Aquatic Biota	Participation in Flow Management Forums
AQ8	Aquatic Biota	Renewal of Upper Colorado River Recovery Program
AQ9	Aquatic Biota	Best Practices for Gravel Pit Reclamation
AQ10	Aquatic Biota	Landowner Outreach for Fishery Management Best Practices
AQ11	Aquatic Biota	Citizen Science to Track Invasives
AQ12	Aquatic Biota	Evaluate Fish Movement Above Cameo Diversion
AQ13	Aquatic Biota	Monitor Fish Entrainment in Mainstem Diversion Structures
REC1	Recreation	Recreational River Guide
REC2	Recreation	Improvements Silt Boat Ramp
REC3	Recreation	Rifle Whitewater Park and Recreational In-Channel Diversion
REC4	Recreation	Rulison Boat Ramp
REC5	Recreation	Una Bridge Boat Ramp Improvements
REC6	Recreation	De Beque Canyon Boat Ramp
REC7	Recreation	Riverside Camping Town of Parachute
REC8	Recreation	River Access Facility Improvements
REC9	Recreation	Property Ownership River Signage
REC10	Recreation	River Camping Opportunities
REC11	Recreation	Land Acquisition for River Access
REC12	Recreation	River Trail Planning
REC13	Recreation	Participation in Flow Management Forums
REC14	Recreation	Glenwood Recreational In-Channel Diversion
REC15	Recreation	Flow Preference Survey
REC16	Recreation	Track River Use, Needs, Contributions
WQR1	Water Quality	Water Quality Monitoring Strategy
WQR2	Water Quality	Site-Specific Temperature Standards
WQR3	Water Quality	Riparian Restoration and Invasives Control
WQR4	Water Quality	Pilot Gravel Pit Reclamation
WQR5	Water Quality	Interpretive Education at River Stop
WQR6	Water Quality	Securing Shoshone Water Rights
WQR7	Water Quality	Contract Water for Environmental Support
WQR8	Water Quality	Participation in Flow Management Forums
WQR9	Water Quality	Targeted Outreach for Salinity Control
WQR10	Water Quality	Best Management Practices for Floodplain Uses
WQR11	Water Quality	Incentive Programs for River Habitat Protection
WQR12	Water Quality	Best Practices for Gravel Pit Reclamation
WQR13	Water Quality	Educational Programming to Protect Local Water Resources

Code	Topic	Description
CONS1	Consumptive Use	Agricultural Infrastructure Upgrades
CONS2	Consumptive Use	Streamflow Monitoring
CONS3	Consumptive Use	Kendig Reservoir
CONS4	Consumptive Use	Support Colorado River District
CONS5	Consumptive Use	Encourage Keeping Water Rights Tied to Land
CONS6	Consumptive Use	Local Water Market
CONS7	Consumptive Use	Pilot Local Market for Agricultural Products
CONS8	Consumptive Use	Limit out of Basin Water Exports
CONS9	Consumptive Use	Connect Ag Producers with Funding
CONS10	Consumptive Use	Opportunities ATMs
CONS11	Consumptive Use	Multi-Benefit Water Storage
CONS12	Consumptive Use	Demand Management Investigations
CONS13	Consumptive Use	Irrigation Scheduling Study

These Actions are discussed in greater detail below. For ease of presentation, the watershed is divided into three regions - Upper, Middle and Lower – with corresponding descriptions of physical characteristics, present and future needs and risks, and how the Actions function to secure existing and future water uses in those areas. Actions that apply on a watershed-wide scale are presented in subsequent sections. A one-page, conceptual description of each Action is provided in section 4 of this report.

Upper Section of the Middle Colorado River – Glenwood Canyon to New Castle

Physical Setting

Mainstem: The upper portion of the Middle Colorado River begins where the river descends into Glenwood Canyon. The river flows deep in the canyon here through a variety of rock – igneous, metamorphic and sedimentary – exposing 2400 vertical feet of magnificent and steep terrain. The river gradient is relatively high, forming plunges and rapids along its length. The canyon widens as it reaches the City of Glenwood Springs where it is joined by its largest tributary in the Middle Colorado region, the Roaring Fork River. Here flows increase significantly and the canyon widens to accommodate a narrow ribbon of human settlement extending from Glenwood to New Castle. The upper portion ends where the Grand Hogback, a prominent ridge of inclined sedimentary rock, cuts through the riverbed at the Town of New Castle.

Tributaries: A number of tributaries draining the Flat Tops Plateau enter the river in Glenwood Canyon. Grizzly, No Name, and Dead Horse Creek typify this set of perennial cold-water tributaries - they are steep, numerous, and generally exhibit good water quality. Several small and likewise steep drainages enter Glenwood Canyon on its south side, mostly inaccessible from the canyon bottom. Canyon and Elk Creeks are larger tributaries that join the river downstream of South Canyon. Both are cold-water, perennial stream systems populated with human development where the terrain allows. Other than the Roaring Fork River, South Canyon Creek is the only other significant tributary entering the river from the south through this stretch. Several concentrations of hot springs contribute high loads of warm saline mineralized water in the Glenwood Spring-New Castle corridor.

Present and Future Needs and Risks

Environment: The Grizzly Creek fire of 2020 burned the upper portions of the watershed through Glenwood Canyon, creating an immediate need for a coordinated, long-term recovery and rehabilitation response to reduce the risk of expected post-fire hazards. Water quality in the canyon and downstream will be periodically impacted and coordinated monitoring has taken on a new degree of importance. Water quality in South Canyon Creek is impaired by a combination of natural and human-induced sources. Future decreases in streamflow may exacerbate water quality conditions in the mainstem below wastewater discharges, including temperatures that currently exceed state standards between Glenwood and Rifle. Tamarisk and Russian olive, two aggressively spreading nonnative riparian species, emerge at Glenwood and become increasingly abundant moving downstream and up into the tributaries, outcompeting native vegetation. Cool water conditions support a high-quality trout fishery in the mainstem which could benefit significantly from the removal or reconfiguration of physical barriers that limit fish spawning in the tributaries (i.e., diversion structures and culverts).

Agriculture: Elk Creek supports irrigated agriculture through its lower reaches and higher up along the Hogback through transbasin imports from East Rifle Creek. Much of the existing diversion and conveyance infrastructure is aging and in need of upgrades.

Municipal + Industrial Uses: No Name and Grizzly Creeks are the primary drinking water sources for the City of Glenwood Springs, with auxiliary rights on the Roaring Fork River. Recent fire damage in Glenwood Canyon highlights the risk of reliance on fire-prone watersheds as a municipal drinking water resource; this source will be compromised for years until the area is stabilized and revegetated. New Castle relies on diversions from East Elk Creek, another fire-prone watershed, with supplemental supplies diverted from the Colorado River.

Recreation: River recreation from the Shoshone Power Plant in Glenwood Canyon downstream to New Castle is a significant use from spring through fall. Whitewater paddling, trout fishing, trail usage and visits to local hot springs make significant contributions to the local economy. Future issues include planning for and managing the increasing demand for expanded recreational uses at existing facilities, and maintaining river flows to support the existing number of boater-user days in the face of climate change and a predicted decrease in annual runoff volume.

Managing Needs for the Future

Environment

Water Quality and Riparian (WQR) topic area planning Actions

- WQR1. Water Quality Monitoring Strategy. Water quality monitoring in this reach is needed largely to establish a broader baseline to detect, evaluate and measure future trends. This includes sites on

No Name, Mitchell, South Canyon, and Elk Creeks and sites on the mainstem at Glenwood and South Canyon.

- WQR2. Site-Specific Temperature Standards. The magnitude of and impacts from existing temperature exceedances in the mainstem need to be studied in more detail to understand underlying influences and to develop site-specific standards that are appropriate and achievable moving into a warmer climate.
- WQR3. Riparian Restoration and Invasives Control. Focused tamarisk and Russian olive removal and riparian restoration efforts should be conducted in Elk Creek, as this is the upstream-most tributary that contains large patches of nonnatives. Removal of seed from upstream locations should slow the spread of invasives into downstream waters.

Aquatic Biota (AQ) topic area planning actions

- AQ1 and AQ2. Reconfigure Fish Barriers and Install Screens. Both nonnative trout and native fishes will benefit from the restoration of passage into spawning tributaries. Reconfiguring existing barriers like diversion structures and culverts, along with installing screens to minimize fish entrainment into ditches, is recommended in No Name, Grizzly, Mitchell, Canyon, and Elk Creeks. In some instances, barriers should be maintained to protect other resource values like hatcheries or Conservation Populations of native species.
- AQ6. Collaborative Post-Fire Watershed Management. A coalition of interests should be developed to provide a forum for individual stakeholders, both public and private, to discuss actions, arrive at consensus, and implement solutions to address the most vulnerable areas and natural resource assets affected by the Grizzly Creek fire. It is in the best interest of human and watershed health to collaborate on these efforts at a watershed scale to promote efficiencies, effectiveness, and synergies in response.

<u>Agriculture</u>

Consumptive Use (CONS) topic area planning actions

- CONS1. Infrastructure Upgrades. Conduct needed upgrades of water diversion and conveyance infrastructure to improve operational and water use efficiencies. Combine with fish passage efforts in AQ1/AQ2.

<u>Recreation</u>

Recreation (REC) topic area planning actions

- REC14. Glenwood Recreational In-Channel Diversion (RICD). Support ongoing evaluation and feasibility investigations for a RICD in the vicinity of Glenwood Springs to help ensure sufficient seasonal flows for boating into the future.

Middle Section of the Middle Colorado River – New Castle to Rifle

Physical Setting

Mainstem. After passing through the Grand Hogback, the gradient of the river flattens and the floodplain widens. Natural geomorphic features, constructed berms associated with the interstate and railroad, and occasional artificial bank armoring confines lateral river movement. After Silt, a wider floodplain allows the river to achieve a wandering morphology, transitional between meandering and braided forms. Side channels and vegetated riparian areas are present where unobstructed lateral river movement has occurred in recent history. The Town of Silt and City of Rifle have expanded to both sides of the river where mixed-use development occurs; agricultural parcels are scattered throughout the floodplain and adjoining terraces.

Tributaries. Rifle Creek is the only tributary of significance that enters from the north side after draining off the Flat Tops. Natural springs on East Rifle Creek as well as heavy regulation of Rifle Gap Reservoir ensure that Rifle Creek maintains perennial flows. Tributaries entering from the south include Alkali, Garfield, Divide, Dry Hollow and Mamm Creeks. Drier conditions and smaller, mid-elevation headwater basins on the south side combined with agricultural diversions dries many of these creeks' lower reaches from mid- to late-summer through late fall. Cold water conditions exist in the upper portions of these tributaries, transitioning to cool or warm water temperatures in the lower reaches.

Present and Future Needs and Risks

Environment. Rifle Creek is generally of good quality based upon recent monitoring results but experiences heavy loads of nonpoint source pollutants during storm events. Salts leaching from the application of water to soil on the north side of the river contributes salinity to the mainstem. Selenium and nutrients are possible issues in the south side drainages; more monitoring is necessary to evaluate the extent. Trout as well as native fish species occupy the mainstem and utilize the tributaries as spawning and rearing habitat; diversion structures and other impediments restrict native fishes from use of their original habitat. Reconnecting the tributaries with the mainstem and controlling non-native fish are important measures for offsetting an observed decline in native species populations. Riparian areas from Silt to Rifle are heavily infested with nonnative tamarisk and Russian olive which have a negative effect on river channel movement, floodplain processes, riparian habitat diversity, and overall habitat quality for water-dependent species. Predicted decreasing annual flow volumes, decreased frequency of overbanking events, and reduced monthly flow rates in mid-summer produced by climate change will decrease availability and quality of habitat for native fish and limit recruitment potential for riparian vegetation. This potential for future degradation makes proactive management of water resources for the benefit of environment all the more important.

Agricultural. The north side of the river in the Rifle Creek drainage benefits greatly from the Silt Project. Developed to provide storage as well as expansion of water delivery infrastructure, the Bureau of Reclamation's (BOR) Silt Project includes Rifle Gap Reservoir and an augmented Colorado River pump station that distributes water across formerly dry portions of the Rifle and Elk Creek basins as well as portions of Cactus Valley formerly irrigated with a pump from the Lower Cactus Valley Ditch. The Project allows for increased supply to the Dry Elk Valley and Harvey Gap Reservoir via the Grass Valley Canal by augmenting these diversions with releases from Rifle Gap Reservoir. Much of the area's water delivery infrastructure, BOR- and privately-owned alike, are in need of repair and improvements. Many producers have converted to more irrigation efficient methods because of the increase in reliability of supplies, but more conversion is desirable from a water management perspective—which has potentially negative impacts to domestic well users. Existing and future agricultural water use gaps occur in most tributaries on the south side of the river, particularly in Divide Creek and adjoining basins. Little to no water storage exists on the south side of the river to mitigate the gaps. Agricultural producers on the south side are accustomed to working with whatever runoff they receive early in the season while often experiencing large deficits mid- to late-summer. Modeling indicates this region will be hardest hit as temperatures increase and precipitation and snowmelt patterns change.

Municipal + Industrial Uses: The Colorado River serves as the primary water source for both Silt and Rifle; Silt pumps from shallow groundwater wells and Rifle withdraws directly from the river. This supply is risk-prone should runoff from wildfire-impacted areas or spills along the railroad or I-70 pollute the river. Redundancy and backup supply can mitigate the issue. Geomorphic and riparian impacts from historical and active mining of the gravel-rich alluvial floodplains are evident along the mainstem Colorado River. Oil and gas facilities are abundant in the tributary drainages on the south side and northwest of Rifle.

Recreation. Recreational boaters and paddlers frequent the reach of river from Glenwood to New Castle and on to Silt where public boat ramps are readily accessible. Use is also increasing from Silt to Rifle, capitalizing on the new boat ramp installed by City of Rifle. Anglers use the full section of river for trout fishing, accessing it by either boat or on foot. As recreation use increases between New Castle and Silt, and particularly between Silt and Rifle, improved and expanded access facilities and amenities will be needed, including interspersed opportunities for picnicking, fishing, and overnight camping. With increased river use comes the need for outreach and education to minimize impacts on natural resources and private property.

Managing Needs for the Future

Environment

Water Quality and Riparian (WQR) topic area planning Actions

- WQR1. Water Quality Monitoring Strategy. Water quality monitoring is needed to determine whether waters are suitable for existing uses and to establish a baseline against which future trends can be evaluated and measured. This includes sampling on Alkali, Mamm and Dry Hollow Creeks for selenium, on Rifle Creek for storm-related nonpoint source pollution, and on the Colorado River near Divide Creek and Rifle Creeks.
- WQR9. Salinity Control. More opportunity exists for the use of agricultural cost-share programs to increase water conveyance and application efficiencies for reduced salinity loading. More targeted outreach to irrigators is suggested.
- WQR3. Riparian Restoration and Invasives Control. Continue implementing programs for invasives control on private and public lands along the mainstem. Conduct focused control work on Alkali, Garfield and Divide Creeks, and at the Silt River Preserve to allow for reintroduction and management of native riparian species.

Aquatic Biota (AQ) topic area planning actions

- AQ1 and AQ2. Reconfigure Fish Barriers and Install Screens. Native cool and warmwater fishes will benefit from the restoration of passage into tributaries that include Garfield, Divide, Rifle and Mamm Creeks.
- AQ4. Process Based Restoration in Rifle Creek Basin. Design and install hydrologic restoration-oriented elements to elevate groundwater and encourage riparian species growth in the upper reaches of Rifle Creek. West Rifle Creek can be restored to provide important Bluehead Sucker and Leopard Frog habitat while Butler Creek can benefit from restoration work for the native fishery.

Agriculture

Consumptive Use (CONS) topic area planning actions

- CONS1. Infrastructure Upgrades. Conduct needed upgrades and modernization to water diversion and conveyance infrastructure to improve operational and water use efficiencies. Combine efforts with those described for fish passage in AQ1/AQ2.
- CONS3. Kendig Reservoir. Currently under evaluation, Kendig Reservoir may prove feasible for construction, helping to alleviate water supply gaps on the south side of the river. Stored water could benefit agriculture as well as native fish through environmental releases during critical low flow periods.
- CONS13. Irrigation Scheduling. Irrigated areas below along the Colorado River are good candidates for improved water application efficiencies. Test methodologies like irrigation scheduling using locally collected weather data; useful results could be scaled up for application in other parts of the watershed.

Recreation

Recreation (REC) topic area planning actions

- REC2. Silt Boat Ramp Improvements. Increased use of the relatively new boat ramp suggests the need for additional improvements, specifically additional area for boat launching and improved vehicular circulation to access the ramp area.
- REC3. Rifle Whitewater Park and RICD. Develop a whitewater park in Rifle to serve the increasing demand for river-recreation. Support evaluation and feasibility investigation for a recreational in-channel diversion to ensure adequacy of boatable flows into the future.

Lower Section of the Middle Colorado River – Rifle to De Beque

Physical Setting

Mainstem. River gradient in this stretch is relatively low. The floodplain alternates from wide to narrow as influenced by adjoining man-made and natural geomorphic features. Interstate 70 and the railroad often restrict river movement and floodplain extent north of the main channel. Minor industrial development and agricultural fields occupy the floodplain and adjoining terraces. The vast majority of land in the river valley is privately owned. Parachute/Battlement Mesa and the Town of De Beque are situated along the river.

Tributaries. Parachute and Roan Creeks enter from the north. Parachute Creek cuts through the geologic features of the Roan Plateau to create a narrow and steep-sided valley bottom. Natural springs and seeps occur in the upper reaches of this perennial creek. Roan Creek enters from the north at the Town of De Beque. The Roan Creek basin is quite large compared to other tributary basins in the watershed, with numerous tributaries that also cut through the Roan Plateau and coalesce to form a perennial drainage. Tributaries entering from the south are comparatively short and drain much smaller areas. They tend to be steep and some are intermittent or fully diverted by their mouths, responding to spring runoff and short-term precipitation events. These include Beaver, Cache, Battlement, Wallace, Alkali and Horsethief Creeks, among others. The upper reaches of all the tributaries are cold, transitioning to warmer waters near their confluence with the mainstem.

Present and Future Needs and Risks

Environment: The Pine Gulch fire of 2020 burned through a significant portion of the Roan Creek basin, creating an immediate need for a coordinated, long-term recovery and rehabilitation response to reduce the risk of expected post-fire hazards and repair damages to irrigation infrastructure. Although water quality sampling has been conducted by oil and gas entities, large data gaps exist, both spatial and temporal, such that existing conditions and long-term trends cannot be adequately characterized. Focused and coordinated water quality monitoring is needed—this need has been heightened with the fire damages. Upper portions of Parachute and Roan Creek are being managed for native coldwater fish assemblages; more work is planned to expand and protect these reaches. Physical barriers to fish migration into the tributaries restrict fish movement and use of historical spawning and rearing habitat. The reach of the Colorado River beginning at Rifle (and extending downstream) is designated critical habitat for two federally protected species of fish: the Colorado Pikeminnow and Razorback Sucker. Reconnecting the tributaries and controlling non-native fish will benefit these protected species as well as other natives. Nonnative tamarisk and Russian olive occur in this reach and limit the expansion of native riparian vegetation. Large and small pockets of native cottonwood-willow riparian forests are highly visible from the interstate. These are critically important to connect, protect, and manage as biologically valuable habitat. Predicted decreasing annual flow volumes, decreased frequency of overbanking events, and reduced monthly flow rates in mid-summer produced by climate change will decrease availability and quality of habitat for native fish and limit recruitment potential for riparian vegetation. This potential for future degradation makes proactive management of water resources for the benefit of environment all the more important.

Agriculture Agricultural fields occupy a small portion of lower Parachute Creek and are more extensive in the valley bottom of Roan Creek and its drainages. Information suggests that water rights currently sustaining these ag operations are owned by oil and gas interests; the water continues to be used for irrigation until it is needed for future resource extraction. Irrigated agriculture extends along the south side of the Colorado River and up some of the adjoining terraces and tributaries. Infrastructure upgrades and modernization of diversion and conveyance structures may be beneficial to current users. Opportunities for irrigation efficiencies exist in the north side tributaries, but are difficult to accomplish when most water is owned by oil and gas interests and leased to agricultural producers.

Municipal + Industrial Uses: The Colorado River serves as the primary water source for De Beque and as part of the supply for Parachute and Battlement Mesa. Parachute and Battlement Creeks, as well as nearby springs, make up the remainder of the municipal water portfolio. These supplies are risk-prone from wildfire, oil/gas leaks and spills, or waste spills along the railroad or I-70. Oil and gas development is extensive in this reach and within all the tributaries. The eventual exercise of absolute and conditional water rights owned by oil/gas interests could have a significant impact on water use and availability in this region. Several open water features, including former and active gravel pits, exist along the mainstem.

Recreation: Recreational use in this reach is minimal. New boat ramps have been installed at Parachute and De Beque, allowing for long floats from Rifle to Parachute and from Parachute to De Beque. The Town of Parachute's river concession facilitates short flatwater floating excursions up and downstream of its boat ramp. There is a jet boat concession operating from the De Beque boat launch. Expanded use of the river is currently limited by access as most of the river valley in this reach is privately owned. Waterfowl hunting, on foot or by boat, occurs mostly through arrangement with private landowners. Pressure is increasing to more fully utilize this reach; any expanded uses should be planned and managed to avoid impacts to and conflicts with private landowners. The inclusion of new intermediate access points, picnic facilities, and overnight camping opportunities will allow for expansion of the use for boaters, hunters and naturalists. The numerous islands occupying this reach may be suitable for accommodating visitor use. Outreach and education should be used to minimize impacts on natural resources and private property.

Managing Needs for the Future

Environment

Water Quality and Riparian (WQR) topic area planning Actions

- WQR1. Water Quality Monitoring Strategy. Water quality monitoring is needed to determine whether waters are suitable for existing uses and to establish a baseline to evaluate and measure future trends. This includes sampling on Parachute, Battlement, Dry Fork, and Roan Creeks and on the Colorado River near De Beque to detect and monitor for energy development-related impacts.

- WQR3. Riparian Restoration and Invasives Control. Continue implementing programs for invasives control on private and public lands along the mainstem. Focus effort on areas that can be restored to create large, contiguous corridors of native cottonwood gallery forests.

Aquatic Biota (AQ) topic area planning Actions

- AQ1 and AQ2. Reconfigure Fish Barriers and Install Screens. Native cool and warmwater fishes will benefit from the restoration of passage into Parachute and Roan Creeks.

- AQ3. Roan Creek Barrier. Install a new physical barrier in the upper portions of Roan Creek to isolate and protect a population of native cold-water fish.

- AQ8. Renewal of Recovery Program. Undertake a letter writing campaign to Congress to signify support for reauthorization of the Upper Colorado River Endangered Fish Recovery Program. The current Program benefits all local water users by implementing Endangered Species Act compliance for existing and future water development activities.

- AQ12. Evaluate Fish Movement above the Cameo Diversion. Study the current migration patterns of endangered fish as they attempt to move up and through the Cameo diversion structure. Develop recommended handling procedures based on study results. Downstream of the watershed planning area, this study could help advance goals of the Endangered Fish Recovery Program and benefit water users as described in AQ8.

- AQ6. Collaborative Post-Fire Watershed Management. A coalition of interests should be developed to provide a forum for individual stakeholders, both public and private, to discuss actions, arrive at consensus, and implement solutions to address the most vulnerable areas and natural resource assets affected by the Pine Gulch fire. It is in the best interest of human and watershed health to collaborate on these efforts at a watershed scale to promote efficiencies, effectiveness, and synergies in response.

Agriculture

Consumptive Use (CONS) topic area planning Actions

- CONS1. Infrastructure Upgrades. Conduct needed upgrades to water diversion and conveyance infrastructure to improve operational and water use efficiencies. Combine efforts with those described for fish passage in AQ1/AQ2.

Recreation

Recreation (REC) topic area planning Actions

- REC4. Boat Ramp at Rulison. Construct a new boat ramp at County Road 323. This will provide an intermediate river access point between Rifle and Parachute.

- REC5. Boat Ramp at Una Bridge. Construct a new boat ramp and ancillary facilities at the Una Bridge. This location will provide intermediate river access between Parachute and De Beque, a popular area for waterfowl hunting.
- REC6. Boat Ramp in De Beque Canyon. Construct a boat take-out access ramp in De Beque Canyon upstream of the Cameo diversion. This location, although downstream of the watershed planning boundary, can help promote river recreation in and around the Town of De Beque.
- REC7. Riverside Camping at Parachute. Develop camping and other overnight and day use facilities at Parachute Island Park. Facilities of this kind will help promote river recreation in and around the Town of Parachute.

Watershed-wide Actions

Resource and Habitat Protection through Gravel Mine Reclamation

Existing gravel pits situated along the Colorado River present challenges for aquatic resource managers. Completed gravel pits are largely reclaimed by their original operators as deep, open water bodies that serve as breeding grounds for non-native fishes. During periods of high spring runoff, many of these pits will merge with the Colorado River allowing non-natives to escape to the river where they compete with and severely impact native fish. Opportunities exist to reclaim existing and new gravel pits to conditions that mimic naturally occurring habitats, like riparian forests. Not only will this eliminate breeding grounds for non-native fish, but can also mitigate for losses of riparian habitat often associated with gravel mine operations and conserve water through decreasing evaporation. Actions to address these issues include:

- WQR4 – Pilot Gravel Pit Reclamation. Partner with a gravel mining company interested in piloting a set of best practices for reclamation. Results of the pilot would be used to inform updated county gravel mine reclamation requirements.
- WQR12/AQ9 – Best Practices for Gravel Pit Reclamation. Develop a set of best practices or code/ordinance that could be used by counties and local government when reviewing and permitting future gravel operations.
- AQ5 – Signage about Illegal Transport of Aquatic Species. Install signage in public locations indicating a prohibition against moving non-native aquatic species between waterbodies.
- AQ10 – Landowner Outreach for Fishery Best Management Practices. Conduct outreach to private landowners along the river with open water ponds regarding ways to best manage the resource to prevent escapement of non-native aquatic species.
- AQ11 – Citizen Science Program to Track Invasives. Develop and distribute an app to anglers, guides, and other river users that can help identify and track the location of non-native invasive aquatic species. Data can be used by resource managers for management and control purposes.

Resource and Habitat Protection

Protection of existing aquatic, riparian and floodplain resources is of critical importance for maintaining watershed health and future resiliency. Actions that further this objective include:

- WQR10 – Best Management Practices for Floodplain Uses. Using a recently completed Fluvial Hazards Zone mapping for the Colorado River, develop a set of best management practices to guide allowable future land uses that occur along the river to reduce risks to life, property, and ecosystem function of the river corridor.

- WQR11 – Incentive Programs for River Habitat Protection. Use new and developing tools and funding sources to acquire conservation easements on river corridor properties with significant conservation values.
- AQ13 – Monitor Fish Entrainment. Conduct studies to evaluate the extent to which fish are being entrained in mainstem Colorado River diversion structures. This measure is particularly focused on entrainment of warmwater native fish from Rifle downstream, but can also be applied to trout trapped in ditches upstream of Rifle. Results can be used to inform the need for diversion structure improvements to minimize fish capture.

Protection of Water Flows

Water is already a scare commodity in the Middle Colorado River Watershed. Exercise of existing water rights upstream of the watershed has significantly changed the natural flows patterns and overall runoff volume of the river, most notable by reducing the magnitude and duration of spring flushing flows. Future management of river flows will be challenging in the face of further shifts in flow patterns and diminishing volumes. The following actions have been identified as ways to mitigate these changes:

- WQR6 – Secure Shoshone Water Rights. Work together with other west slope interests to secure the Shoshone Power Plant rights in perpetuity. These senior rights pull flows from the Colorado River headwaters that might otherwise be diverted to the front range, providing a relatively consistent base flow through the Middle Colorado River Watershed during the summer season benefiting irrigation, municipal, recreational, and environmental interests.
- WQR7 – Contract Water for Environmental Support. Identify and secure existing or new sources of upstream reservoir contract water that can be managed to improve habitat or water quality conditions in the middle Colorado River.
- WQR8/AQ7/REC13 – Participation in Flow Management Forums. Designate a representative to participate regularly on behalf of the Middle Colorado River Watershed to articulate local flow management needs and desires during stakeholder-based discussion forums.
- REC15 – Flow Preference Study. Conduct a flow preference study to provide data for both a boatable and fishable days analysis to inform future water use needs.
- CONS2 – Increased Streamflow Monitoring. Install stream gages on priority tributaries to better understand, predict and manage for water availability.
- CONS4. Support for the Colorado River District (CRD). Garner local/regional support for the CRD as it continues its work to protect west slope water – through supporting funding initiatives and ballot measures.

Protecting Water Rights and Agriculture

- CONS5 – Keep Water Right Tied to Land. Promote the development and use of incentive programs that encourage producers to keep their water tied to the underlying land, as an alternative to "buy and dry" programs.
- CONS6 – Local Water Market Leasing. Develop a local market where water rights can be leased to support environmental, recreational, or consumptive uses.
- CONS7 – Pilot a Local Agricultural Goods Market. Design and pilot a market for locally-produced agricultural goods.

- CONS8 – Limit Out-of-Basin Water Exports. Work collaboratively to identify potential basin exports or changes in water rights ownership that could be detrimental to middle Colorado River water uses. Utilize county 1041 authority to limit transactions that may cause economic or water rights injury.
- CONS10 – Agricultural Transfer Mechanisms. Host informational seminars for ag water rights holders on the options for and benefits of leasing water for other uses.
- CONS11. Multi-Benefit Water Storage Projects. Additional study and analysis is needed to evaluate the potential for additional small-scale storage projects within the tributaries. Additional storage and infrastructure upgrades are needed to fill gaps and ensure consistent delivery.
- CONS12 – Demand Management Investigations. Conduct a survey to solicit feedback from consumptive water users on their expectations and requirements for participation in a future water demand management program.

Promoting Responsible River Recreation to Support Local Economies

- REC8 – River Access Facilities Improvements. Ensure that all river access facilities are adequately equipped with trash, picnic, restroom, and other basic amenities. Install uniform and consistent educational information on river use and protection.
- REC9 – Property Ownership Signage. Install riverside signage demarcating boundaries between public and privately-owned property to facilitate responsible river use.
- REC10 – Increase River Camping Opportunities. Support coordination for development of primitive overnight camping opportunities for river visitors.
- REC11 – Land Acquisition for River Access. Coordinate development of a strategic plan for acquiring open space properties for river access and conservation.
- REC12 – River Trail Planning. Coordinate local trail planning efforts to connect each of the communities along the river corridor from Glenwood to De Beque.
- REC16 - Track River Use, Needs and Contributions. Track and assess future river recreational use for prioritizing future recreational development projects, initiatives, and investments.

Education

- REC1 – Recreational River Guide. Develop a hard copy and GeoPDF version of a river atlas that illustrates and locates recreational facilities from Shoshone to the Cameo Diversion. Include information on river ecology, responsible use and river etiquette.
- CONS9 – Connect Ag Producers with Funding Sources. Host events for ag producers to match interested parties with potential partners and funders.
- WQR5 – Interpretive Education at River Stop. Utilize the River Stop Interpretive Center in Rifle as the watershed-wide outlet for public education on watershed-related issues.
- WQR13 – Educational Programming to Protect Local Water Resources. Develop and deliver education programming for: 1) protection and proper management of private drinking water wells, 2) source water protection for municipal water systems, 3) municipal and private water conservation strategies, 4) proper use and need for private water softener systems, and 5) proper use and maintenance of onsite wastewater treatment systems.

TERMS & ACRONYMS

1041 Authority: provides the authority for local governments to identify, designate, and regulate areas and activities of state interest through a local permitting process as defined by C.R.S. § 24-65.1-101

Alluvial: River segments characterized by broad floodplains and active lateral channel movement.

ATM: Alternative water transfer methods

AVLT: Aspen Valley Land Trust

AW: American Whitewater

BIP: Basin Implementation Plan

BLM: U.S. Bureau of Land Management

BOR: U.S. Bureau of Reclamation

BWCD: Bluestone Water Conservancy District

CAWA: Colorado Ag Water Alliance

CBRT: Colorado Basin Roundtable

CCA: Colorado Cattlemen's Association

CCALT: Colorado Cattlemen's Agricultural Land Trust

CDOT: Colorado Department of Transportation

CDPHE: Colorado Department of Public Health and Environment

CDs: Mount Sopris, Bookcliff, South Side Conservation Districts

CDSS: Colorado Decision Support System

Cfs: Cubic feet per second

CHIP: Colorado Headwaters Invasives Partnership

CNHP: Colorado Natural Heritage Program

CMC: Colorado Mountain College

Conditional water rights: Water rights that are decreed by a Colorado Water Court but are not yet in use.

Consumptive use: Uses of water that remove physical water from the system through evaporation, transpiration, or export from a basin. Agricultural and industrial uses are generally considered consumptive uses.

CRD: Colorado River District

CROS: Coordinated River Operations

CSU: Colorado State University

CPW: Colorado Parks and Wildlife

CWCB: Colorado Water Conservation Board

DCP: Drought contingency plan

Decreed water rights: Water rights confirmed by a Colorado Water Court for beneficial use.

Demand shortages: The difference between the water available to support a given consumptive or non-consumptive use and the demand for that use.

DOLA: Colorado Department of Local Affairs

DMRS: Colorado Division of Mining, Reclamation and Safety

DWR: Colorado Division of Water Resources

EQIP: Environmental Quality Incentives Program

ERWC: Eagle River Watershed Council

ESA: Endangered Species Act

FHZ: Fluvial Hazard Zone

GRIT: Greater Rifle Improvement Team

GVIC: Grand Valley Irrigation Company

GVWUA: Grand Valley Water Users Association

HUP: Historic Users Pool

Hydrological regime: The characteristic behaviors of streamflow observed or expected on a given segment of stream.

Invasive species: Plants or animals that are not native to a basin or stream. These organisms tend to disrupt local ecosystems and can, eventually, displace many native species.

IPP: Identified Project and Processes included in the Colorado Basin Implementation Plan

ISF water right: Instream flow water rights held by the CWCB for the protection of aquatic species.

IWMP: Integrated Water Management Plan

LoVa: Lower Valley Trails Group

MCWC: Middle Colorado Watershed Council

MGPD: million gallons per day

NGWOS: Next Generation Water Observing System

NRCS: U.S. Natural Resource Conservation Service

NWS: National Weather Service

ORV: Outstanding Recreational Value

OWTS: On-site wastewater treatment system

Prior appropriation doctrine: The system of water right allocations and administration in Colorado that gives older users in a system the first opportunity to use water in periods of scarcity.

Recurrence interval: The inter-annual frequency with which an event occurs.

Recovery Program: Upper Colorado River Endangered Fish Recovery Program

REW: RiversEdge West

RFC: Roaring Fork Conservancy

RFTA: Roaring Fork Transportation Authority

RICD: Recreational In-Channel Diversion

Riparian zones: The vegetated areas adjacent to streams and rivers that tend to support high levels of biodiversity.

SDO: Colorado State Demographer Office

StateMod: The simulation model used by the CWCB to simulate hydrology and water rights administration in basins across Colorado.

T&E: Threatened and endangered species

TU: Trout Unlimited

TMD: Transmountain diversion of water from the Colorado's west slope to the east slope.

USDA: United States Department of Agriculture

USFS: United States Forest Service

USGS: United States Geological Service

USFWS: U.S. Fish and Wildlife Service

Water supply gaps: The amount of water required to make up the difference between the water available to support a given consumptive or non-consumptive use and the demand for that use.

WRTDS: Weighted regression of time, discharge and season

W&S SG: Upper Colorado River Wild and Scenic Stakeholders Group

WCCC: Western Colorado Conservation Corps

WDWCD: West Divide Water Conservancy District

1. BACKGROUND AND PURPOSE

As residents of the state of Colorado, we collectively have an obligation to manage our water resources wisely to ensure we have adequate future supplies. Current estimates show a statewide shortfall in supply of nearly 600,000 acre-feet of water by the year 2050. Most of this shortfall is based on demands from anticipated urban growth in the Front Range. While actual water use can vary widely from one geography to another, a typical household uses about 1/2 an acre-foot of water per year. The effects of shortages will be felt by water users throughout the state.

In recognition of projected shortages and the need for cooperative planning, the Colorado Water Conservation Board (CWCB) is encouraging and supporting development of water management plans at a localized, watershed scale. Local water users are in the best position to determine their individual and collective water needs and how best to manage and fulfill those needs in the face of increasing demands and diminishing supplies. Grassroots planning efforts enjoy more success because of the local cooperation and partnerships that form in the process. The term ‘integrated’ is used in the planning process to signify that all water uses -- agricultural, industrial, municipal, environmental and recreational -- are important to consider in a balanced manner that reflects local values. Together, water users from these various sectors have joined the discussions in developing voluntary-based, solution-oriented projects and programs, all part of the integrated plan, to ensure our local water security into the future.

The Middle Colorado River Integrated Water Management Plan (IWMP) was conceived as a locally-driven problem-solving process to address the increased likelihood of water scarcity while working to achieve water security for all uses in the Middle Colorado River Watershed. The Middle Colorado Watershed Council (MCWC) and Mount Sopris, Bookcliff and South Side Conservation Districts (Conservation Districts) spearheaded development of the IWMP on behalf of the local communities that rely on the Middle Colorado River. Water users, water rights holders, community members and vested stakeholders all participated in the plan’s development. This local input was critical for defining water needs, constraints and issues, and opportunities for optimizing land and water management within the watershed.

Values, needs, and expectations associated with rivers and water use are expanding as economies and demographics in the Middle Colorado River evolve. The Middle Colorado River and its tributaries support the communities of Glenwood Springs, New Castle, Silt, Rifle, Parachute/Battlement Mesa, and De Beque. Each of these communities rely on Colorado River water in a variety of ways. Integrated planning offered the opportunity for our communities and their various economic sectors to come together to identify the collective water needs necessary to continue to improve and grow. Key concerns that provided the impetus for stakeholder discussion and evaluation included:

- Population growth: Garfield County’s (which encompasses most of the watershed) population was recently estimated at roughly 60,000 people. The County is expected to surpass 80,000 people somewhere between 2025 and 2030, and top 100,000 people between 2035 and 2040, according to a growth forecast from the State Demographers Office. More people will place new and changing demands on the region's water supplies.

- Aridification: This term describes a period of transition to an increasingly water scarce environment. Future predictions based on past data and current trends portend temperature-induced runoff declines of 35% or more by the end of the century.[1] Locally, we need to figure out efficiencies and how to do more with less water.
- Colorado River interstate agreements: Water use in western Colorado is ultimately governed by the Law of the River; a collection of interstate laws and agreements apportioning the water and creating a management framework for the multi-state basin. If Colorado fails to uphold its obligations to other states, water use could be curtailed. The two agreements are the Colorado River Compact of 1922 and the Upper Colorado River Compact of 1948.
- Agricultural water shortages and aging infrastructure: The south side of the Colorado River already faces chronic shortages in available water to irrigate crops and raise livestock. As water becomes scarcer, the agricultural water gap is likely to extend to all regions of the Middle Colorado River. Rising temperatures will drive increased plant water needs, increasing agricultural demand as supply shrinks.
- Impaired waterways: Native fish populations have declined in the watershed due to habitat and flow limitations. Non-native, invasive vegetation increasingly dominates waterways, reducing riparian species preferred by native wildlife. Water quality issues have been identified in various locations but require further study into pollutant sources and remediation solutions.
- Demands for recreational uses: As our local communities undergo economic diversification, all appear to be turning to the stream and river corridors as prime opportunities for recreational development. Sufficient flows at key times of year along with environmentally-sensitive developed river access will be in demand as this sector of use increases.
- Public lands: Beetle kill, forest fires, access roads, and aridification are intersecting to impact the quality of forest and rangelands in the watershed's headwaters.

The MCWC and Conservation Districts spent nearly two years working side by side to determine water-related needs for agricultural, municipal, industrial, environmental and recreational uses within the watershed. For consistency with the Colorado Water Plan, the planning time frame extends a look 30 years forward to 2050.

- Agricultural Needs Assessment. The Districts worked closely with the agricultural communities in the tributary basins to the Colorado River. A needs assessment was performed to map irrigated acreages and understand water efficiencies in existing irrigation water conveyance and application systems.
- Municipal Needs. Adequacy of short-and long-term potable water needs for residential, business, and municipal use were evaluated in cooperation with each of the communities in the watershed.

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[1] Udall, B. and J. Overpeck (2017), The twenty-first century Colorado River hot drought and implications for the future, Water Resour. Res., 53, 2404– 2418, doi:10.1002/2016WR019638.

- Industrial Needs. The largest industrial consumers of water are those that extract resources. These needs are expected to grow over time and may increase significantly depending on the development of oil shale.
- Environmental Needs. The ecological health and integrity of the mainstem Colorado River was characterized to identify problematic reaches and issues, any sources of degradation that can be mitigated, and to identify flows needed to maintain system resiliency.
- Recreational Needs. Community members and user group representatives were engaged in a process to identify existing and future recreational development needs along the 77-mile continuum of the mainstem Colorado River.

IWMP Mission Statement:

To improve security for all water uses in the Middle Colorado River by understanding and protecting existing uses, meeting shortages, and promoting healthy riverine ecosystems and agriculture in the face of increased future demand and climate uncertainty.

Tight interrelationships between water, agriculture, recreation, tourism and industry create a complex template for understanding and optimizing management of limited water resources to support the diversity of use needs in the Middle Colorado River Watershed. Nonetheless, comprehensive water management decision making supported by this planning effort can promote collaborative learning about the system, help develop a shared understanding of tradeoffs involved in any given management action, and identify projects and processes to help optimize management of water for the full diversity of needs. The primary goals of the IWMP were defined by local stakeholders to include the following:

- Foster a collaborative approach to water management through shared stewardship.
- Protect existing water uses and secure future water supplies.
- Maintain, or enhance where appropriate, healthy watersheds, rivers and streams.
- Enhance and promote responsible recreational use of local streams and rivers.
- Promote, preserve and protect agriculture.
- Increase resiliency in the regional water supply.
- Promote a resilient and diverse economy.
- Plan to adaptively meet impacts of a changing climate.

1.1 Planning Context

The Middle Colorado River Watershed is large and complex from a water-use standpoint. Mainstem Colorado River flows are determined in large part by water management actions upstream and downstream of the watershed, beyond local users or jurisdictional control. This work establishes environmental and recreational water needs for the mainstem Colorado River where these uses are most visible and, perhaps, critical. Agricultural uses are more extensive on the tributaries and, accordingly, the analysis focuses on irrigation system needs in the sub-basins that are tributary to the Colorado River. The results are not complete or exhaustive, but establish a significant foundation for launching future evaluations and implementing cooperative projects and programs. The Plan is considered a working document and should serve as a guide, reference document, and testament to what local communities can achieve when working cooperatively in partnership with each other.

1.1.1 Connections to Statewide and Regional Water Planning

The Colorado Water Plan, completed in 2015, was developed to understand the state's water needs, identify gaps and promote projects and processes to meet those needs. Colorado's Water Plan leveraged and integrated the work accomplished by Colorado's nine Basin Roundtables to determine how to implement water supply planning solutions that meet Colorado's future water needs while supporting healthy watersheds and the environment; robust recreation and tourism economies; vibrant and sustainable cities; and viable and productive agriculture. As the regional level water planning cooperative, the Colorado Basin Roundtable (CBRT) identified basin-wide integrated water management planning as a top priority in its Basin Implementation Plan (BIP). Planning is a vital part of meeting agricultural and municipal needs while providing sufficient water for environmental and recreational needs in addition to satisfying the many other uses and demands for water. The CBRT planning goal articulates restoring and protecting ecological processes that connect land and water while ensuring that our rivers also serve the needs of human populations. Implementation of plan recommendations is intended to be voluntary and will only be successful with collaboration and cooperation among affected stakeholders and water rights holders. The BIP begins with the following vision statement:

> "… a Colorado River basin that is home to thriving communities benefiting from vibrant, healthy rivers and outstanding water quality that provides for all of the Colorado Basin's needs. We acknowledge the interdependence of the varied Basin water users. Protecting the water and river flows that will ensure the future for all of us is a high priority. We also recognize that the influence of historic drought patterns, the uncertainty of climate change, population growth, energy development and Compact compliance are interwoven within this vision. Much of this vision's success depends on how we collectively adapt to these forces."

The relationships between local, regional and state-level water planning can be viewed as a hierarchy. Numerous IWMPs, created at the scale of the watershed or stream reach, inform the priorities articulated in each Roundtable's BIP. The BIPs, in turn, respond to the needs for regional planning and project prioritization called out in the Colorado Water Plan. MCWC implemented this planning effort to reflect the broad goals laid out by the CWP and the CBRT, while also responding to the specific conditions and concerns that present themselves in rivers and communities across the Middle Colorado River Watershed. The list of objectives and recommended actions produced by this planning effort provide a locally-vetted set of Identified Projects and Processes (IPPs) that can be readily incorporated into future versions of the BIP.

The scope of this planning effort was tailored to recognize potential overlap and/or synergies with other ongoing planning activities. The Wild and Scenic Alternatives process and the Garfield County Comprehensive Plan Update were two of the concurrent planning efforts recognized by the IWMP.

1.1.2 Wild and Scenic Rivers Management Alternative

BLM and USFS determined that a portion of the Middle Colorado River was eligible for federal Wild and Scenic designation for having Outstandingly Remarkable Values (ORVs). Wild and Scenic designation can, but does not always, come with some sort of streamflow protection. In 2008, the Upper Colorado River Wild and Scenic Stakeholder Group (W&S SG), a group made up of state and federal agencies, water suppliers and users, and environmental and recreational groups began work on a plan to protect those identified values without designating the reach Wild and Scenic. The reach identified within the Middle Colorado River is essentially Glenwood Canyon, beginning at Dotsero and running to the National Forest boundary on the west end of the canyon. The BLM and USFS determined this reach's ORVs were scenic, recreational, and geological in nature. In 2012, the stakeholder group agreed to a management plan for this reach and others upstream to preserve those ORVs. Alternatives to the designation include supporting CWCB instream flow appropriations, delivering water to downstream demands, protecting downstream senior calls (i.e., Cameo and Shoshone), the potential purchase of additional water supplies for the reach, and strategic reservoir releases. Critically, the stakeholder group agreed to monitor the ORVs to track their protection. In sum, although a portion of the Middle Colorado River has eligibility requirements for Wild and Scenic designation, the BLM and USFS agreed to an alternative management strategy for protecting those ORVs.[2]

Planning around the management activities required to protect the ORVs in this section of river is ongoing. Due to the potential overlapping processes and competing planning recommendations, the geographic scope for most topic areas of the IWMP was limited to the section of the watershed below the confluence of the Colorado River and the Roaring Fork River. Limited analysis of water quality, geomorphic, and riparian conditions still occur here for the Glenwood Canyon reach.

1.1.3 Garfield County Comprehensive Plan Update

Development of the IWMP coincided with an update to Garfield County's Comprehensive Plan for 2030. Throughout the IWMP planning effort, staff from Garfield County were engaged in discussions, goal and objective setting exercises, and in the identification of recommended Actions. At several points, members of the IWMP planning team engaged directly with Garfield County staff to discuss opportunities for the planning process to yield information that could inform or be directly incorporated into the sections of the Comprehensive Plan that deal with water use. This was an important outcome for the IWMP effort as Garfield County covers a majority of the Middle Colorado River Watershed.

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2 Upper Colorado River Wild and Scenic Stakeholder Group. "Upper Colorado River Wild and Scenic Stakeholder Group Management Plan," January 2012.

1.2 Stakeholder Engagement

Stakeholder engagement has been extensive over the 30-month planning period, principally utilizing an Advisory Committee platform, open to the public, that met on twelve occasions between October 2018 and October 2020. The Committee was charged with: 1) understanding water use needs and risks in the watershed through a series of educational and information sharing sessions, 2) developing the scope for technical evaluations on water use needs and gaps, 3) establishing the overarching planning mission and setting goals for achieving that mission, and 4) selecting a set of Actions intended to meet, offset or mitigate existing or future water use-related gaps and needs. This diverse group included representatives from all major water user and management sectors: municipal and local governments; federal and state natural resource agencies; national, state, and regional NGOs; water conservancy districts; conservation districts; energy industry; local universities; local outfitters/guides; special interest groups; and technical consultants.

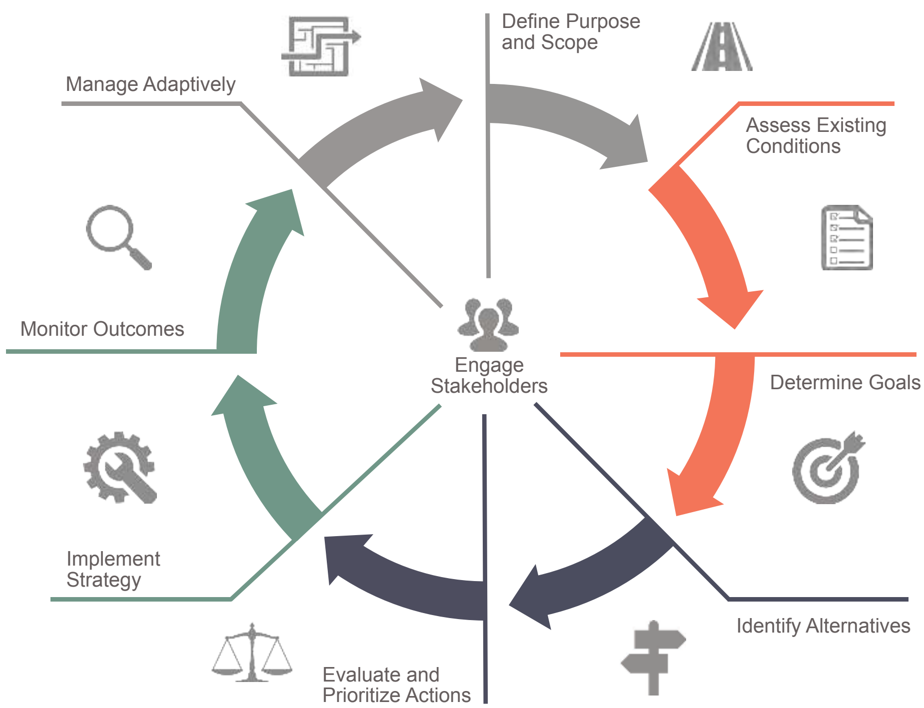

Figure 1. Modification of the Rational Planning Model[3] to accommodate the unique needs of Integrated Water Management Planning on Colorado streams and rivers.

Four focus groups were assembled to address technical matters within the topics of Water Quality and Riparian Areas, Aquatics, Recreation, and Consumptive Uses; the groups collectively met on twenty-three

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[3] Taylor, N., (1998). Urban Planning Theory since 1945. London: Sage Publications. pp. 67–68.

occasions between December 2018 and March 2020. Each group was charged with identifying a set of objectives that would meet the overarching goals set forth by the Advisory Committee, developing a set of recommended Actions to meet the objectives, and presenting its Actions to the Advisory Committee for group consensus.[4] A stepwise planning process, as illustrated in Figure 1, was utilized in working with the Advisory Committee and focus groups. The IWMP process began at the top of the wheel with Defining a Purpose and Scope and continued through the cycle to Evaluation and Prioritization of Actions. It will be up to the collective efforts of stakeholders to continue through the wheel with future work on Implementation, Monitoring and Adaptive Management.

1.3 Planning Area

The Middle Colorado River Watershed, extends from the top of Glenwood Canyon downstream to the head of De Beque Canyon. This 77-mile stretch of the mainstem of the Colorado River supports a number of communities (Glenwood Springs, New Castle, Silt, Rifle, Parachute/Battlement Mesa, and De Beque) that each rely on Colorado River water in a variety of ways. Analyses and evaluations in the various topic areas of this plan (aquatic biota, consumptive use, recreation, water quality and riparian conditions) vary in their geographic scope and coverage within the planning area due to data availability, stakeholder jurisdictions, the desire to avoid overlapping other major existing planning efforts, and other criteria.

[4] Meeting notes and presentations can be accessed at https://www.midcowatershed.org/iwmp-adcomm.

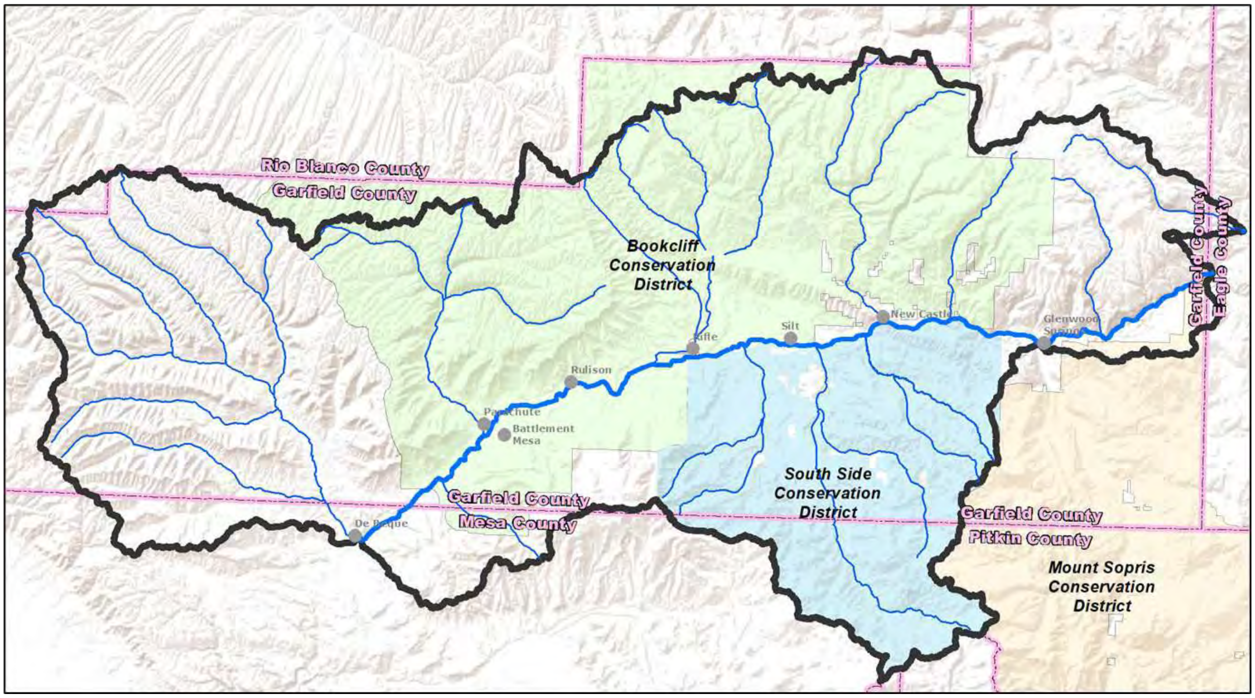

Figure 2. Map of the Middle Colorado River Watershed showing the six communities and the bounds of the three conservation districts.

2 EXISTING CONDITIONS AND RISKS

Rivers and streams freely provide a number of economic and social benefits to communities in the Middle Colorado River Watershed. These include clean water for municipal and agricultural use, flood protection, and landscape aesthetics—values to society that can be measured in terms of human health, direct economic valuation, or quality of life[5]. Reflection on the relationships between ecological conditions and the balance between supply and demand for the services rivers provide to communities can elucidate important opportunities and constraints for resource management actions that benefit river ecology.

Ecosystem goods and services considered here fall into the following categories: provisioning services, regulating and maintenance services, and cultural services. Provisioning services include energy or material outputs from the river system. They include water supply for agricultural, municipal, hydropower, and industrial uses. Regulating and maintenance services include the downstream flood abatement and groundwater recharge provided by unconfined, undeveloped floodplains; erosion control and soil loss avoidance derived from intact and healthy riparian zones; and the self-purification and nutrient-assimilation processes occurring in the water column and floodplain. Cultural services include the sense of identity provided to communities from streams and rivers, the psychological and spiritual value individuals derive from nature, and the numerous socio-economic benefits that arise from recreational boating, angling, and other social uses of river ecosystems.[6]

Planning for optimized water use and management requires a shared understanding of the provision of ecosystem goods and services provided by streams and rivers. The IWMP explores the known connections between the physical and biological conditions of the river corridor and the quality and quantity of ecosystem goods and services enjoyed by local residents and visitors. Comprehensive assessment of ecological conditions helps reduce the chance that recommended projects or management actions produce unforeseen detrimental effects. Recommendations for structured evaluations of ecosystem condition were made by the CBRT in 2016[7] and are used here to organize results from field investigations and data analysis exercises. This approach is designed to integrate multiple river science perspectives to give a holistic view of stream health. Characterizations of ecosystem condition fall into the following categories: flow regime, sediment regime, water quality, network connectivity, floodplain hydrology, riparian vegetation, fluvial geomorphology, structural complexity, and aquatic biota.

The structural form and functional integrity of a riverine system is described by a suite of hydrological, physiochemical, biological, geomorphological, and hydraulic processes. Complex interactions occur between

[5] Maes, J., Liquete, C., Teller, A., Erhard, M., Paracchini, M.L., Barredo, J.I., Grizzetti, B., Cardoso, A., Somma, F., Petersen, J.E. and Meiner, A., (2016). An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem services, 17, 14-23.

[6] Lotic Hydrological, Integrated Water Management Planning In The Colorado River Basin, June 2018.

[7] Id.

each process, complicating evaluation of any one component of the system in isolation from the others. However, the overall form and function of a river is heavily influenced by its natural hydrology. In turn, fluvial ecologists often treat flow regime as the "master variable" exerting the largest influence on riverine ecosystem form and function.[8] The Natural Flow Paradigm postulates that hydrology is a key driver of riverine structure and function. It follows, then, that a general understanding of the ways in which water use and management activities affect patterns of streamflow in the planning area is crucial for evaluating the interplay between ecosystem structure and the ability of a river system to provide valuable goods and services to local communities.

To support scenario planning that considers the provision of ecosystem goods and services, several of the following sections identify numeric streamflow metrics and/or thresholds related to channel morphology, riparian forest health, aquatic habitat quality, etc. that can be used to compare the current state of the system to potential future states. Please note that care should be taken in the adoption and application of these metrics as the basis for management decisions. While these targets may be useful for supporting some aspects of ecosystem condition, the strict adherence of management regimes to these numerical flow thresholds without broader consideration of the influence of land and vegetation management, resource extraction, invasive species, etc. will likely end in failure to meet broadly stated goals or objectives.

2.1 Hydrological Regime Behavior

Broad patterns of precipitation, air temperature, and topography determine a river's natural flow regime. The flow regime may be altered by human activities such as water management (withdrawals, augmentation), dams and reservoirs, or by widespread land use changes in the watershed. Alterations to natural patterns of flow, including the frequency and timing of floods and droughts, impact fish, aquatic insects, and other biota with life history strategies tied to predictable flow patterns. Changes to peak flows may impact channel stability, riparian vegetation, floodplain functions, and biological community reproductive cues. Impacts to base flows may alter water quality and the availability of aquatic habitat.[9] High inter-annual variability in the timing and volume of snowmelt flows is a key feature of the Colorado River system, making long term trends in either climate/hydrology or human uses a significant endeavor to sort out (Figure 3).

Analysis of the natural vs. existing/managed flow regime along the Colorado River mainstem through the planning area consisted of a review of hydrographs and statistical summaries of Colorado Decision Support System (CDSS) StateMod simulation model outputs provided by the Colorado Mesa University IWMP Data Dashboards. Those results indicate that impacts of human water management manifest on both high flow and low flow behaviors in this reach of river. Water storage and use upstream of the Middle Colorado River Watershed contributes to an estimated 27% reduction in the median 3-day maximum annual flows downstream of Glenwood Springs. Conversely, late summer releases of water from upstream reservoirs

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[8] Poff et al., "The Natural Flow Regime," BioScience, vol. 47, no. 11, pp. 769–784, Dec. 1997.

[9] Id.

needed to satisfy the Cameo Call increase 7-day minimum flows by an estimated 19%. This pattern of decreased peak flows and increased base flows is typical of streamflows altered by reservoir operations. The combined effects of reservoir development, increasing consumptive water use and, perhaps, climate change and long-term drought are readily observed in the historical streamflow records collected on the Colorado River downstream of Glenwood Springs (USGS 09085100) and on the Colorado River near Cameo (USGS 09095500). Cameo is the closest long-term gauge site to the outlet of the study area, and relatively little tributary water enters the river between the study area boundary (Roan Creek/De Beque) and this gauge, making it an accurate representation of mainstem flow in the Middle Colorado River region. Over the period of record (1933-2020), a significant (p-value < 0.05) downward trend is observed in annual maximum 1-day, 7-day, and 30-day flows (Figure 3). Trends in low-flow behavior are less definitive. No significant trend is observed over the entire period of record for annual minimum 1-day or 7-day flows (Figure 4). However, the period from 1980 to the present day shows a decline in both metrics toward values similar to those observed in the early 20th century.

A further exploration of the data for significant temporal step changes shows statistically significant differences in minimum flow behavior on the Colorado River mainstem for the following time periods: 1933-1960, 1960-1999, and 1999-2020 (Figure 6). These periods roughly coincide with the completion of Dillon Reservoir in 1960 and the changes in operation of Green Mountain Reservoir following the release of the Programmatic Biological Opinion in 1999. Although the details of reservoir operations can be complicated, the headwaters reservoirs and their associated transmountain diversions tend to reduce peak spring and summer flows during reservoir fill, then release water during late summer. The combined effect tends to alter hydrographs to have lower peak-flows and higher low-flows than would occur naturally.[10,11,12] The observed step changes in low flow behavior may be related to upstream water management actions, multi-decadal flow variability, or some combination of the two.

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[10] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction. 57 pp.

[11] Osmundson, D. B., Ryel, R. J., Lamarra, V. L., & Pitlick, J. (2002). Flow–sediment–biota relations: implications for river regulation effects on native fish abundance. Ecological Applications, 12(6), 1719-1739.

[12] Schmidt, J. C., & Wilcock, P. R. (2008). Metrics for assessing the downstream effects of dams. Water Resources Research, 44(4).

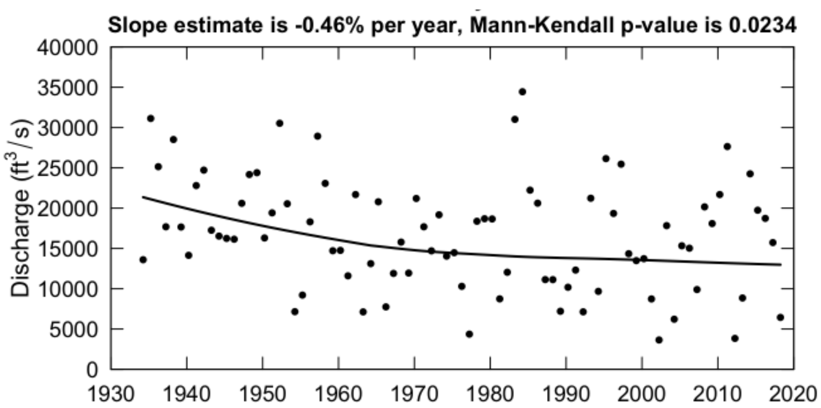

Figure 3. Trends in annual maximum 7-day streamflow observed on the Colorado River near Cameo. Observed data points plotted as dots and a loess fit to the data is indicated as a black line.

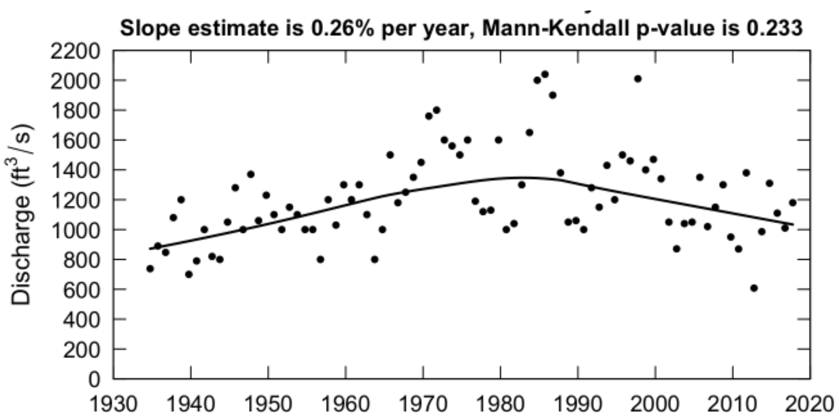

Figure 4. Trends in the annual minimum 1-day flow observed on the Colorado River near Cameo. Observed data points plotted as dots and a loess fit to the data is indicated as a black line.

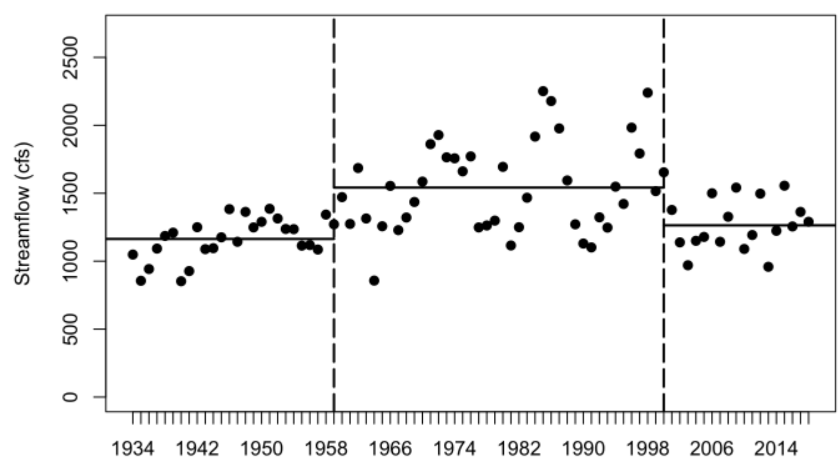

Figure 5. Time series of mean annual 7-day minimum flow on the Colorado River near Cameo. Statistically significant temporal step changes indicated by vertical dashed lines.

Effective planning requires assessment of the risks to high value water uses both now and in the future. This section discusses historical administration and management of water and potential changes in hydrology in the Middle Colorado River Watershed brought about by climate change, population growth, water development, and other human or natural factors.

2.1.1 Overview of Colorado Water Rights System

At its heart, the IWMP is a water planning document. As such, it is critical to view it within the context of existing legal and administrative frameworks for water use and management in Colorado. A brief introduction to those frameworks and some major controls on water use and management in the Middle Colorado River Watershed are discussed in the sections below.

The Colorado Division of Water Resources (DWR), a state agency housed within the Department of Natural Resources, administers water rights in Colorado.[13] Water rights are a property rights, separate and distinct from land ownership, that entitles the holder to use water from a natural stream, without waste, for a beneficial use.[14] Water rights are created through application of water to a beneficial use, and are confirmed by the state's system of water courts. There is no official enumerated list of authorized beneficial uses[15], though the most common ones are irrigation, domestic, industrial, and municipal uses. A water right's water court decree will typically specify a point of diversion, maximum flow rate (in cubic feet per second or "cfs"), beneficial use, and place of use. Any desired modification of a water right's use not contemplated in its decree must be approved by the water court through what is commonly known as a 'change case.' A water court will approve the desired modifications if the applicant shows the proposed change will not injure other water users.

Colorado allocates water according to the Prior Appropriation Doctrine. In times of water shortage, the water right first confirmed by judicial decree has a superior right to divert as against those confirmed subsequently, giving rise to the phrase "first in time, first in right."[16] Upon an administrative 'call', DWR will curtail so-called junior water rights in order to deliver water to the calling senior right. Water rights with senior priorities are more reliable in drier years than water rights with junior priorities; however, there are statutory mechanisms that may improve the reliability of junior water rights, such as plans for augmentation.[17] The same is true for reservoirs: water stored in reservoirs must be stored under the reservoir's priority – usually at

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[13] The Division's homepage is http://water.state.co.us/Home/Pages/default.aspx

[14] A great introduction to water rights in Colorado is "Colorado Water Law for Non-Lawyers" by P. Andrew Jones and Tom Cech.

[15] However, some beneficial uses have been specifically authorized by statute, such as instream flow and agricultural water protection water rights.

[16] A water right's first use, known as its 'appropriation date', is also taken into account in determining priority. The relationship between adjudication date and appropriation date is known as the Postponement Doctrine. Between two water rights adjudicated in the same year, the water right with the earlier appropriation date is senior.

[17] For more detail, visit https://waterknowledge.colostate.edu/water-management-administration/water-rights/types-of-water-decrees-rights/#1532968027727-8a64f4df-4a12

peak flow during runoff. However, once legally stored and released, the released water no longer carries a priority and may be delivered to its place of use downstream regardless of intervening senior priorities.

Groundwater in Colorado is presumed to be tributary to natural streams, and therefore well pumping also operates within the prior appropriation system. The list of exceptions to this rule is extensive and beyond the scope of this document.[18]

Nearly a third of Colorado's river miles have flow protections for environmental and habitat purposes.[19] Slotted into the priority system, instream flow (ISF) water rights specify an upper and lower terminus, a flow rate (often with rates that vary by season[20]), and are held by the CWCB. These water rights are administered in priority in the same manner as all other water rights. When in priority, the flow in that river segment may not be reduced beyond the decreed flow rate by junior water users. Because the legislature did not recognize the validity of instream use of water until 1973, most instream flows are junior in priority; however, the CWCB may acquire through voluntary transactions senior water rights to restore flows to rivers.[21] In addition, there are other mechanisms to improve river flows, such as downstream deliveries of stored water, discussed throughout.

Water courts began recognizing in-river recreational uses of water as early as 1992.[22] Several communities, including Vail, received decrees for recreational flows before the legislature stepped in to create process and restrictions around those river recreation projects in 2001.[23] Now formally known as Recreational In-Channel Diversions (RICDs), these non-consumptive water rights are tied to structures that control flow in rivers to enhance boating experience. They have decreed flow rates to be delivered to the boating structures in priority. Only certain types of government entities are authorized to hold RICDs.[24]

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[18] For more detail, visit https://waterknowledge.colostate.edu/water-management-administration/water-rights/groundwater-rights/

[19] More information on the State's Instream Flow Program can be found at http://cwcb.state.co.us/environment/instream-flow-program/Pages/main.aspx

[20] For example, a summer protected flow rate may be larger than the winter protected flow rate. This is due to water availability.

[21] These acquisitions may be permanent or temporary. For more detail, visit http://cwcb.state.co.us/environment/instream-flow-program/Pages/WaterAcquisitions.aspx

[22] Findings of Fact, Conclusions of Law, Judgment and Decree After Remand from the Colorado Supreme Court, No. 86CW317 (District Court, Water Division 1 December 5, 1994); See also Thornton v. Fort Collins (Colorado Supreme Court April 20, 1992).

[23] Concerning the Establishment of a Procedure for the Adjudication of a Recreational In-Channel Diversion by a Local Government, and Making an Appropriation Therefor, Senate Bill 01-216.

[24] For more information on RICDs, visit http://cwcb.state.co.us/environment/recreational-in-channel-diversions/Pages/main.aspx

GUIDE TO THE PRIOR APPROPRIATION DOCTRINE ON COLORADO'S WESTERN SLOPE

Water rights are system for equitable resource allocation in the face of water scarcity in arid Colorado. The system is called the Prior Appropriation Doctrine, and it is based on the **"first in time, first in right"** principle. The oldest water rights are given the highest priority for use when water is limited. Water rights must be issued by a water court. The court determines the seniority based on the initial date of water use and the date of filing with the court. The court also determines the size of the water right based on reasonable expectations for its intended beneficial use.

Water Right Use Types

Storage
Instream Flows
Recreational
Municipal
Agricultural
Industrial

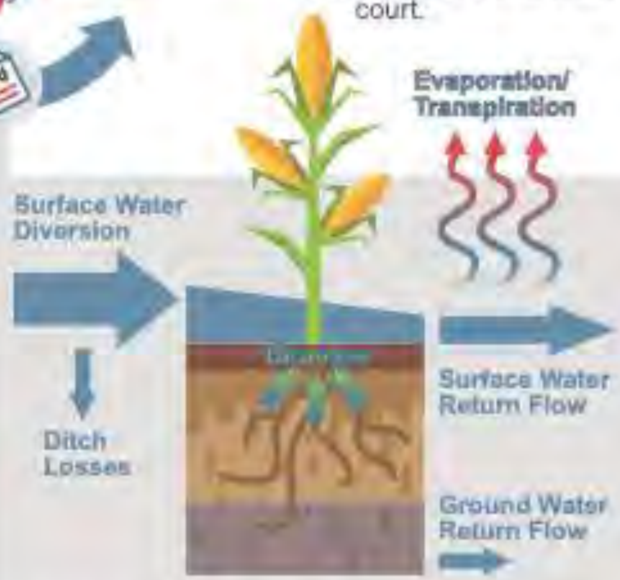
A variety of water uses are eligible for water rights. Most utilize surface water from streams and rivers. Groundwater sources are generally considered tributary to surface water. Therefore, wells often require a water right and may also require purchasing water in a reservoir so that water extraction from a well does not harm senior surface rights.

Water rights are real property rights with titles that may be sold or transferred. In most cases where the new use does not change type or location, the sale or transfer will not require filing with a water court.

In times of shortage, the Colorado Constitution spells out that domestic water use has a preference over agricultural use. The Colorado Supreme Court has interpreted this to mean that cities can condemn agricultural rights, with just compensation.

Water Rights Administration

Water rights are administered by the Colorado Division of Water Resources. A local water commissioner ensures that water rights are met according to their priorities. In times of shortage, the holder of an older (senior) water right can place a "call" on the river and the water commissioner will shut off newer (junior) rights – as many as necessary to satisfy the calling right. In some locations, juniors can satisfy the needs of seniors through water exchanges or augmentation plans that provide compensatory water for the senior user equivalent to the amount of the junior use.



Agricultural water may be sold separately from the land. However, only the ***consumptive*** portion of the water right is transferrable and the transfer cannot cause other water rights holders to suffer loss of the water they are entitled to in time, place, or amount. The consumptive portion of typical agricultural water uses includes the water converted to **plant biomass** and the water **evaporated** from the ground or **transpired** through plant leaves to the atmosphere. Consumptive use is typically calculated as the difference between diversions and return flows.

2.1.2 *Water Administration on the Middle Colorado River*

The Middle Colorado River Watershed is situated in Water Division 5, a water administration division that encompasses the mainstem of the Colorado River within Colorado and its tributaries (except the Gunnison River). Major tributaries in Division 5 upstream of the Middle Colorado River are the Eagle, Fraser, Blue, and Roaring Fork Rivers. The lead water administrator in Division 5 is the division engineer based in Glenwood Springs. Water commissioners, employed by the division engineer, manage the day-to-day administration of water rights within the basin. At writing, 12 water commissioners manage water in 11 districts within Water Division 5, from Rocky Mountain National Park to the Utah state line.[25] The Middle Colorado River Watershed includes portions of District 53 (No Name and Grizzly Creeks), District 39 (Rifle, Elk, and Parachute Creeks), District 45 (Divide Creek), and District 70 (Roan Creek).

With the major exception of the Shoshone Power Plant, water users within the Middle Colorado River do not greatly impact or control the timing or magnitude of streamflows on the mainstem Colorado River. Instead, the Middle Colorado River acts as a thruway for deliveries of upstream stored water to large demands downstream. The largest downstream water demands exist below De Beque. Major irrigation canals near Grand Junction and Palisade hold some of the largest and most senior water rights in Colorado's portion of the Colorado River basin. Taken together, these water rights are known as the Cameo Call and have a current Administration Call amount of 1,950 cfs.[26]

The Grand Valley Irrigation Company (GVIC) diverts Colorado River water near Palisade to irrigate around 27,720 acres on the north side of the Colorado River. The diversion canal has a capacity of 650 cfs with two water rights, a very senior right for 520.81 cfs and a relatively senior right for 119.47 cfs.[27] Another is the Grand Valley Project, a U.S. Bureau of Reclamation (BOR) irrigation system operated by the Grand Valley Water Users Association (GVWUA) that delivers water to 23,350 acres under a 730 cfs water right. The system also delivers water to Palisade, Mesa County, and Orchard Mesa Irrigation Districts, whose water rights include an additional 580.2 cfs. The Grand Valley Project diverts water at the roller dam in De Beque Canyon into the Government Highline Canal. In addition to irrigation, the Grand Valley Project also diverts water for generating electricity in the Grand Valley Power Plant, operated by the GVWUA and Orchard Mesa Irrigation District.[28] Operations at the Grand Valley Power Plant can impact the magnitude of the call, as discussed later in more detail. Note that the senior Cameo Call would have the potential to curtail junior water uses in every Upper Colorado River tributary, including agricultural, domestic, and transmountain diversions. Yet at times those junior uses continue because of a complex system of reservoir operations upstream.

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[25] http://water.state.co.us/DivisionsOffices/Div5ColoradoRiverBasin/Pages/Div5ColoradoRB.aspx

[26] State of Colorado. "Upper Colorado River Basin Information." Colorado Division of Water Resources, January 2007, Table 2.4, pg. 2-36. See also pg. 2-38.

[27] Id. at 2-35

[28] Id. at 2-36

The Shoshone power right is the most impactful water right operating within the Middle Colorado River. The Shoshone Dam sits in Glenwood Canyon, backs water up behind an on-channel dam, diverts water into tunnels on the north side of the canyon, and releases that water through turbines at the Shoshone Power Plant adjacent to Interstate 70. Although the hydropower use is non-consumptive, at times the Shoshone Power Plant dewaters the Colorado River between the dam and the plant outlet, where the water is returned to the river after use. Its senior right is decreed for 1,250 cfs.[29] Because of Shoshone's position farther up the basin, water rights in the Roaring Fork basin are not directly affected. And because the Shoshone power right is non-consumptive, operation of the Shoshone water right at times provides all or a majority of the water required at Cameo. Therefore, the Shoshone and Cameo water rights are tightly interrelated in the management of the river.

The continued operation of these administrative calls is of high priority to the CBRT.[30] The calls greatly impact streamflows on the Colorado and its major tributaries, supporting fish habitat, recreational and aesthetic benefits, as well as water to the Cameo and Shoshone rights. To ensure ongoing certainty of those benefits in the face of aging power plant conditions, a 2016 agreement between several major transmountain diverters and west slope interests set out procedures for Colorado River operations when the Shoshone Power Plant shuts down for repairs, maintenance, or other reasons.[31] An outage at the plant can reduce streamflows throughout the Upper and Middle Colorado segments river because it allows upstream junior water users to divert more water than they could historically. Under the agreement, when such an outage occurs, entities such as Denver and the Colorado River District (CRD) agree to operate their water resources as if the Shoshone call was in place to preserve the historical flow regime.

Due to Shoshone and Cameo's seniority, many irrigation, transmountain, and municipal water rights are shut off for significant periods of time to provide enough water downstream. However, some junior water users in the Middle Colorado and its tributaries continue to divert in spite of the downstream calls because of compensatory supplies. Northern Colorado Water Conservancy District and the BOR large transmountain diversion known as the Colorado-Big Thompson Project (C-BT) are one example. As part of the political compromise to authorize this large federal project, western slope entities negotiated for compensatory water in the form of a large reservoir on the Blue River. Green Mountain Reservoir, completed in 1943, can store 154,000 acre-feet at full capacity. Congress, authorizing the project under the terms of a document known as Senate Document No. 80, provided storage in Green Mountain Reservoir for 52,000 acre-feet of replacement water to offset the water C-BT would import from the upper Colorado River basin. In addition, the reservoir provides 100,000 acre-feet of power pool water or compensatory storage pool water. Today, 66,000 acre-feet of Green Mountain's power pool (a.k.a. Historic Users Pool or HUP) is provided to allow Colorado basin irrigation and domestic uses existing prior to October 15, 1977 to continue to divert even though they are

29 Id. 2-45.

30 Colorado Basin Roundtable. "Colorado Basin Implementation Plan," April 17, 2015, pg. 17.

31 "Shoshone Outage Protocol Agreement," U.S. Department of the Interior, et al. 2016.

junior to Shoshone and/or Cameo, at no cost to the beneficiaries.[32] Colorado's federal district court confirmed these practices in a basin-wide exchange decree in 1992.[33] In practice, when Cameo places a call, water rights decreed for irrigation or domestic uses in the Middle Colorado River basin which would normally be curtailed may still divert because those downstream calls are satisfied by releases out of Green Mountain Reservoir. In this way, many irrigation and domestic water rights in the Middle Colorado River benefit from Green Mountain operations. Note, however, that DWR only provides this benefit to water rights decreed for irrigation and domestic uses based on an interpretation of congressional intent in Senate Document No. 80.

2.1.2.1 Instream Flows

The mainstem of the Colorado River has instream flow protection from sections above Granby Reservoir to its confluence with the Eagle River. From there, a gap exists from the Eagle River to the 15-Mile Reach. In the 15-Mile Reach, the CWCB holds two instream flow water rights. The first, from the tailrace of the GVIC to the Gunnison River, protects 581 cfs from July 1 to September 30.[34] It is junior, with a 1992 appropriation date. The second is an increase of the first, but only from 27.5 Road Gage to the Gunnison River, adding 300 cfs of protection during those same months under a 1994 appropriation.[35]

Within the Middle Colorado River Watershed, the majority of ISF water rights occur on cold, fish-bearing tributaries north of the Colorado River. They protect minimum flows in Grizzly Creek, No Name Creek, Possum Creek, Keyser Creek, Canyon Creek, the Elk Creek system, the Rifle Creek system, and the Parachute and Roan systems. These instream flow protections tend to extend to their confluences with the Colorado River. South of the Colorado River, the upper reaches of Baldy Creek, East Divide Creek, West Divide Creek, Beaver Creek, Battlement Creek, and the Wallace Creek system have ISF water rights. All of the southern tributary instream flow reaches terminate well above their confluences with the Colorado River. Likely due to of lack of water availability in the lower sections of these tributaries or for ease of administration by terminating protections above senior ditches.

One of the most unique ISF water rights in Colorado protects streamflows in Dead Horse Creek. Almost all instream flow rates are determined by the habitat needs of trout or warm water fish and tend to focus on baseflows. The Dead Horse Creek instream flow appropriated "all unappropriated flows", thereby capturing the entire hydrograph of Dead Horse Creek.[36] Instead of focusing on fish flows, the CWCB focused on protecting a unique bird species, the black swift, that nests under the waterfall at Hanging Lake. The CWCB

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[32] Basin Information, supra note 15, at 2-6.

[33] Concerning the Application for Water Rights of the United States in Summit, Grand, Eagle, Routt, Mesa, Pitkin, and Garfield Counties, Consolidated Case Nos. 2782, 5016, and 5017; Case No. 88CW382.

[34] Findings of Fact, Conclusions of Law, Judgment and Decree, Case No. 92CW286 (District Court, Water Division No. 5 September 2, 1997).

[35] Findings of Fact, Conclusions of Law, Judgment and Decree, Case No. 94CW330 (District Court, Water Division No. 5 September 2, 1997).

[36] Findings and Ruling of Referee and Decree of the Water Court, No. Case No. 96CW350 (District Court, Water Division No. 5 May 7, 1997).

determined the entire flow of Dead Horse Creek was the minimum necessary to preserve the natural environment to a reasonable degree.

2.1.2.2 Recreational In-Channel Diversions

The Middle Colorado River has no existing RICDs, but has one pending. In 2013, the City of Glenwood Springs applied to water court for a RICD decree for three structures to be built in the Colorado River near the city: Two Rivers, Horseshoe Bend, and No Name.[37] The City claimed flow rates of 1,250 cfs from April 1 to June 7; 2,500 cfs from June 8 through July 23; and 1,250 cfs from July 24 through September 30. During the June 8 to July 23 period, the flow rate claimed may be raised to 4,000 cfs for up to four days. The filing has not been without controversy. During its review process, the CWCB found that the RICD would materially impair the state's ability to fully develop its compact entitlement and would not promote the maximum utilization of Colorado's water.[38] In response, Glenwood Springs offered conditions limiting when it could call for the highest flow rates – essentially curbing its ability to call for those highest flow rates in drier years. In March 2019, the CWCB amended its findings, determining that with the new terms the RICD would not materially impair the state's ability to fully develop its compact entitlements and that the RICD would promote maximum utilization of the Colorado's waters.[39] As of this writing, a final decree has not yet been entered.

2.1.2.3 The 15-Mile Reach

The Fish and Wildlife Conservation Act and the Endangered Species Act (ESA) play significant roles in the administration of water in the Colorado River basin. Between 1967 and 1980, the U.S. Fish and Wildlife Service listed four Colorado River native fish species as endangered: Colorado Pikeminnow, humpback chub, Razorback Sucker, and Bonytail.[40] One of the cornerstone pieces to their recovery is the 15-Mile Reach – a section of the Colorado River from the GVIC headgate to the confluence with the Gunnison River. The Cameo call, of which the GVIC is a part, provides a critical role of ensuring water flows downstream along most of the Colorado River in Colorado. However, after diversions at the Grand Valley Project and the GVIC, streamflows in the Colorado can drop precipitously, impacting the survival and recovery of these fishes.

Water use and development continues thanks to the Upper Colorado River Endangered Fish Recovery Program ("Recovery Program") administered by the U.S. Fish and Wildlife Service. The Recovery Program

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[37] Application for Surface Water Rights in Recreational In-Channel Uses, No. Case No. 13CW3109 (District Court, Water Division No. 5 December 31, 2013).

[38] Newman, Brent. "CWCB Board Update Memo Glenwood Recreational In-Channel Diversion." Colorado Water Conservation Board, September 19, 2018.

[39] Newman, Brent, and Erik Skeie. "Glenwood Springs RICD Findings of Fact." Colorado Water Conservation Board, March 20, 2019.

[40] "2017-2018 Highlights Upper Colorado River Endangered Fish Recovery Program & San Juan River Basin Recovery Program." Upper Colorado River Endangered Fish Recovery Program & San Juan River Basin Recovery Implementation Program, pg. 7.

provides ESA compliance for 1,232 water projects that deplete 2,122,895 acre-feet of water on average from the Upper Colorado River every year. The Recovery Program's goal is to delist those four species, and tackles recovery through restocking, river connectivity and efficiency projects, nonnative species control, and reservoir operations.

Reservoirs and their operators play two key roles. The first is to maximize peak flows in the 15-Mile Reach for ten days to two weeks without jeopardizing storage opportunities under a program called Coordinated Reservoir Operations (CROS). Target peak day flows depend on drought conditions, but are at least 12,900 cfs in most years, and anything greater than 23,500 cfs in five of 20 years.[41] Many water suppliers and their reservoirs upstream of the Middle Colorado River, including Green Mountain Reservoir, Granby Reservoir, Wolford Mountain Reservoir, Homestake Project, and Ruedi Reservoir, have participated in some manner in CROS.[42] In 2017, CROS operations added 37,165 acre-feet to the 15-Mile Reach from Green Mountain, Ruedi, Williams Fork, Willow Creek, Wolford Mountain, and Moffat Tunnel. These operations do not occur in the wettest or driest years.[43]

The second role reservoirs play is maintaining minimum baseflows. Problematic drops in streamflows in the 15-Mile Reach can occur before or after runoff. For example, in April, irrigation demands at Cameo can start before snowmelt upstream naturally releases water supply, and that demand and supply imbalance reduces streamflows within the 15-Mile Reach, causing the so-called April Hole. Likewise, after runoff, irrigation demand can continue after snowpack's natural storage is exhausted, leading to low streamflows in late summer and early fall. In wet years, the Recovery Program's goal is a baseflow of 1,630 cfs in the 15-Mile Reach. In average years, that minimum goal falls to 1,240 cfs. In the driest 20 percent of years, 810 cfs is the minimum goal.[44]

Supplies for the maintenance of late summer and fall baseflows in the 15-Mile Reach have come from a variety of upstream reservoirs since 1990, changing over time in amounts and locations as a result of the Orchard Mesa Check Case Settlement, the 1999 Programmatic Biological Opinion, and water contracting phases at Ruedi.[45] The 1999 Programmatic Biological Opinion required water suppliers and users to provide 10,825 acre-feet of water to the 15-Mile Reach.[46] Water suppliers and users split this amount evenly between the east slope and the west slope. The east slope eventually used water from Red Top Valley Ditch in Grand

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[41] U.S. Fish and Wildlife Service. "Final Programmatic Biological Opinion for Bureau of Reclamation's Operations and Depletions, Other Depletions, and Funding and Implementation of Recovery Program Actions in the Upper Colorado River above the Confluence with the Gunnison River," December 1999, pg. 39

[42] Michelle Garrison, and Victor Lee. "Colorado River Recovery Program FY 2017 Annual Report," 2017.

[43] Id.

[44] Biological Opinion supra note 28, at 39.

[45] "Sources of Water for the Endangered Fish to Be Delivered to the 15 Mile Reach," n.d.

[46] Biological Opinion supra note 28, at 8-9

County water to provide its permanent 5,412.5 acre-feet out of Granby Reservoir. The west slope provides its permanent 5,412.5 acre-feet from Ruedi.[47]

Four other pools of water are also used in the 15-Mile Reach for baseflow maintenance. Ruedi holds two of those additional pools: a 5,000 acre-foot permanent pool and a 5,000 acre-foot pool available in four out of five years. Wolford Mountain Reservoir now contains a 6,000 acre-foot permanent pool. Finally, if a surplus is declared from Green Mountain's HUP, a portion of that water is made available to the 15-Mile Reach. In total, all these sources add up to 26,825 acre-feet, plus any surplus Green Mountain Reservoir water.[48]

Since 2015, Ute Water Conservancy District has leased annually 6,000 acre-feet of water it owns in Ruedi Reservoir to the CWCB for instream flow use in the 15-Mile Reach. Ute Water leases this water at a rate solely to cover its costs, likely below its market value.[49]

2019 saw the first operation of a new project managed by the Grand Valley Water Users Association, the Orchard Mesa Irrigation District, and the Colorado Water Trust. Under an agreement signed by these three parties, water secured by the Colorado Water Trust from upstream sources is delivered for hydropower use at the Grand Valley Power Plant and subsequently released into the 15-Mile Reach, creating instream benefits in the Middle Colorado River and the 15-Mile Reach. The project is designed to be more-nimble than CROS, and in 2019, the project delivered an additional 25 cfs from Ruedi Reservoir over a critical seven-day period. In 2020, the project delivered 25 cfs for 20 days, and 50 cfs for three days. Importantly, the arrangement supports the rehabilitation of the power plant, thus ensuring the long-term exercise of the Cameo Call and its incidental benefits to the Middle Colorado River.

Neither CROS, the Ute WCD lease, nor Colorado Water Trust water is administered for actual use in the Middle Colorado River. However, it all runs through the Middle Colorado River and therefore provides streamflow benefits to that section of the river.

2.1.2.4 Colorado River Cooperative Agreement

The Colorado River Cooperative Agreement, originally signed in 2012, created a framework for projects and management actions related to transbasin diversions by Denver Water. The agreement details how water from the Fraser and Williams Fork River basins may be used within the Colorado River for instream flow purposes, including downstream to the 15-Mile Reach.[50] The decree permits the use of 1,375 acre-feet of Fraser and Williams Fork Rivers water and 2,500 acre-feet from Williams Fork Reservoir to be used in a host of instream flow segments, including from the tailrace of the Grand Valley Power Plant to the 27.5 Road Gage, and from the 27.5 Road Gage to the confluence with the Gunnison River. In addition, if the CWCB should make findings on levels of instream flow use in the Colorado River from the Eagle River to the Grand

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[47] Meyer, Don. "Recovery Program Pools," May 13, 2019.

[48] Id.

[49] https://www.postindependent.com/news/colorado-water-board-oks-leases-for-ruedi-reservoir-water-to-help-endangered-fish/

[50] Decree, No. 11CW152 (District Court, Water Division No. 5 March 1, 2016).

Valley Power Plant tailrace, this water may be used there as well. Until CWCB obtains an instream flow water right on the Middle Colorado River, that section of river would benefit only incidentally from downstream instream flow uses of CRCA water. Depending on exchange potential within the Middle Colorado River, that may be a distinction without a difference.

2.1.3 Predicting Hydrological Change

Future water management activities or shifts in climate that deplete or augment streamflow have the potential to impact important regime characteristics, including: total annual volume, magnitude and duration of peak and low flows, and variability in timing and rate of change. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g., the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change.[51]

Different perspectives on future hydrological behavior and its relationship to consumptive and non-consumptive water uses are gleaned from trends analysis on historical streamflow records and scenario modeling. While trends analysis may be the best tool for understanding near-term hydrological conditions, extrapolation of historical trends out to 30 or 50-year time horizons may be an insufficient or inappropriate approach for understanding future conditions. This is especially true where historical behavior in the joint hydrological/socio-political/administrative system is not necessarily predictive of potential future behavior. Simulation models of future hydrology, water use, and water management provide a tool for evaluating the effects of various future scenarios. Scenario modeling is used extensively across Colorado for risk assessment and decision support. That approach is adopted here as well to provide local stakeholders with insights into the ways in which changes in water availability and water use may alter local waterways' ability to deliver goods and services to local communities.

The CWCB recently provided a Technical Update to the Colorado Water Plan.[52] That update includes a set of revised StateMod scenario planning models for the Colorado River Basin. The models simulate the effects of several climate change and development futures (Table 2). Results generated by the models provide a lens through which potential future conditions in the Middle Colorado River Watershed can be evaluated. Modeled scenarios encompass a wide range of future conditions according to the best available science and stakeholder inputs. This scenario planning approach, unlike the more simplistic low to high stress conditions, recognizes that the future holds a degree of uncertainty where the various drivers will impact each other. The nine impact drivers considered by the Technical Update include:

- Population/Economic Growth
- Social/Environmental Values

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[51] B. Johnson, M. Beardsley, and J. Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams.," 2016.

[52] "Technical Update to the Colorado Water Plan," Colorado Water Conservation Board, Volume 1., 2019.

- Climate Change/Water Supply Availability
- Urban Land Use/Urban Growth Patterns
- Energy Economics/Water Demand
- Level of Regulatory Oversight/Constraint
- Agricultural Economics/Water Demand
- Municipal and Industrial Water Demands
- Availability of Water-Efficient Technologies

Each of the planning scenarios presented in the Technical Update reflects a possible future state, which depends on a variety of environmental and social drivers. The differentiating components of the planning scenarios are listed below:

Baseline – Current Conditions

- Current irrigated acreages and irrigation practices
- Historical Irrigation Water Requirement (IWR)
- Historical hydrology

Scenario A – Business as Usual

- Includes reduction of irrigated acreage near urbanized areas
- Increased stress to streamflow and water supplies
- Climate is similar to conditions in the 20th century

Scenario B – Weak Economy

- Reduction of irrigated acreage near urbanized areas
- Economy struggles with reduced population growth
- Climate is similar to conditions in the 20th century
- Little change in social values, levels of water conservation, urban land use patterns, and environmental regulations

Scenario C – Cooperative Growth

- Reduction of irrigated acreage
- 20% increase to IWR due to climate factor (i.e., warmer)
- Population growth consistent with current forecasts
- Increased water and energy conservation
- Emergence of water saving technology
- Water development more restrictive requiring high efficiency as well as environmental/recreational benefits
- Moderate warming of the climate increasing water demands in all sectors (Ag + M&I)

Scenario D – Adaptive Innovation

- Much warmer climate with technological innovation to address associated socio-environmental problems
- Population growth higher than current projections
- Reduction of irrigated acreage, but less than other scenarios due to demand for locally produced food
- 31% IWR increase from climate factor (i.e., warmer)
- 10% IWR reduction from improved technology or efficiency (i.e., lower water use by crops)
- 10% system efficiency increase to offsets water use in warmer climate

Scenario E – Hot Growth

- Much warmer climate with increased population
- Rapid transition of agricultural lands to urban
- Reduction of acreage
- Decline in streamflow and water supply
- 31% IWR climate factor

Critically, <u>none of the above scenarios include the effects of additional transmountain diversion of water brought about by Windy Gap Firming Project, Moffat Firming Project, or the Eagle River Memorandum of Understanding Joint Use Water Project (Eagle River MOU)</u>. The former two projects were in the final stages of approval at the time of writing. Planning work is ongoing under the Eagle River MOU. Unfortunately, the CWCB did not include build-out or operations of those projects in any of the Technical Update models and sufficient information characterizing how those projects would operate under East Slope and West Slope climate change and population growth was not readily available elsewhere. <u>This is an important data gap that almost certainly affects the assessment of risk for hydrological change in the Middle Colorado River Watershed</u>. Future assessments and scenario modeling products generated by CWCB and others should incorporate the effects of these three large Transmountain Diversion (TMD) projects and stakeholders in the Middle Colorado River Watershed should review those results, revising objectives and recommended actions as needed.

The Technical Update to the Colorado Water Plan provided additional scenarios that characterize hydrological conditions in the absence of human water use and management. These "naturalized" flow scenarios, representing unimpaired or "free flowing" river conditions were included in a limited fashion in the assessment of hydrological conditions in the Middle Colorado Watershed. The Naturalized Historical scenario represents the existing historical river hydrology in the last century simulated without any human diversions. This scenario provides some indication of the overall degree of hydrological alteration experienced by the Colorado River through the planning area (*Table 3*) and to provide meaningful context for evaluating changes in available high-quality fish habitat and other attributes in response to changes in flow.

Table 2. Climate change and development scenarios included in Technical Update to the Colorado Water Plan.

Drivers	A Business as Usual	B Weak Economy	C Cooperative Growth	D Adaptive Innovation	E Hot Growth
A. Economy/ Population					
B. Urban Land use	No change	No change	Higher density	Higher density	Lower density
C. Climate Status/ Water Supply	Same as 20th century observed	Same as 20th century observed	Between hot and dry and 20th century observed	Hot and dry	Hot and dry
D. Energy Water Needs	Low (no oil shale)	Moderate (no oil shale)	Low (no oil shale)	Low (no oil shale)	High (oil shale)
E. Agricultural Conditions	Total ag water demands slightly higher • Decrease in irrigated acres due to urbanization • Ag exports and demands lower • Ag is less able to compete with urban areas for water	Total ag water demands decrease • Decrease in irrigated acres due to urbanization • Ag exports and demands constant • Ag is less able to compete with urban areas for water	Total ag water demands slightly higher • Slight decrease in irrigated acres due to urbanization • Ag exports down and local demands up • Ag is better able to compete with urban areas for water • Increased ET due to climate change	Total ag water demands slightly higher • Slight decrease in irrigated acres due to urbanization • Ag exports down and local demands up • Ag is better able to compete with urban areas for water • Increased ET due to climate change	Total ag water demands higher • Significant decrease in irrigated acres due to urbanization • Ag exports and demands high • Ag is better able to compete with urban areas for water • Increased ET due to climate change
F. Availability of New Water Efficiency Technology	• M&I Moderate • Ag: Efficiencies are increased	• M&I Moderate • Ag: Efficiencies are increased	• M&I High • Ag: Efficiencies are increased	• M&I High • Ag: Much higher efficiencies are implimented	• M&I Moderate • Ag: Efficiencies are increased
G. Social/ Environmental Values	No change	No change	• Increased awareness • Increased willingness to protect environment and stream recreation	• Increased awareness • Increased willingness to protect environment and stream recreation	• Full use of resources • Low willingness to protect environment and stream recreation
H. Regulatory Constraints	Regulation Deregulation No change	Regulation Deregulation No change	Regulation Deregulation Increased	Regulation Deregulation Increased but expedited	Regulation Deregulation Reduced
I. M&I Water Demands	Lowest of the five scenarios	Middle of the five scenarios	Second lowest of the five scenarios	Second highest of the five scenairos	Highest of the five scnarios

Table 3. Predicted changes in monthly average streamflow behavior for the Colorado River at Cameo as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan.[53] *Top: simulated changes in streamflow relative to naturalized flows. Bottom: simulated changes in streamflow characteristics relative to the Baseline scenario.*

Regime Behavior Relative to Natural Flow	**Baseline**	**Scenario 1: Business as Usual**	**Scenario 2: Weak Economy**	**Scenario 3: Cooperative Growth**	**Scenario 4: Adaptive Innovation**	**Scenario 5: Hot Growth**
Change in Average January Flow	27%	26%	27%	25%	8%	8%
Change in Average February Flow	20%	19%	20%	24%	10%	11%
Change in Average March Flow	12%	12%	12%	34%	22%	22%
Change in Average April Flow	-25%	-25%	-25%	8%	1%	0%
Change in Average May Flow	-39%	-38%	-38%	-20%	-29%	-31%
Change in Average June Flow	-34%	-33%	-33%	-48%	-58%	-60%
Change in Average July Flow	-29%	-28%	-28%	-59%	-67%	-68%
Change in Average August Flow	-17%	-17%	-17%	-42%	-48%	-47%
Change in Average September Flow	-1%	-1%	-1%	-20%	-28%	-28%
Change in Average October Flow	17%	16%	16%	3%	-14%	-10%
Change in Average November Flow	24%	23%	23%	14%	-5%	-2%
Change in Average December Flow	27%	26%	26%	20%	2%	3%

Regime Behavior Relative to Baseline	**Baseline**	**Scenario 1: Business as Usual**	**Scenario 2: Weak Economy**	**Scenario 3: Cooperative Growth**	**Scenario 4: Adaptive Innovation**	**Scenario 5: Hot Growth**
Change in Average January Flow	-	-1%	0%	-2%	-19%	-19%
Change in Average February Flow	-	-1%	0%	4%	-10%	-9%
Change in Average March Flow	-	0%	0%	22%	10%	10%
Change in Average April Flow	-	0%	0%	33%	26%	25%
Change in Average May Flow	-	1%	1%	19%	10%	8%
Change in Average June Flow	-	1%	1%	-14%	-24%	-26%
Change in Average July Flow	-	1%	1%	-30%	-38%	-39%
Change in Average August Flow	-	0%	0%	-25%	-31%	-30%
Change in Average September Flow	-	0%	0%	-19%	-27%	-27%
Change in Average October Flow	-	-1%	-1%	-14%	-31%	-27%
Change in Average November Flow	-	-1%	-1%	-10%	-29%	-26%
Change in Average December Flow	-	-1%	-1%	-7%	-25%	-24%

The predictions for changes in hydrological regime behavior, water use, and water management made in the Technical Update to the Colorado Water Plan were used to explore risks for alteration of ecosystem conditions and the delivery of important ecosystem goods and services to local communities. Those risk assessments, along with a characterization of existing conditions, are discussed in subsequent sections. Notably, the scenario models included in the Technical Update run on a monthly timestep.

For the purposes of evaluating impacts of climate change, population growth, etc. on ecological characteristics of the Middle Colorado River, a daily timestep was required. Monthly simulation results were disaggregated to daily results using a method of fragments approach.[54] The validity of the disaggregation approach was initially assessed by comparing 100 computed metrics of annual streamflow behavior (e.g.,7-day minimum flow, average September flow, 3-day maximum flow, etc.) for Baseline simulation results

[53] "Technical Update to the Colorado Water Plan," Colorado Water Conservation Board, Volume 1., 2019.

[54] Acharya, A., & Ryu, J. H. (2014). Simple method for streamflow disaggregation. Journal of Hydrologic Engineering, 19(3), 509-519.

representing the Colorado River below Glenwood Springs and the Colorado River at Cameo to the same metrics computed on observed streamflow data from those location using a Wilcox Rank Sum test. Results indicate no statistically significant difference in the computed metrics between the simulation results and observation data for all metrics except the flow percentiles and min/max flows computed for April and November. We expect this is due to the way that irrigation demands are turned "on" and "off" in the simulation models in these months. Nonetheless, we found these results encouraging and supportive of our intention to use scenario modeling results to characterize changes in annual flow characteristics—leaving out comparisons of April and November regime behavior—throughout the planning area (Table 4).

Table 4. Selected annual streamflow characteristics for the Colorado River below Glenwood Springs computed for disaggregated simulation data. Top: streamflow metric values produced by simulation modeling. Bottom: characteristic changes from the baseline condition realized by each of the five scenarios.

Streamflow Characteristic	Statistic	Units	Baseline	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
30-day Minimum	Mean	cfs	1292	1283	1285	1239	1048	1067
	Standard Deviation	cfs	182	177	176	208	196	198
3-day Minimum	Mean	cfs	1107	1103	1103	1054	897	916
	Standard Deviation	cfs	165	159	161	187	176	173
Timing of 75% Runoff Volume	Mean	Julian Day	224	223	223	212	211	215
	Standard Deviation	Julian Day	17	16	16	21	21	21
7-day Minimum	Mean	cfs	1191	1185	1181	1134	969	990
	Standard Deviation	cfs	161	154	155	183	184	179
Annual Maximum	Mean	cfs	16078	16188	16197	14800	12764	12281
	Standard Deviation	cfs	8427	8455	8456	7908	7195	7142
August Minimum	Mean	cfs	2160	2170	2151	1567	1392	1498
	Standard Deviation	cfs	741	732	712	420	317	283
September Minimum	Mean	cfs	1927	1918	1927	1508	1308	1330
	Standard Deviation	cfs	542	547	544	351	311	340

Streamflow Characteristic	Statistic	Units	Baseline	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
30-day Minimum	Mean	cfs	-	-1%	-1%	-4%	-19%	-17%
	Standard Deviation	cfs	-	-3%	-3%	14%	8%	9%
3-day Minimum	Mean	cfs	-	0%	0%	-5%	-19%	-17%
	Standard Deviation	cfs	-	-4%	-2%	13%	7%	5%
Timing of 75% Runoff Volume	Mean	Julian Day	-	0%	0%	-5%	-6%	-4%
	Standard Deviation	Julian Day	-	-6%	-6%	24%	24%	24%
7-day Minimum	Mean	cfs	-	-1%	-1%	-5%	-19%	-17%
	Standard Deviation	cfs	-	-4%	-4%	14%	14%	11%
Annual Maximum	Mean	cfs	-	1%	1%	-8%	-21%	-24%
	Standard Deviation	cfs	-	0%	0%	-6%	-15%	-15%
August Minimum	Mean	cfs	-	0%	0%	-27%	-36%	-31%
	Standard Deviation	cfs	-	-1%	-4%	-43%	-57%	-62%
September Minimum	Mean	cfs	-	0%	0%	-22%	-32%	-31%
	Standard Deviation	cfs	-	1%	0%	-35%	-43%	-37%

Comparison of the various climate change and population growth scenario simulation results to the baseline simulation result indicate a shift toward earlier peak runoff and lower total annual runoff volumes associated with increasingly warm climate futures (Figure 6,

Figure 7). These patterns are typical of predictions elsewhere on Colorado's western slope. Simulation results for the mainstem Colorado indicate relative insensitivity to the changes from the baseline condition included in scenarios A and B. Simulation results from Scenario D and E were also very similar. This clustering of simulation results allowed us to explore the entire simulation space by comparing outcomes associated with the Baseline scenario, Scenario C, and Scenario E.

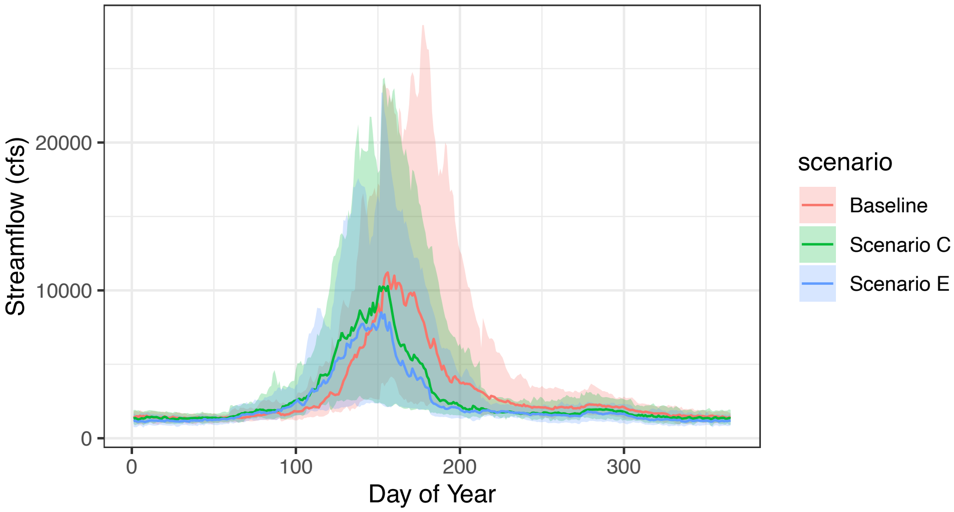


Figure 6. Disaggregated simulation results from three different scenarios for the Colorado River below Glenwood Springs. Mean annual streamflow characteristics indicated by the sold lines. Shaded areas indicate the full range of simulated daily flow conditions for a given scenario. Results indicate a shift toward earlier snowmelt runoff, lower average peak flows, and a decrease in annual water yield. This pattern is representative of expected changes elsewhere in the planning area.

The methods used to develop, calibrate, and analyze simulation model results are not well suited to understanding the potential impacts of climate change on stochastic events like extreme rainfall. Characterizing the effects of increasingly severe rainfall on the mainstem Colorado River requires some consideration of all the potential locations of such events across the entire upper Colorado River drainage, the relative intensity and duration of any given event, and the effects of flow routing on flood wave propagation along the stream network—not a trivial task. These mechanisms of runoff generation are not represented in modeling results. Aa a consequence, model outputs are better suited to representing changes in snowmelt runoff processes than late summer extreme rainfall events. This caution is particularly relevant to the presentation of peak flow return periods (

Figure 7) that indicate declining snowmelt runoff peak flows at, for example, a 10-year return period. These predicted declines reflect warmer winters, diminished snowpack and earlier snowmelt. Increased atmospheric moisture content in a warming climate and an associated increase in extreme rainfall event frequency and/or severity might produce the opposite pattern during the summer monsoon period. A simplistic approach to accounting for increasing summer monsoon activity is provided by Colorado Dam Safety Office proposed

Rule 7.2.4. The proposed 107% increase (as per Rule 7.2.4) was applied to observed July-September peak flows in the Colorado River below Glenwood Springs. Results are displayed graphically and in tabular form (Figure 8). The overall impact of a warmer climate on flows in the Middle Colorado River might then be a trend toward earlier snowmelt runoff, lower peak flows in the May-June period, and larger spikes in streamflow in the late summer and fall in response to large precipitation events.

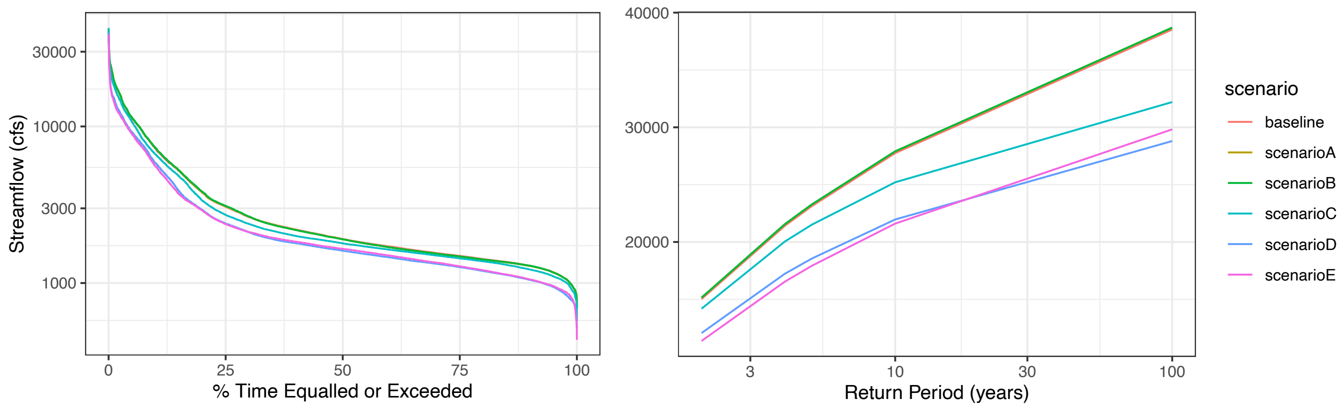
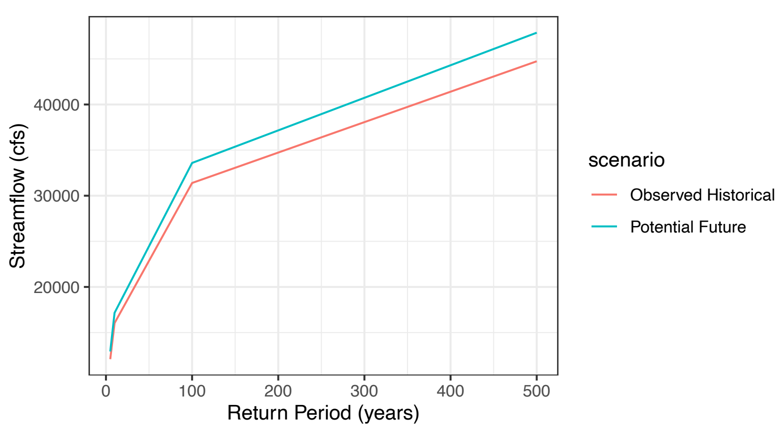


Figure 7. Streamflow exceedance probabilities (left) and peak snowmelt runoff return periods (right) for the Colorado River below Glenwood Springs under the various planning scenarios. Simulation results indicate increasing flow reductions corresponding to increasingly warm climate futures captured in scenarios C, D, and E.



Return Period (years)	Observed Historical Flood Magnitude (cfs)	Potential Future Flood Magnitude (cfs)
5	12084	12929
10	16040	17163
100	31396	33594
500	44737	47868

Figure 8. Potential changes to summer monsoon 1-day peak flow events as characterized by Colorado Dam Safety Office proposed Rule 7.2.4 that accounts for increasing atmospheric moisture produced by a warming climate.

The outputs from scenario modeling were used to characterize potential shifts in environmental, recreational, and consumptive use characteristics and opportunities across the planning area. Disaggregated daily data was used primarily for evaluating potential environmental impacts of growing populations and climate change. Monthly simulation results were used to characterize existing and potential future water supply limitations for municipalities and agricultural producers. A more comprehensive presentation of hydrological simulation results is included in Appendix C. The aspects of existing and potential future hydrology relevant to fluvial geomorphology, riparian areas, aquatic communities, recreational use opportunities, agricultural use shortages, and municipal supply shortages are summarized in the sections below. It's worth noting that the CWCB developed each of the scenarios discussed above as representative positions along a continuum of equally probable future conditions. No weighting is provided by CWCB or by this effort regarding the "best" scenario to plan for. Instead, the reader is encouraged to consider how results associated with the full range of scenarios might inform a "no-regrets" strategy for managing conditions in the Middle Colorado Watershed.

2.2 Fluvial Geomorphology

Fluvial geomorphology is the study of the physical and biological processes that interact to control stream channel form and evolution across a range of spatial and temporal scales. Channel dynamics respond to interactions between patterns of rainfall and runoff, catchment-scale physical attributes (e.g., surficial geology, topography), riparian community structure, and local use practices (e.g., transportation corridor alignment, grazing practices).

In a preferred state, channel dynamics maintain aquatic habitat quality and provide the disturbance template upon which riparian vegetation thrives. Modification of the hydrological regime, altered patterns of erosion and sediment delivery (e.g., due to wildfire), anthropogenic adjustments to the structure of the channel bed, or changes in riparian community composition and extent may yield fundamental shifts in the geometry and behavior of the stream at the channel scale (tens of yards) or reach scale (hundreds of yards). These changes may reduce the stability or reliability of critical human infrastructure within the watershed. Infrastructure in the Middle Colorado planning area that may be impacted by evolving channel morphologies include surface water diversion structures, bridges, railroads, houses, and highways. Changes in channel form or behavior that impact infrastructure may also negatively impact the quality of aquatic habitat and riparian vegetation communities.

Consideration of the concepts of connectivity, capacity, and complexity are useful for process-level understanding of patterns and distribution of different morphological river states across the planning area. Interplay between these critical components of the physical system govern a stream or river's resilience to perturbation. There are no ideal targets for the degree to which a stream reach is connected to adjacent hillslopes or floodplains, for its capacity to move water, sediment, and woody debris, or for the complexity of longitudinal and planform channel structures. Rather, the manifestation of connectivity, capacity, and complexity play out on stream reaches differently depending on landscape position, climate, hydrology, etc. Where these considerations are useful is in understanding existing conditions and natural or management-induced changes to one of the three concepts that may trigger rapid or dramatic changes in system and different—and, potentially, undesirable—fluvial geomorphological state.

River classification simplifies communication about active physical processes and floodplain/riparian conditions and helps with evaluation of potential management action outcomes. Understanding predictable relationships between local channel form and the physical and biological processes that govern that form allows river classification schemes to be useful in resource use decision-making. Application of a modified River Styles[55] framework to the Middle Colorado River yields insight into the likely physical responses of different stream reaches to existing management practices, or anticipated flow regime or land use changes (Figure 9). For example, confined streams may undergo little geomorphologic change as a result of flow regime modification. Unconfined streams can experience rapid shifts in channel form and ecosystem function following human-induced changes to flow or riparian integrity. Characterization of geomorphological behavior is also useful when predicting channel response to: 1) human infrastructure like bridges, culverts, and surface water diversion structures, 2) altered hydrology due to reservoir operation or upstream water use, or 3) changes in sediment supply due to the creation of impoundments or changes in land use or land cover (e.g., large wildfires). Stream reaches in the planning area were initially classified as either confined, partly-confined, or unconfined. These categories were further subdivided into River Styles based on the local geomorphic, hydrologic, and biotic conditions found from Glenwood Springs to De Beque (Table 5). Through confined reaches such as Glenwood or De Beque Canyons the classification type is either "Entrenched bedrock canyon" or "Occasional floodplain pockets". In partly-confined areas (e.g., Silt-Rifle), the Colorado River is classified as "Margin-controlled discontinuous floodplain wandering". Wandering rivers straddle a transitional form between braided and meandering, with multiple channel threads, regular changes to bar deposits, islands, and often well-developed floodplains with diverse riparian communities.

Table 5. Modified River Styles classification descriptions, as applied to the Middle Colorado River.

Characteristics	River Style	Key Features
Confined valley setting. High-energy streams with low width-depth ratios. Little to no floodplain and small riparian zones.	Entrenched bedrock canyon	Active channel is almost entirely confined within bedrock margins. Small riparian areas line the margins, with no floodplain. Active channel location is very stable. Substrate ranging from small boulders to sand.
Partially confined valley setting. Moderate energy streams with higher width-depth ratios. Variable riparian zone widths. Sensitive to land and water use activities.	Occasional floodplain pockets	Small and discontinuous floodplain pockets, riffles, runs, and rapids with occasional pools. Small riparian areas line the margins, with occasional floodplain pockets where bedrock constriction is less extreme. Substrate ranging from cobbles to sand.
	Margin-controlled discontinuous floodplain wandering	Active channel abuts confining margins for a minority of linear valley distance but is not fully unconfined. Floodplain and instream geomorphic features characteristic of wandering and lateral migration including alternating bars, multiple side

[55] Brierley, G. J., & Fryirs, K. (2000). River Styles, a Geomorphic Approach to Catchment Characterization: Implications for River Rehabilitation in Bega Catchment, New South Wales, Australia. Environmental Management, 25(6), 661–679.

channels, and vegetated islands. Substrate ranging from cobble to silt.

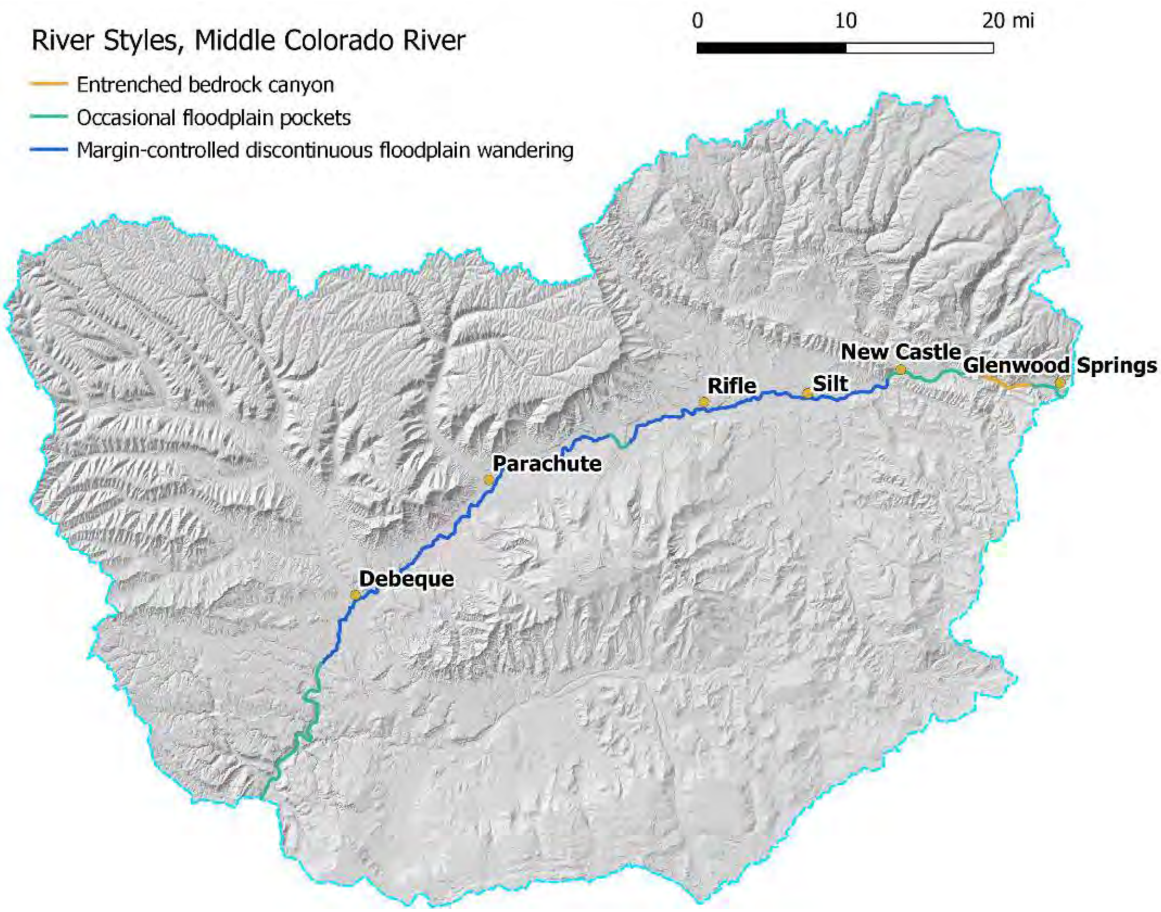


Figure 9. River Styles mapped for segments of the Middle Colorado River.

Throughout the project area, the Colorado River alternates between unconfined reaches with accessible floodplains, and reaches that are either naturally or artificially confined by valley margins or human alterations like levees, transportation corridors, or hardened embankments. Structures like Interstate-70 (I-70) or railroad fill are persistent and regularly maintained, while others such as gravel pit levees or irrigation ditch embankments are less permanent and could be reclaimed by the channel if, at some point in time, they exceed their social or economic utility. Partly-confined reaches have low width-to-depth ratios and show low rates of natural lateral channel movement. Channel geometries migrate within the alluvial floodplain but are frequently constrained in movement by resistant valley margins. Riparian corridors often occupy the full extent of the floodplain up to the confining margin, which can be either the valley wall or elevated terraces and resistant colluvial deposits or alluvial fans. De Beque Canyon and just downstream of Rifle are examples of partly-confined reaches.

Where the Colorado River has an unconfined floodplain, such as those reaches between Silt and Rifle, wandering channel dynamics are apparent. Wandering river types represent a transitional form between meandering and braided channel types. Multiple side channels, active gravel bars, and abandoned channels create a dynamic and complex river corridor that supports a rich patchwork mosaic of riparian habitats. These reaches are characterized by high width-to-depth ratios and constant reworking and migration of stream channels over relatively short time frames--years to decades. These reaches may have well-developed channel meanders that are fully contained in the active floodplain. Unconfined and partly-confined channel segments in this region are more sensitive to change in flow regimes than upstream reaches that are resistant, confined canyons such as Glenwood Canyon and South Canyon.

In most parts of the Middle Colorado River corridor, channel morphologies and behaviors reflect the characteristics expected for the biophysical setting. However, human activities in the river corridor have strongly impacted the riparian corridor through a loss of lateral connectivity to overbank areas. While human impacts are evident throughout the study area, the most heavily impacted areas are close to towns or have been intensively mined for river gravels.

2.2.1 Risks for Altered Fluvial Geomorphological Dynamics

Channels respond in varying degrees to regional and local conditions, including: local topography, patterns of hillslope erosion, livestock and wildlife browsing in riparian areas, precipitation regimes, and patterns of peak- and low-flow discharges. Additionally, local channel dynamics frequently reflect recent changes in land use/land cover or water management. Classifying river channel types provides a useful framework to discuss dominant physical processes and ecosystem functions at different locations in the watershed.

Table 6. Changes in channel morphology on the Colorado River between Rulison and De Beque over the period between 1937 and 1995 as assessed by Pitlick and Crees.[56]

Feature	Total Area (ha) 1937	Total Area (ha) 1995	Change in Total Area (ha)	Change per Unit Channel Length (m)	Change in Area (%)
Main Channel	469	455	-14	-3	-3
Islands	386	311	-75	-13	-20
Side Channels	105	72	-33	-6	-31

[56] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction. 57 pp.

Previous evaluations of planform characteristics in reaches of the Middle Colorado River show decreases in channel complexity over the previous 85 years[57] corresponding to a period of increasing upstream reservoir storage, transmountain diversions, and consumptive water use that reduced the ability of the channel to mobilize and transport sediment out of side channels and backwaters (Table 6). These effects were quantified reaches below Rulison using historical aerial photography. A similar qualitative evaluation of aerial photographs collected between the 1940s and present day on reaches between Silt and Rulilson suggest a similar pattern of decreasing side-channel and backwater area, decreasing island and mid-channel bar area, and modest channel narrowing.

Some of these changes are likely due to transmountain diversions, dam construction and alteration of sediment and hydrological regimes.[58,59] It is possible that reductions in annual peak flows over the previous century (see Figure 3) limit the channel's ability to mobilize sediment supplied by local source areas. Such a reduction in sediment conveyance capacity can have deleterious effects on channel structure and habitat quality.[60] This sediment instead aggrades in backwaters and side channels, eventually filling them Colonization of these areas by riparian vegetation makes if much less likely that they are re-claimed by subsequent high flow events. If trends toward decreasing annual peak flows continue under climate change and future population growth or development of additional transmountain diversions (e.g., Windy Gap Firming, Moffat Firming, or Eagle River MOU projects) then this trend toward increasing channel simplification is likely. Increases in sediment supply due to wildfire or changes in land use may overwhelm the channel's existing ability to effectively transport sediment and lead to similar reductions in channel complexity. Notably, reduction in channel complexity may yield corresponding reductions in habitat quality for native fish Species of Concern.[61]

2.2.1.1 Sediment Transport Capacity

Coarse sediment supply and transport in rivers is critical in maintaining channel geometry and is a critical variable in riverine habitat formation, flood inundation, and riparian condition. The potential for cascading impacts between alteration of hydrology or sediment supplies, channel morphology, and habitat quality for native species make sediment transport characteristics an area of specific management concern to local stakeholders. Research conducted on the Colorado River, including segments that flow through the Middle Colorado River Watershed indicate that the biomass of primary producers and macroinvertebrates—a critical

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[57] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction.

[58] Osmundson, D. B., Ryel, R. J., Lamarra, V. L., & Pitlick, J. (2002). Flow–sediment–biota relations: implications for river regulation effects on native fish abundance. Ecological Applications, 12(6), 1719-1739.

[59] Schmidt, J. C., & Wilcock, P. R. (2008). Metrics for assessing the downstream effects of dams. Water Resources Research, 44(4).

[60] Wohl, E. (2015). Legacy effects on sediments in river corridors. Earth-Science Reviews, 147, 30-53.

[61] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction.

food source for many fish and avian species—is strongly correlated to the degree to which the streambed is free of fine sediment.[62] Sediment transport analysis is, therefore, a useful approach for characterizing the potential impact of changing hydrology on bed sediment dynamics and secondary impacts on aquatic biota.

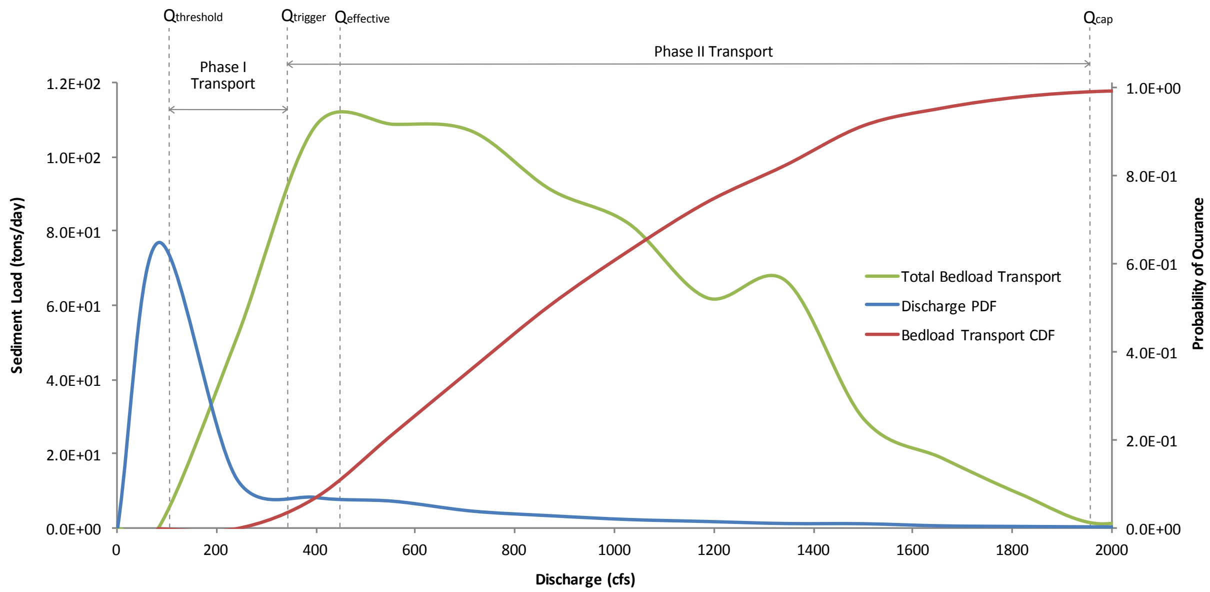

Figure 10. Example magnitude-frequency plot estimating the mass of sediment transported through a channel cross-section across a range of discharges. Total bedload transport results are a function of the hydraulic characteristics of the cross section and the probability of occurrence of various flow states along the interval.

Channel geometry, sediment particle size, and water discharge control two dominant phases of sediment transport in the alluvial reaches (areas with unconfined floodplains) of the Colorado River. Phase I transport includes fine-grained particles such as sand and fine gravel. Phase II transport mobilizes all particle sizes in the stream bed including large gravel, cobbles, and small boulders (Figure 10). Previous studies calculated bedload transport thresholds and estimated bankfull discharges for the Colorado River below Rulison. An extensive assessment of longitudinal changes in particle size distributions and channel cross sectional geometry estimated the average threshold for initiation of Phase II transport to be 8,687 cfs between Rulison and De Beque and 7,451 cfs through De Beque Canyon.[63,64] Similar work was carried out under this planning effort to characterize thresholds for bedload mobilization in alluvial reaches of the Colorado River mainstem

[62] Osmundson, D. B., Ryel, R. J., Lamarra, V. L., & Pitlick, J. (2002). Flow–sediment–biota relations: implications for river regulation effects on native fish abundance. Ecological Applications, 12(6), 1719-1739.

[63] Id.

[64] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction. 57 pp.

above Rulison. Specifically, bedload transport evaluations were completed at field sites in Silt, Rifle, and Parachute. Our estimates for the initiation of Phase II transport between Silt and Parachute ranged from 7057 to 7742 cfs, in good agreement with the findings on downstream reaches presented by others.[65]

The bedload transport rating curve from Rifle was applied to the hydrologic record for the Colorado River at Glenwood Springs to complete a sediment transport magnitude-frequency analysis. The flows responsible for transporting the majority (80%) of sediment at the three sites ranged between ~20,900—22,850 cfs. These estimates aligns well with the structurally-indicated bankfull flow (~20,482 to 22,001 cfs) approximated for reaches between Rulison and De Beque.[66]

Variability of thresholds for initial motion within stream reaches can be high, especially in reaches where river morphology is highly variable. Sediment discharge rating curves showed divergent patterns of sediment transport as modeled flows increased. Both the Rifle and Parachute sites showed increasing levels of width-averaged bed load transport as flows increased. Modeled sediment transport rates were almost an order of magnitude higher at Rifle than at Parachute. However, at the Silt site, width-averaged bed load transport decreased at higher flows after peaking during intermediate flows. This behavior reflects the wandering/multi-channel characteristics of the channel in the vicinity of Silt Island, where side channels and low riparian surfaces are activated during periods of high flow and stream energy is dissipated across the floodplain.

Flood return periods calculated from the annual peak flow record from the USGS gage at Glenwood Springs show that the threshold for Phase II transport corresponds roughly to a 1.11-year flow event (Figure 11). This means that the Phase II transport threshold will be exceeded almost every year except for extreme low flow years. However, significant volumes of sediment transport do not occur until higher discharges are reached. Research indicates that the majority of sediment is mobilized by the highest 10% of streamflows.[67] Historical streamflow data indicates that the upper bound of the range of flows responsible for transporting the majority of sediment on the Colorado River between Silt and Parachute is achieved at a frequency of approximately one-in-five years. This relatively low frequency of occurrence may reflect the progressive declines in peak flow discharges noted in the historical record and suggests that the section of the Colorado River near Rifle may be particularly prone to geomorphological change following further reductions in annual peak flows. Research indicates that the flood events sufficient to mobilize a majority of bed sediments now occur at a lower frequency than would have naturally occurred—an effect attributed to river regulation.[68,69]

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[65] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction. 57 pp.

[66] Id.

[67] Id.

[68] Osmundson, D. B., Ryel, R. J., Lamarra, V. L., & Pitlick, J. (2002). Flow–sediment–biota relations: implications for river regulation effects on native fish abundance. Ecological Applications, 12(6), 1719-1739.

[69] Schmidt, J. C., & Wilcock, P. R. (2008). Metrics for assessing the downstream effects of dams. Water Resources Research, 44(4).

The mean duration of the period separating sediment flushing events approximately doubled in the Colorado River in the period following the completion of major water storage and transmountain diversion projects in the Colorado River headwaters.[70] Previous researchers considered the observed link between benthic biomass and fine sediment accumulation in the streambed and inferred that recent hydrological changes artificially lowered macroinvertebrate productivity and had a corresponding negative effect on local fish populations.[71]

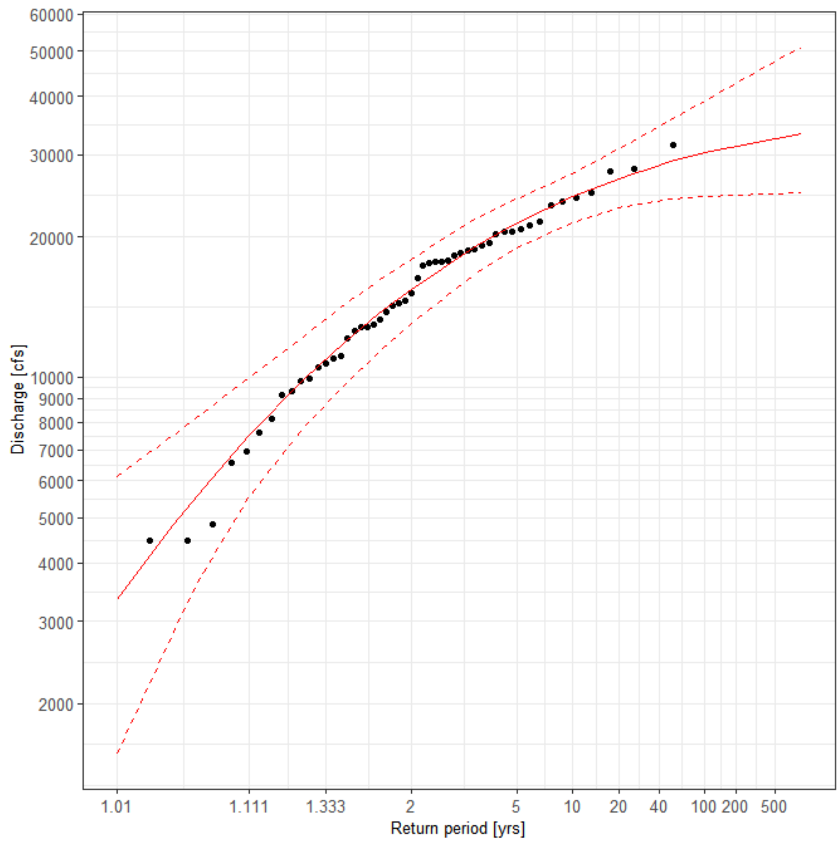

Figure 11. Observed flood magnitude recurrence interval for the Colorado River through the planning area.

Comparison of sediment transport modeling results to previous studies[72] shows that sediment mobilization thresholds remain essentially constant as one moves downstream along the Colorado River from Silt to Cameo. However, variability exists in bed load transport volumes in reaches with different morphologies.

[70] Osmundson, D. B., Ryel, R. J., Lamarra, V. L., & Pitlick, J. (2002). Flow–sediment–biota relations: implications for river regulation effects on native fish abundance. Ecological Applications, 12(6), 1719-1739.

[71] Id.

[72] Pitlick, J. & Cress, R. (2000). Longitudinal Trends in Channel Characteristics of the Colorado River and Implications for Food-Web Dynamics. Final Report. U.S. Fish and Wildlife Service, Grand Junction.

Sediment-discharge rating curves show that width-averaged sediment transport decreases as discharge increases in multi-threaded reaches such as those found near Silt. This does not mean that the absolute amount of sediment transport is decreasing, but instead means that the inundated width of the river increases at a greater rate than the rate of sediment transport. This demonstrates the flood mitigation capacity of complex, unconstrained river corridors. Reaches near Rifle, which are partly constrained by human development or geomorphic features, show higher sediment transport responses as discharge increases. Sections of straightened channel appear to be transporting sediment at a much faster rate than upstream locations. This likely results in some down-cutting, streambed and bank armoring, and reduced likelihood for lateral channel movement through those reaches.

Scenario modeling results that reflect a warming climate (i.e., Scenarios C, D and E) indicate significant reductions in snowmelt runoff peak-flows on the Colorado River below Glenwood Springs (Table 7). Changes in the magnitude of flows associated with a 4-year peak flow return interval decrease between 6% and 24%, depending on the scenario considered. This reduction in peak flows would likely produce further simplification of the stream channel, accumulation of fine sediments in the streambed and secondary effects on benthic biomass and aquatic habitat quality. The combined impacts of reduced peak flows and increased sediment loading due to wildfire or other significant land-use changes may accelerate the sedimentation and channel simplification process.

Table 7. Snowmelt runoff peak flow return periods for the Colorado River below Glenwood Springs associated with various planning scenarios. Top: peak flow values calculated from disaggregated simulation modeling for the full set of scenarios. Bottom: percent change from the baseline condition realized by each of the five scenarios.

Return Period (yr)	Baseline	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
2	15028	15141	15151	14182	12058	11368
4	21418	21551	21563	20046	17234	16546
5	23127	23264	23276	21507	18554	17921
10	27750	27897	27908	25206	21962	21603
100	38530	38693	38695	32204	28802	29822

Return Period (yr)	Baseline	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
2	-	1%	1%	-6%	-20%	-24%
4	-	1%	1%	-6%	-20%	-23%
5	-	1%	1%	-7%	-20%	-23%
10	-	1%	1%	-9%	-21%	-22%
100	-	0%	0%	-16%	-25%	-23%

Maintaining the remaining complexity and sediment transport capacity of sections of the mainstem Colorado River through the planning area will likely require streamflow management actions, perhaps via the CROS organized by the Colorado River Recovery Program, that work to ensure adequate magnitude and duration of high flow events.[73] Alternatively, active engagement by local stakeholders in decision-making processes that contemplate additional upstream water storage or transmountain diversion projects may be required to ensure that decisions made in other parts of the state do not negatively impact the Middle Colorado River.

Work completed during this planning effort (Appendix D) and recommendations provided in previous studies[74,75] support management actions designed to maintain sediment transport dynamics in the Colorado River mainstem. This collective body of work indicates that flows ranging between ~7500 cfs and ~22,000 cfs should occur, on average, for 30 or more days each year on the Colorado River between Silt and De Beque in order to maintain existing sediment transport characteristics. Three-day peak flow events exceeding ~22,000 cfs at a frequency of 2-4 years will also help maintain historical and existing rates of channel change and bedload mobilization in this section of river. These management targets assume no significant alteration of land cover characteristics or alterations in sediment supply.

2.2.1.2 Sediment Regime Change

A warming climate may increase the frequency and severity of fire in the upper Colorado River basin.[76] Wildfires are known to increase rates of hillslope erosion and sediment delivery to stream networks for several years after fire occurs.[77] Rapid increases in the rate and volume of suspended and bedload sediment delivered to the Colorado River through the Middle Colorado Watershed may result in rapid sediment accumulation in remaining side channels and backwaters. Without corresponding high flows to remobilize this sediment and transport it downstream, the newly created bars and depositional surfaces may become vegetated and stabilized, further reducing measures of channel complexity though the planning area. In the event that a large wildfire affects the planning area or upstream watersheds, quick action to stabilize soils or revegetate burn scars may be necessary to prevent significant deleterious effects on channel characteristics, especially in the alluvial reaches between Silt and Rifle and in the vicinity of De Beque.

2.3 Riparian Vegetation

Riparian areas are both rare and critical ecosystems. These landscape elements act as transitional zones from the riverbed to drier uplands and provide important habitat for wildlife. They can provide water quality

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[73] Recommendations for sediment transporting flows in the Middle Colorado reach are similar enough to those for the 15-mile reach to benefit from management actions that target downstream areas. However, active participation by local stakeholders in regional flow management decision-making would help ensure that specific needs of the Middle Colorado River are not overlooked.

[74] Id.

[75] Osmundson, D. B., Ryel, R. J., Lamarra, V. L., & Pitlick, J. (2002). Flow–sediment–biota relations: implications for river regulation effects on native fish abundance. Ecological Applications, 12(6), 1719-1739.

[76] Rocca, M. E., Brown, P. M., MacDonald, L. H., & Carrico, C. M. (2014). Climate change impacts on fire regimes and key ecosystem services in Rocky Mountain forests. Forest Ecology and Management, 327, 290-305.

[77] Moody, J. A., & Martin, D. A. (2001). Initial hydrologic and geomorphic response following a wildfire in the Colorado Front Range. Earth Surface Processes and Landforms: The Journal of the British Geomorphological Research Group, 26(10), 1049-1070.

benefits by absorbing and filtering runoff originating in hillslopes and overbank areas. Riparian area extent and function is largely a function of landscape position, local hydrology, and development activities in the floodplain. Despite their relatively small total land coverage in the Middle Colorado River Watershed and elsewhere in Colorado, riparian zones produce outsized contributions to biological diversity and abundance, as well as strong controls on water quality, aquatic habitat, and physical channel dynamics. Riparian lands consist of less than 3 percent of the total area of western Colorado, but 72 percent of reptile species, 77 percent of amphibian species, 80 percent of mammal species, and 90 percent of all bird species use riparian areas "for food, water, cover, or migration routes." [78]

The Middle Colorado River hosts a lengthy riparian corridor. The extent of riparian forests along the mainstem Colorado River varies as a function of channel and floodplain morphology. In the areas between Glenwood Springs and New Castle, steep banks and narrow or non-existent floodplains conspire to significantly limit the occurrence of riparian vegetation in areas that are not immediately adjacent to the river channel. In downstream reaches, particularly between Silt and Rifle, riparian vegetation occupies wide floodplains and low terraces that extend large distances from the river channel (Figure 12). Two reaches, Glenwood Canyon and the Rifle Stretch, are considered riverine wetland areas by the Colorado Natural Heritage Program (CNHP).[79] Unfortunately, these riparian areas are "profoundly altered from their pre-settlement state."[80] The I-70 corridor, railroad, and agricultural practices modified or destroyed many riparian areas. [81] Despite these impacts, the Middle Colorado still boasts a diversity of riparian plant life, including narrowleaf and Rio Grande cottonwoods, aspen, blue spruce, dogwood, and silverberry.[82] CNHP designated the Rifle Stretch a 'Potential Conservation Area', with very high biodiversity significance and high protection urgency, supporting "a fair occurrence of a globally imperiled plant community." [83]

Riparian vegetation communities exist in a dynamic state both physically (between the river and its floodplain) and in time (between periods of snowmelt runoff and late season baseflows). Occasional scouring of overbank areas provides the necessary habitat for germination of many riparian plant species. Active channel migration in wide floodplains provides a particularly conducive disturbance regime for promoting diverse riparian communities. Following germination on scoured or newly created surfaces (e.g., point-bars), seedlings require a relatively slow reduction in water table height over the progression of the growing season. Rapid water table elevation reductions or late season water table heights that drop below the maximum rooting depth of cottonwoods and other riparian plants can stress vegetation and can lead to seedling mortality.

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[78] Rare Earth Science, LLC, "Baseline Documentation Report: Silt River Preserve Conservation Easement." at 7.

[79] Rocchio, supra note 2, at 18.

[80] Id. at 9.

[81] Id. at 94.

[82] Rocchio, Lyon, and Sovell, "Survey of Critical Biological Resources of Garfield County, Colorado. Volume II: Survey of Critical Wetlands and Riparian Areas in Garfield County." at 36-40.

[83] Rocchio, Lyon, and Sovell, "Survey of Critical Biological Resources of Garfield County, Colorado. Volume II: Survey of Critical Wetlands and Riparian Areas in Garfield County." at 36-40.

Changes in channel and floodplain structure, channel alteration designed to limit lateral migration, or adjustments in the magnitude, timing or frequency of peak flows and baseflows may, therefore, limit the establishment of younger plants and lead to decadent stands of vegetation.

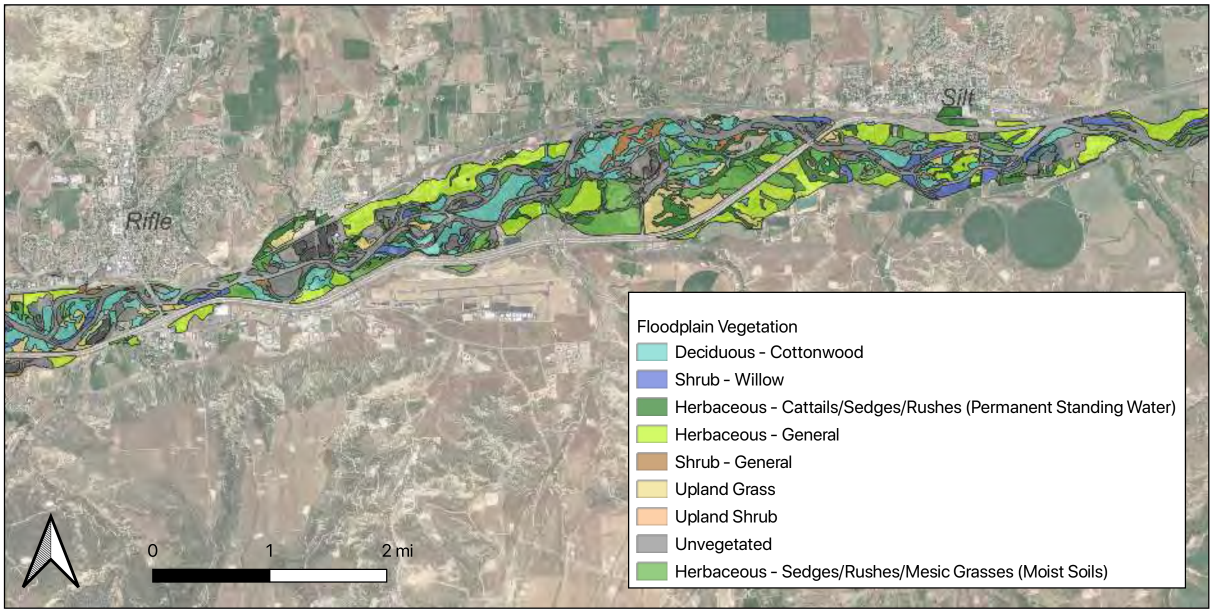

Figure 12. Dominant vegetation types found along the Colorado River between Silt and Rifle.

2.3.1 Risks to Riparian Vegetation

Riparian areas are frequently disturbed or degraded. Within Colorado, hydrological modifications (i.e., decreases in flood flows), stream bank stabilizations, gravel pits, transportation corridors, grazing, recreation, and non-native plants diminish the vitality and function of riparian zones.[84] Riparian area disturbances impact aquatic habitat and may produce negative secondary impacts including elevated water temperatures and increased sediment loading from streambanks.[85]

2.3.1.1 Land Use and Land Cover Change

Development of transportation corridors and extensive gravel mining operations within the Colorado River floodplain over the last century directly reduced the extent of riparian areas in many sections of the Middle Colorado Watershed. Gravel mining likely poses the largest potential impact to currently intact riparian areas throughout the planning area. Reducing impacts from gravel mines may be achieved through acquisition and conservation of existing high-quality riparian forests, extensive reclamation of existing gravel pits, or

[84] Rocchio, Lyon, and Sovell, "Survey of Critical Biological Resources of Garfield County, Colorado. Volume II: Survey of Critical Wetlands and Riparian Areas in Garfield County." at 36-40.

[85] White River National Forest, "Five-Year Monitoring and Evaluation Report: October 2002 - September 2007." at 8.

institution of regulations that restrict mining from occurring in the active river corridor and/or require reclamation techniques that are more effective at promoting a greater degree of riparian regrowth following mining. Zoning overlays that prohibit or restrict land clearing or development activities in the active river corridor may provide similar long-term benefits to riparian areas. To this end, this planning effort produced a preliminary mapping of riparian areas between Glenwood Springs and De Beque ripe for either preservation or restoration (Appendices B and E).

2.3.1.2 Invasive Plant Species

Local management challenges for maintaining riparian health include invasive species, water management, gravel pit operation and human encroachment (for agriculture and recreation).[86] Organizations like Rivers Edge West operating under the Colorado Headwaters Invasive Partnership (CHIP) identified two reaches within the Middle Colorado for control of invasive woody species including tamarisk and Russian olive, and invasive herbaceous species including Russian Knapweed. These reaches extend between Glenwood Springs and Silt, and Silt to De Beque.[87] The section between Silt and Rifle is particularly affected by invasive species colonization. This area is also designated as a Potential Conservation Area by CNHP and should receive special management focus for reducing the presence of species like Russian olive. See Section 2.11 for additional discussion.

2.3.1.3 Frequently Inundated Areas

Flow recommendations for support of existing riparian communities reflect the assessment peak flow hydrology present on the alluvial sections of the Colorado River and the expectation that existing riparian extents will be partially maintained through overbanking conditions that scour streambanks, mid-channel bars, and other floodplain features. While limited data on historical riparian condition makes it difficult to establish causality between changes in hydrological regime behavior and reductions in riparian area extent in the Middle Colorado River, first principles of riparian ecology suggest that reductions in the magnitude of flows occurring at 5- or 10-year return intervals may limit the aerial extent of active riparian recruitment, thereby reducing riparian forest widths over time.

As discussed in previous sections, hydrological simulation modeling suggests a reduction in snowmelt runoff magnitude under those scenarios that represent a warming climate. Scenarios A and B show a 1% increase in the 10-year snowmelt peak, while scenarios C, D and E indicate a 9-22% decrease (Table 7). One-dimensional hydraulic flood models provided by Garfield County for the sections of the Colorado River flowing through Silt, Rifle, and Parachute were used to characterize changes in inundation area (a proxy for the likely area of riparian recruitment) under the potential range of reductions in snowmelt runoff peak flows indicated by hydrological scenario modeling (Table 8).

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[86] Id.

[87] Colorado River Water Conservation District, The Nature Conservancy, Tamarisk Coalition, "Colorado Headwaters Invasives Partnership: A Consolidated Woody Invasive Species Management Plan for Colorado's Colorado, Gunnison, Uncompahgre, Dolores, White, and Yampa/Green Watersheds." at 57.

Table 8. Changes in inundated area associated with reductions in 10-year runoff magnitudes at three different locations along the Colorado River mainstem.

Change in 10-year Peak Flow (%)	Potential Change in Riparian Area (%)		
	Parachute	Rifle	Silt
0	0	0	0
-5	-8	-5	-7
-10	-16	-10	-14
-15	-24	-15	-21
-20	-32	-20	-28
-25	-40	-26	-35

The high-end estimates for peak flow reductions correspond to significant decreases in the area suitable for recruitment of new riparian vegetation suggesting that the alluvial sections of the Colorado River through the Middle Colorado Watershed may be particularly vulnerable to climate change induced shifts in riparian community structure and extent. As noted in the previous section, opportunity exists for stakeholders in the Middle Colorado Watershed to more proactively engage in water management decision-making processes focused on new upstream water development projects or participate in CROS conversations with an eye on ensuring that management actions taken to benefit conditions or users in other parts of the state do not negatively impact high-value characteristics in the Middle Colorado Watershed.

Taken together, the suite of historical, existing, and potential-future impacts on riparian areas throughout the planning area highlight the need for focused management attention on these unique landscape elements. Preservation and enhancement of riparian conditions is likely to yield secondary benefits to aquatic biota and the numerous riverine goods and services that human communities enjoy and rely on.

2.4 Aquatic Biota

Much public attention on efforts to recover and protect aquatic species in the mainstem of the Colorado River in Colorado has tended to focus on the so-called 15-Mile Reach. Stretching from Palisade downstream to the Gunnison confluence, the 15-Mile Reach serves the Grand Valley's critical agricultural economy. Multiple factors, including depleted flows through this stretch, are thought to contribute to native fish declines. The Middle Colorado River, sitting just upstream of the 15-Mile Reach, is often an incidental beneficiary of these recovery and protection efforts – deliveries of water to the 15-Mile Reach occur from reservoirs and other actions upstream of both reaches.

Middle Colorado River reaches provides important habitat for both endangered fishes and other native fishes of special concern. The Middle Colorado River downstream of the Highway 13 bridge in Rifle, where the river transitions from a cold to warm-water classification, is designated critical habitat for two federal endangered fishes: Razorback Sucker and Colorado Pikeminnow. A third endangered fish, the Bonytail, is stocked between Rifle and De Beque, and has been documented to occur downstream of Silt as recently as

2017. Hydrologic alteration, competition from non-natives, and habitat loss or fragmentation have resulted in the loss of these native warm water species throughout the Colorado basin.

Species of special concern also occupy this reach and extend further upstream into the cold-water portions of the watershed; these include the Roundtail Chub, Flannelmouth Sucker, and Bluehead Sucker. The so called "three species of concern" are given this designation due to significant population reductions resulting from fragmentation and degradation of historic range by dams, hydrologic alteration, competition from non-native species, and other factors. Further degradation of their habitat and subsequent reductions in populations could eventually result in a threatened and endangered (T&E) listing under the ESA if insufficient action is taken.

Native cold-water fish found higher in the watershed include Colorado River Cutthroat Trout and Mottled Sculpin. The Colorado River Cutthroat Trout is designated a state-level species of concern. Non-native coldwater species comprise the main sport fishery and include Rainbow Trout and Brown Trout. Primary challenges to fishery health in the Middle Colorado River Watershed include habitat loss, diminished stream network connectivity, and competition/hybridization between native and non-native species. Non-native invasive species present in the mainstem include several species of bass, white suckers, pike, and carp. Appendix F provides detailed information on area fishes from Glenwood Canyon to De Beque, including their life histories, habitat requirements, limitations, and opportunities for conservation and enhancement.

2.4.1 Razorback Sucker

Razorback Suckers occupy the mainstem Colorado and large tributaries, adapted to warmer waters. Adults may live for decades, occupying deep runs, backwaters, and inundated floodplains in spring, primarily feeding on benthic invertebrates, algae, detritus, and other plant material picked from the substrate.[88] They are vulnerable to loss of floodplain habitat and predation from non-native fishes, moving between deeper channel habitats and slackwater areas during different life stages and seasons. Adults may migrate long distances to spawn in habitats that include in-channel bars and shorelines in gravel, cobble, and sand substrates; once hatched, larvae and later stages drift to slackwater rearing areas including inundated floodplains, channel margins, backwaters, and tributary mouths (USFWS 2018). Spawning occurs from mid-April to June when water temperatures rise above 14°C (~57°F). Hatchlings may be impaired or fail in temperatures near or below 10°C (~50°F).[89]Adults and subadults are documented are documented in the mainstem downstream of Rifle. Rifle to De Beque has the potential support spawning and rearing, but this activity has not been documented.[90] Downstream of the Highway 13 bridge in Rifle is designated Critical

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[88] USFWS. 2018. Species status assessment report for the Razorback Sucker *Xyrauchen texanus*. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

[89] Upper Colorado River Endangered Fish Recovery Program and San Juan River Basin Implementation Program. 2019. 2018–2019 Highlights. Available at: https://www.coloradoriverrecovery.org/general-information/general-publications/briefingbook/2019-BriefingBook.pdf [accessed February 2020]

[90] ibid.

Habitat. Western tributaries in the Middle Colorado River Watershed that have a perennial or extended seasonal connection the mainstem Colorado may support some life stages.

Threats to survival include loss of connectivity between seasonal habitats, loss of connectivity between populations in the lower Colorado River, altered hydrology, competition and predation, hybridization, and potential water quality impacts from parameters like increased selenium. Opportunities for conservation and enhancement exist via improved flow management, reconnection of the lower reaches of significant tributaries to the mainstem to Colorado during spring and early summer, protection and restoration of off-channel habitats, control of non-native species, and improved mainstem connectivity to the lower Colorado and lower Gunnison rivers.

2.4.2 Colorado Pikeminnow

Colorado Pikeminnow once served as the large river system's top predator. These large and long-lived fish preferably occupy deep, low-velocity pools, runs, and eddies near shore. Reaching several feet in length, adults are piscivorous predators while juveniles utilize plankton and benthic invertebrates.[91] They are vulnerable to flow regulation impacts and disconnection of mainstem populations and habitats. Pikeminnow may complete long migrations to spawn in riffles and bars during the receding limb of the hydrograph when temperature shave risen near 18–23°C (65-70°F).[92] Larvae drift to sandy alluvial backwaters and connected secondary channels.

No pikeminnow are documented in rivers and streams in the project area and previous habitat modelling has estimated De Beque as the likely upstream limit of thermally suitable habitat.[93] Warming instream water temperatures associated with climate change and decreasing flows may increase available habitat upstream for all life stages at some time in the near future. Tributary streams like Rifle, Mamm, Parachute, and Roan may support spawning/rearing, and adult life stages if seasonal connections to the mainstem river are maintained.

Limiting factors to this species in the project area include flow regulation, especially attenuation of peak flows and increases in warm season base flows (which favor non-native species), impaired mainstem connectivity, modification to habitats vital during young/juvenile life stages, and competition and predation from non-natives. Opportunities to support species conservation and enhancement may exist via non-native species control, preservation and enhancement of natural flow regimes, protection of backwater and side channel habitats, and reconnection of mainstem habitats.

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[91] USFWS. 2002b. Colorado Pikeminnow (*Ptychocheilus lucius*) recovery goals: amendment and supplement to the Colorado squawfish recovery plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6) Denver, Colorado.

[92] ibid

[93] Osmundson, D.B. 2011. Thermal regime suitability: assessment of upstream range restoration potential for Colorado Pikeminnow, a warmwater endangered fish. River Research and Applications 27:706–722.

2.4.3 Bonytail

Bonytail may be the least well-understood member of the long-living native species of the Colorado River mainstem. These fish reach several feet in length, with an omnivorous diet consisting of plant material and aquatic invertebrates. Very large individuals may consume other fish.[94] They are vulnerable to flow regulation impacts, non-native species predation and displacement, and disconnection of mainstem populations and habitats. Bonytail are believed to spawn in clean gravel or rocky substrates, although floodplain wetlands may also provide habitat.[95]

CPW and USFWS stock Bonytail between Rifle and De Beque Canyon, with adults and subadults being documented downstream of Silt in recent years. The project area includes no designated Critical Habitat. Species also have the potential to occur in or use the lower reaches of larger tributary streams that maintain an adequate seasonal or perennial connection to the mainstem such as lower Rifle, Mamm, Parachute, and Roan Creeks.

Limiting factors to this species in the project area include non-native fish competition, flow regulation that attenuates floodplain and side channel inundation frequency, interrupted connectivity to the lower Colorado River, and a generally lower understanding of life history strategy and species needs. Opportunities to support species conservation and enhancement may exist via non-native species control, continuation of stocking programs, enhancements or restoration of natural flow regimes, and increased mainstem and tributary connectivity.

2.4.4 Bluehead Sucker

Of the native warm-water species, the Bluehead Sucker ranges highest in the basin, as they prefer steeper, faster streams. Species success is dependent on adequate base flows and the availability of high-quality riffle habitat.[96] Bluehead Suckers prefer rocky-bottomed streams with moderately cool temperatures (~68° F). Spawning is triggered by a critical water temperature (~60° F) and, therefore, starts earlier for fish residing at lower elevations in the watershed. Young Bluehead Suckers prefer slow-moving water close to streambanks. They move to deeper, covered areas away from streambanks as they progress into juvenile and adult life stages. Feeding preferences mirror habitat preferences: larval fish find vertebrates in the deep rocky pools and riffles near shore, and older fish feast on algae, plant detritus and invertebrates in their covered pools and riffles further away from streambanks.[97]

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[94] USFWS. 2002c. Bonytail (*Gila elegans*) recovery goals: amendment and supplement to the Bonytail chub recovery plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

[95] Bestgen, K.R., R.C. Schelly, R.R. Staffeldt, M.J. Breen, D.E. Snyder, and M.T. Jones. 2017. First reproduction by stocked Bonytail in the Upper Colorado River Basin. North American Journal of Fisheries Management 37:445–455. DOI: 10.1080/02755947.2017.1280571

[96] D. Kowalski, “Native and Sport Fish of the San Miguel and Dolores Rivers,” 15-Dec-2010.

[97] “Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker.” Utah Department of Natural Resources, Sep-2006.

In the upper Colorado River Basin, the Bluehead Sucker is reported to occur most commonly in small and medium-sized tributaries but is also found in larger mainstem rivers where suitable habitat is present.[98] Hooley-Underwood et al. documented heavy use of an intermittent tributary in the Gunnison River basin by spawning Bluehead Suckers, demonstrating that tributaries provide important habitat for this species.[99] In the project area, Bluehead Suckers occur in the mainstem Colorado River from Glenwood Canyon downstream to De Beque and in numerous tributaries. Tributary streams known to be occupied by Bluehead Suckers include Garfield Creek, the Divide Creek complex, the Rifle Creek complex, lower Parachute Creek, lower and upper Roan Creek, and Kimball Creek.[100] Other tributaries in the project area with potential to support Bluehead Sucker (but with no documented present-day occurrence) include Baldy Creek, lower Elk Creek, Butler Creek, East Rifle Creek, Mamm Creek, Dry Fork Roan Creek, Conn Creek, Kimball Creek, Carr Creek, Brush Creek, and Clear Creek.

2.4.5 Flannelmouth Sucker

Like the Bluehead Sucker, the Flannelmouth Sucker is also dependent on adequate base flows and the quality of riffle and run morphology.[101] Flannelmouth Suckers generally inhabit unvegetated murky pools or riffle/run areas in gravel, rock, sand, or mud bottomed streams. Younger fish seek out shallow riffles and eddies near the shore, migrating towards the deeper riffles and runs in adulthood. Larval Flannelmouth Suckers prey on invertebrates, transitioning to a variety of algae, detritus, plant debris and invertebrates in later life stages. This species will migrate long distances in the spring to find suitable spawning habitat.[102]

In the upper Colorado River Basin, the Flannelmouth Sucker is reported to occur in warmer, slower rivers including mainstem rivers and smaller tributary streams, but is generally absent from colder headwater streams and reservoir tailwaters.[103] Hooley-Underwood et al.[104] documented heavy use of an intermittent tributary in the Gunnison River basin by spawning Flannelmouth Suckers, demonstrating that tributaries provide important habitat for this species.

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98 Ptacek, J.A., D.E. Rees, and W.J. Miller. 2005. Bluehead Sucker (Catostomus discobolus): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available at: http://www.fs.fed.us/r2/projects/scp/assessments/blueheadsucker.pdf

99 Hooley-Underwood, Z.E., S.B. Stevens, N.R. Salinas, and K.G. Thompson. 2019. An intermittent stream supports extensive spawning of large-river native fishes. Transactions of the American Fisheries Society 148:426–441.

100 CPW, BLM, and USFS biologists, pers. comm., December 2018 and March 2019.

101 D. Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers," 15-Dec-2010.

102 "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker." Utah Department of Natural Resources, Sep-2006.

103 Rees, D.E., J.A. Ptacek, R.J. Carr, and W.J. Miller. 2005b. Flannelmouth Sucker (Catostomus latipinnis): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available at: http://www.fs.fed.us/r2/projects/scp/assessments/flannelmouthsucker.pdf

104 Hooley-Underwood, Z.E., S.B. Stevens, N.R. Salinas, and K.G. Thompson. 2019. An intermittent stream supports extensive spawning of large-river native fishes. Transactions of the American Fisheries Society 148:426–441.

In the project area, Flannelmouth Suckers occur in the mainstem Colorado River from Glenwood Canyon downstream to De Beque and in numerous tributaries.[105] Tributary streams known to be occupied by Flannelmouth Suckers include Garfield Creek, the Divide Creek complex, lower Elk Creek, lower Rifle Creek, lower Parachute Creek, and lower and upper Roan Creek.[106] Other tributaries in the project area with potential to support Bluehead Sucker (but with no documented present-day occurrence) include Baldy Creek, Mamm Creek, Dry Fork Roan Creek, and Kimball Creek.

2.4.6 Roundtail Chub

Roundtail Chub are habitat generalists; however, the species remains sensitive to baseflow reductions.[107] Roundtail Chub prefer slow-moving, deep pools for cover and feeding but will inhabit streams with a variety of substrate types -- silt, sand, gravel -- and occur in both murky and clear water. Preferred habitat varies by life stage. Juveniles and young-of-year seek out pools and quiet backwaters, while adults gravitate towards eddies and pools adjacent to strong currents. Spawning is triggered by water temperatures, beginning in June or early July when temperatures have reached 65° F. Roundtail Chub are carnivorous, opportunistically feeding on available insects, fish, snails, crustaceans, algae and sometimes lizards. They are more likely to be limited by available food resources than by habitat.[108]

In the project area, Roundtail Chub are found from Glenwood Springs downstream to De Beque, primarily in the mainstem Colorado River. Abundance in the mainstem generally increases moving downstream from Glenwood Springs and is greatest downstream of Parachute.[109] Roundtail Chub have also been documented in tributaries to the Colorado River in the project area, including Garfield Creek, the Divide Creek complex, lower Rifle Creek, lower Parachute Creek, and lower Roan Creek.[110] Other tributaries in the project area with potential to support Roundtail Chub (but with no documented occurrence) include Baldy Creek, Lower Elk Creek, Mamm Creek, and Dry Fork Roan Creek. Hooley-Underwood et al.[111] documented heavy use of an intermittent tributary in the Gunnison River basin by spawning Roundtail Chub, demonstrating that tributaries provide important habitat for this species.

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[105] CPW. 2018. Aquatic data request. Provided to A. Keith, Stillwater Sciences on December 19, 2018.

[106] CPW, BLM, and USFS biologists, pers. comm., December 2018 and March 2019

[107] D. Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers," 15-Dec-2010.

[108] "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker." Utah Department of Natural Resources, Sep-2006.

[109] CPW. 2018. Aquatic data request. Provided to A. Keith, Stillwater Sciences on December 19, 2018.

[110] CPW, BLM, and USFS biologists, pers. comm., December 2018 and March 2019

[111] Hooley-Underwood, Z.E., S.B. Stevens, N.R. Salinas, and K.G. Thompson. 2019. An intermittent stream supports extensive spawning of large-river native fishes. Transactions of the American Fisheries Society 148:426–441.

2.4.7 *Colorado River Cutthroat Trout*

Colorado River Cutthroat Trout are found predominantly in small to medium sized (2nd to 4th order) streams at elevations of 6,000–10,500 feet, with the majority of populations occurring at 6,500–9,200 feet elevation. In the Upper Colorado Geographical Management Unit, 87% of streams supporting Colorado River Cutthroat Trout are 20 feet wide or less.[112] Occurrence in these streams is correlated to habitat characteristics unfavorable to non-native fish. While Cutthroat once moved throughout large basin systems in seasonal feeding and spawning patterns similar to other salmonids, they are typically now confined to reaches where they are not out-competed by introduced trout. Seasonal movements for spawning within their remaining resident reaches is triggered by photoperiod and water temperature. Once in spawning habitat, Cutthroat wait until water temperatures reach 44-50° F and peak runoff subsides before depositing redds and returning to their stream of origin. The extent of movement between spawning grounds and other stream habitats is largely dictated by stream network connectivity. After emergence, fry move to shallow, slow moving areas near spawning zones before migrating to larger streams. Juveniles and adults favor covered, slow-moving pools and protected areas for feeding in the summer and deep pools, beaver ponds and groundwater upwelling zones during the winter.[113]

In the project area, Colorado River Cutthroat Trout occur in the mainstem Colorado River from Glenwood Canyon downstream to New Castle and in numerous tributaries.[114] Specific tributaries with known populations are catalogued and maintained by CPW but are not generally advertised to the public in order to protect populations. They include high elevation streams draining the southwest flanks of the Flattops and southeast portions of the Roan Plateau, as well as some tributaries draining the Divide Creek headwaters and Battlement Mesa. Parties seeking to be involved in fisheries restoration, conservation, or habitat work involving Cutthroat should seek to collaborate directly with CPW and/or USFS.

A Conservation Population of native Cutthroat Trout is one that reproduces and recruits naturally and is managed to preserve its unique genetic, ecological, and/or behavioral characteristics.[115] Genetically, Conservation Populations are generally at least 90% pure. A Core Conservation Population is genetically at least 99% pure and is considered representative of the historical genome. The 2010 Range-wide Status Assessment of CRCT[116] identified additional streams in the project area containing Conservation Populations or Core Conservation Populations of Colorado River Cutthroat Trout in the upper Divide Creek drainages.

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[112] Hirsch, C.L., M.R. Dare, and S.E. Albeke. 2013. Range-wide status of Colorado River Cutthroat Trout (Oncorhynchus clarkii pleuriticus): 2010. Colorado River Cutthroat Trout Conservation Team Report. Colorado Parks and Wildlife, Fort Collins.

[113] "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker." Utah Department of Natural Resources, Sep-2006.

[114] CPW, BLM, and USFS biologists, pers. comm., December 2018 and March 2019

[115] CRCT Coordination Team. 2006. Conservation strategy for Colorado River Cutthroat Trout (Oncorhynchus clarkii pleuriticus) in the States of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins. 24p.

[116] Hirsch, C.L., M.R. Dare, and S.E. Albeke. 2013. Range-wide status of Colorado River Cutthroat Trout (Oncorhynchus clarkii pleuriticus): 2010. Colorado River Cutthroat Trout Conservation Team Report. Colorado Parks and Wildlife, Fort Collins.

Due to historical translocation and stocking, Colorado River Cutthroat Trout populations in the project area include both Blue Lineage (native to the Green, Yampa, and White River drainages) and Green Lineage (native to the upper Colorado River, and Dolores and Gunnison River basins) populations.[117,118]

2.4.8 Non-Native Sport Fish

The dominant non-native cold-water species in the Middle Colorado Watershed include Brown Trout, Rainbow Trout and Brook Trout. These species occupy similar ecological niches to Colorado River Cutthroat Trout, and have become important keystone species and indicators of overall health of riverine ecosystems. Additionally, USFS considers them a Management Indicator Species. Wild reproducing and stocked non-native trout populations are managed and promoted by CPW as sportfisheries in many waters throughout the Middle Colorado Watershed. Whirling disease-resistant Rainbow Trout are often stocked due to the presence of the whirling disease parasite. Brook Trout are widely established throughout cold, higher elevation streams. The stocking of non-native trout is limited to waters where ecological impacts to native Cutthroat Trout are negligible. Control efforts of invasive non-native trout (generally, Brook Trout) to protect and expand native Cutthroat populations are ongoing in various streams in occupied and historic Cutthroat habitat.

Both brook and Brown Trout prefer clear streams that support robust and diverse riparian vegetative cover. Brook Trout can exist in high population densities, thriving in beaver ponds and other confined areas. Brown Trout prefer slightly deeper, slower and warmer water, undercut banks and covered bankside areas, and can tolerate lower quality habitat. Rainbow Trout are habitat generalists, but often occupy mid-channel areas. Rainbow and Brook Trout feed mainly on insects, while adult Brown Trout are piscivorous, surviving mainly on other fish.[119] Non-native trout prefer warmer water temperatures than native Cutthroat Trout. Of the three non-native species, Brook Trout tolerates the coldest water temperatures (~57° F). Rainbow Trout prefer warmer water temperatures (~70° F), and Brown Trout need the warmest water temperatures of the three, (~65-75° F) and are, therefore, generally found in the lowest elevations. Brown Trout are abundant in the Colorado River mainstem above Rifle.

Spawning and incubation periods for all non-native trout species are partially queued by and dependent on photoperiods and water temperatures. Brook and Brown Trout spawn in the late fall (September-November) when days get shorter and water temperatures fall. Rainbow Trout spawn in the spring prior to snowmelt runoff when water temperatures begin to rise.

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[117] Bestgen, K.R., K.B. Rogers, and R. Granger. 2019. Distinct phenotypes of native Cutthroat Trout emerge under a molecular model of lineage distributions. Transactions of the American Fisheries Society 148:442–463. DOI: 10.1002/tafs.10145

[118] Rogers, K. 2013. Recent developments in Cutthroat Trout taxonomy: implications for Colorado River Cutthroat Trout. Appendix A in: Hirsch, C.L., M.R. Dare, and S.E. Albeke. 2013. Range-wide status of Colorado River Cutthroat Trout (Oncorhynchus clarkii pleuriticus): 2010. Colorado River Cutthroat Trout Conservation Team Report. Colorado Parks and Wildlife, Fort Collins.

[119] M. Dare, M. Carrillo, and C. Speas, "Common Trout Species and Conservation Assessment for the Grand Mesa, Uncompahgre, and Gunnison National Forests," Grand Mesa, Uncompahgre, and Gunnison National Forests, Mar. 2013.

Mountain Whitefish are native to Colorado but not to the Middle Colorado River region. They were introduced to the Roaring Fork watershed in the 1940's and have since moved both upstream to Grand County and downstream towards Rifle. Important spawning streams for whitefish are the Roaring Fork River, Grizzly Creek, No Name Creek, Canyon Creek, and Elk Creek. They are known to congregate in large aggregations to spawn. Throughout their native and introduced ranges they cohabitate with various trout with little influence of direct competition. Indeed, they can contribute a valuable prey base to predatory trout.[120]

2.4.9 *Risks to Native and Sport Fisheries*

Most limitations to native fish survival and recovery are common among species, with some exceptions. Many are hydrological: reduced seasonal connectivity to spawning and rearing habitat, reduced spring flood flows, and reduced late summer baseflows. Others are physical: entrainment in diversion ditches and canals; modification of backwaters, side channels, and other off-channel habitat; and fragmentation of habitat by dams and other in-channel structures. Water quality impairment (including temperature), non-native fish competition and predation, and hybridization round out the top challenges these fishes face. The effects of climate change are predicted to exacerbate many of these limitations.

Conservation opportunities for native fishes in the Middle Colorado arise from addressing limitations: increasing or protecting flood and summer streamflows; protecting and restoring off-channel habitat; installing fish screens in diversions; providing for fish passage for all resident fish species around or through any man-made structures, particularly during key times of movement (e.g., spawning, seasonal migrations to more-optimal habitat); managing non-native species; improving water quality; controlling or eliminating invasive fish species, and supporting stocking efforts.

2.4.9.1 Connectivity

Connectivity refers to the physical and biological linkages between stream segments throughout the watershed, as well as linkages between streams and the upland landscape. Longitudinal connectivity relates to upstream-downstream travel of aquatic species and downstream transport of sediment, nutrients, and woody debris. In the management context, stream network connectivity most often relates to the ability for fish and other aquatic species to move throughout a stream network and utilize a range of habitats within a basin or watershed. For many species, unimpeded upstream-downstream movement is vital to spawning success and migration. Wide ranging native fish species may be particularly sensitive to reductions in network connectivity. Connections between large and small streams in different geomorphological settings allows organisms to locate and utilize refugia during short-term stressful events (e.g., summer temperature warming events). The degree of network connectivity may also dictate how biota within the physical system are able to respond to the long-term land use changes or the effects of climate change. Protecting and expanding stream network connectivity can, thus, reduce long-term risks for fish and other aquatic organisms created by a

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[120] CPW staff, 2021, personal communication.

changing environment by maximizing opportunities for use of various habitat types at different points in a given year or season.

Barriers to longitudinal connectivity include all channel-spanning structures such as weirs, large dams and small impoundments, push-up dams or other water delivery infrastructure, culverts, flow-depleted stream reaches too shallow for fish and other organisms to traverse, natural features such as waterfalls or extended steep cascades, and recreational whitewater features. The significance of different features varies by species. Some fish, such as brook and Cutthroat Trout, can ascend very steep and powerful headwaters reaches. Other warm-water species endemic to the mainstem and lower tributaries my experience greater difficulty navigating around or through such obstacles.

Increasing connectivity between the mainstem Colorado River and tributary streams (particularly in the lower 0.5-1.0 miles of those tributaries) throughout the planning area is expected to benefit spawning activities of native warm-water species in the Middle Colorado Watershed.[121] Connectivity improvements higher in the watershed on smaller order streams may benefit Cutthroat Trout. These benefits will also support migration and spawning activities of sport fish. Notably, concern about limited tributary access for Rainbow and Brown Trout motivated a recently completed fish passage project at the Ware and Hinds Ditch on Elk Creek.[122] Planning for similar projects on this and other tributaries is ongoing. It is also important to note here that increased connectivity between habitats within a stream network is not always desirable. Ensuring the long-term health and genetic purity of some Cutthroat Trout populations may require establishing or maintaining downstream barriers to passage for other species. Reestablishing connectivity may also allow for the transmission of diseases and parasites or invasion of undesirable non-native fishes.

[121] CPW, BLM, and USFS biologists, pers. comm., December 2018 and March 2019

[122] https://coloradotu.org/blog/2016/08/elk-creek-fish-passage-project

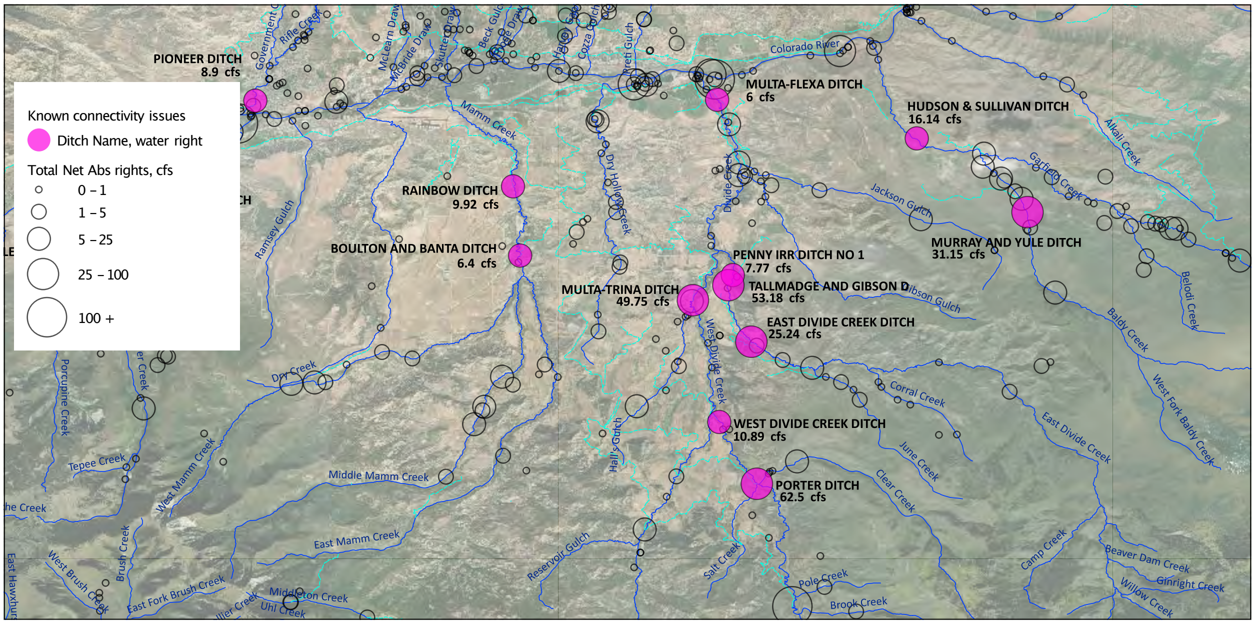

Figure 13. Irrigation diversion structures mapped in the Divide Creek area (open circles). Structures known or expected to create issues for aquatic organism passage are highlighted in pink.

A field reconnaissance of existing barriers to passage in the lower portions of the other major tributary streams in the planning area identified several candidate diversion structures, highway culverts, and other structures for fish passage projects (Figure 13). Additional inventories of select diversion structures have also been recently completed by MCWC partners including Trout Unlimited and Colorado River Engineering. A complete list and maps of these structures in included in Appendix F. As a general rule of thumb, projects that enhance or provide aquatic organism passage around, through, or over a water diversion structure should include fish screens or other devices that aim to limit entrainment of fish in ditches and pipelines. Fish screens are most critical in areas where use by native warm-water species or Cutthroat Trout is known or expected.

2.4.9.2 Habitat Quality

Data gaps exist for habitat suitability for various fish species of interest in the Middle Colorado River. More information tends to be available for sport fisheries due to their economic and recreational interests. To increase information on habitat preferences of three representative species, modelling was conducted to understand the relative availability of suitable habitat for three representative fish species at different flows. Suitability metrics were estimated for two native species (flannelmouth and Bluehead Sucker) and one introduced sport species (Brown Trout). Model outputs indicate habitat for the three species is maximized at 2,000-2,300 cfs in the New Castle and Parachute areas, where river channels are typically single-threaded in a more-confined valley, and above 3,000 cfs in the Rifle area, where wide unconfined floodplains and multi-threaded channels occur. Changes to late summer stream flows under the range of climate and growth scenarios used in the hydrology analysis of this IWMP are then used to understand how usable habitats may change for these species in the future. All species show a significant decline in usable habitat below naturalized mean August and September streamflows. Bluehead Sucker habitat tends to decline most strongly, while Brown Trout habitat is less sensitive to flow changes. At the range of potential stream flow reductions estimated under Scenario E (Hot Growth), estimated usable habitat declines approach 40% of habitat available at naturalized basin flows.

Aquatic habitat quality and availability within a stream network is affected not only by infrastructure like culverts and water diversion structures that impact connectivity, but also by temporally variable hydrological and hydraulic conditions within channels. Various aquatic species/life-stages exhibit preferences for certain habitat types, as described by several hydraulic characteristics (e.g., water depth and velocity in riffles). Where optimal conditions exist, aquatic biota can utilize local habitat for feeding, reproducing, etc. Localized changes in streamflow (in timing, magnitude, and frequency) impact channel hydraulics. Suboptimal hydraulic conditions not only preclude use of local habitat but may present a significant barrier to passage that limits utilization of some upstream or downstream portion(s) of the stream network.

Several methodologies exist for assessing local hydraulic conditions against the preferred conditions for various aquatic species. These methodologies include R2Cross, PHABSIM, RHABSIM, the wetted-perimeter method, the Tennant method, and others. CWCB and CPW rely extensively on the R2Cross methodology[123] to describe minimum flow needs for assemblages of fish as support for development of ISF water rights on rivers across Colorado. ISF water rights are established on some tributaries in the planning area. The R2Cross methodology uses quickly obtainable hydraulic geometry data and assumes that streamflows sufficient to maintain aquatic habitat in critical riffle segments will also maintain habitat quality in other channel segments such as runs and pools. Unfortunately, the methodology is not well suited to large rivers like the Colorado River through the Middle Colorado Watershed and no specific assessment of hydraulic habitat quality for this section of the river exists in the published literature. In an effort to fill this important data gap, a 2-dimensional aquatic habitat modeling effort was undertaken as part of this planning effort (Figure 14).

To characterize habitat in the Middle Colorado River, we used calibrated HEC-RAS water surface elevation models for Grand County coupled with the USGS Flow and Sediment Transport with the Morphological Evolution of Channels (FaSTMECH) model to estimate fish habitat suitability indices at different river flows.[124] This habitat modelling approach describes suitable instream habitat using physical variables like water depth, velocity, and channel substrate. Different combinations of these metrics sum to a composite suitability index (CSI). Using a 2-D hydraulic model, the CSI can be calculated for discrete gridded locations in a channel study reach and compared across a variety of different stream flows. Comparison of hydraulic

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123 D. Espegren, "Development of Instream Flow Recommendations in Colorado Using R2Cross.," Colorado Water Conservation Board., Jan. 1996.

124 FaSTMECH Model Notes. International River Interface Cooperative, 2013, https://iric-gui-user-manual.readthedocs.io/en/latest/01_introduction.html.

modeling outputs across a range of flows to CSI values for each species yields weighted usable habitat area (WUA)[125] curves. These curves reflect changes in suitable habitat in a modeled reach as a function of flow.

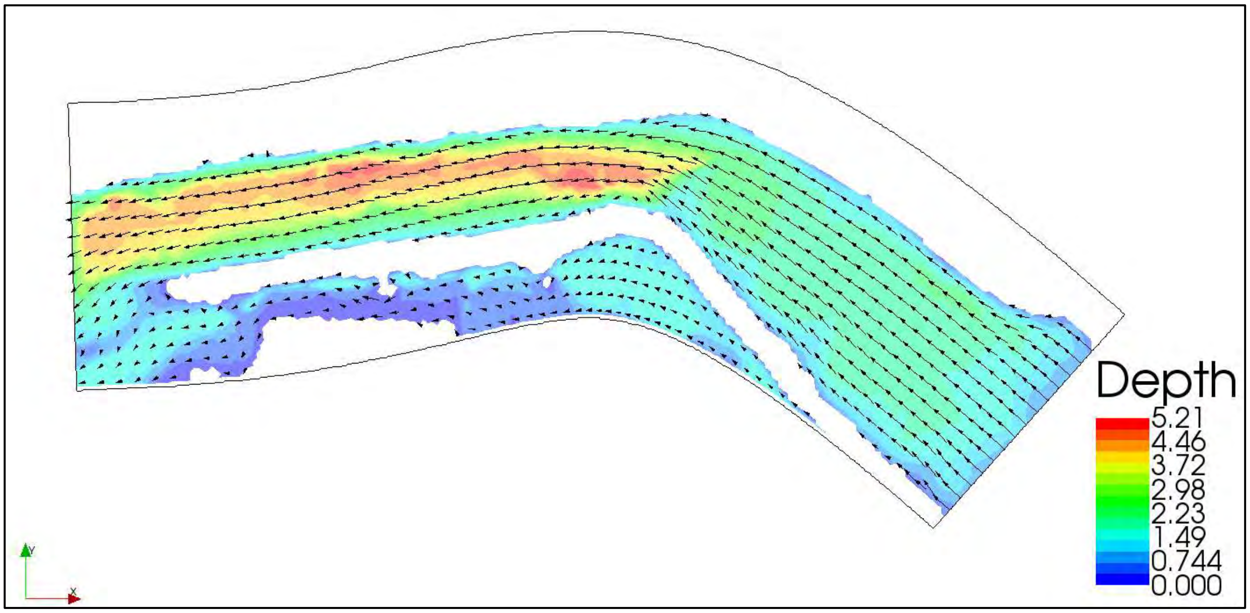

Figure 14. Screen capture of FASTMECH two-dimensional modeling results of depth (color bar) and velocity (arrows) for the Colorado River at the New Castle study site.

Habitat modeling results indicate that is WUA maximized for the three species at flows between 2000-2300 cfs in both Parachute and New Castle. In Rifle, where channel forms are more complex and channel gradients are lower, aggregate habitat area is maximized for the three species at flows above 3000 cfs. Relative comparisons of WUA curves between the three species at each site indicate habitat conditions potentially more favorable to Bluehead Suckers than either Flannelmouth Suckers or Brown Trout. WUA values for the native species at the Parachute and Rifle sites increase or remain stable at flows above 3000 cfs while WUA values for all three species decline rapidly in New Castle above 2500 cfs. This pattern may suggest that the greater channel complexity in alluvial reaches downstream of South Canyon provides important habitat refugia for native species and Brown Trout during periods of high flow. It may then be presumed that natural phenomenon or human management activities that lead to reductions in channel complexity in these reaches may have secondary impacts on fish community composition in the Middle Colorado Watershed.

The relationship between streamflow and habitat suitability metrics (described by WUA values) is most useful for river management decision making when considered within the context of historical hydrology and potential future hydrology changes. Comparing WUAs for each species under the naturalized hydrology scenario to the range of hydrologic regimes described by our various planning scenarios (Section 2.1.3 of this IWMP) allows us to understand habitat impacts under each of those scenarios. Average minimum August and

[125] The concept of Weighted Usable Area is presented by numerous resource management agencies and researchers but is described succinctly here: https://www.ars.usda.gov/ARSUserFiles/60600510/Topashaw/aquatic_habitat_suitability.pdf

September flows on the Colorado River at Cameo were estimated at ~2400 and ~2000 cfs, respectively, using naturalized hydrological simulation models (**Error! Reference source not found.**). Impacts on habitat associated with alteration of late summer streamflow were then assessed by computing then normalizing WUA values at streamflows below 2400 cfs as a percentage of the value computed at 2400 cfs. Reductions in mean August minimum streamflows estimated by comparing the Baseline planning scenario to the Naturalized flow scenario indicate a modest decrease in habitat suitability for each of the three species in Parachute. Further August low flow reductions predicted in planning scenarios C, D and E (Table 4) could decrease habitat suitability at that location between 10-30% (Figure 15). Habitat suitability becomes much more sensitive to changes in streamflow below ~1500 cfs. Below this flow, increasing flow abstraction appear to have proportionally greater impact on habitat suitability for all three species than at flows above this threshold.

Changes in suitable habitat area as a function of discharge showed a much more consistent response as mean August minimum flows decreased below 2400 cfs (Figure 16). Bluehead appear much more sensitive to flow changes than the other two species. Changes in late summer flows (relative to natural conditions) predicted under scenarios C, D, and E (Table 4) may reduce habitat suitability for Flannelmouth Suckers in the Rifle area between 30-45%. Ranges of suitable habitat reductions for Flannelmouth Suckers range from 25-35%, while Brown Trout habitat shows the lowest reduction in the range of 15-25%.

A similar habitat suitability evaluation carried out for the site in New Castle yielded different results (Figure 17). In this reach, bluehead habitat suitability appears highly sensitive to flow abstractions below the natural mean September minimum flow. Brown Trout and Flannelmouth Suckers appear relatively insensitive to changes in flow in this reach—although, flannelmouth habitat suitability does show a modest decline below about 1500 cfs. Changes in mean September minimum flows predicted under scenarios C, D, and E (Table 4) may reduce habitat suitability for Flannelmouth Suckers in the New Castle area by 15-25%.

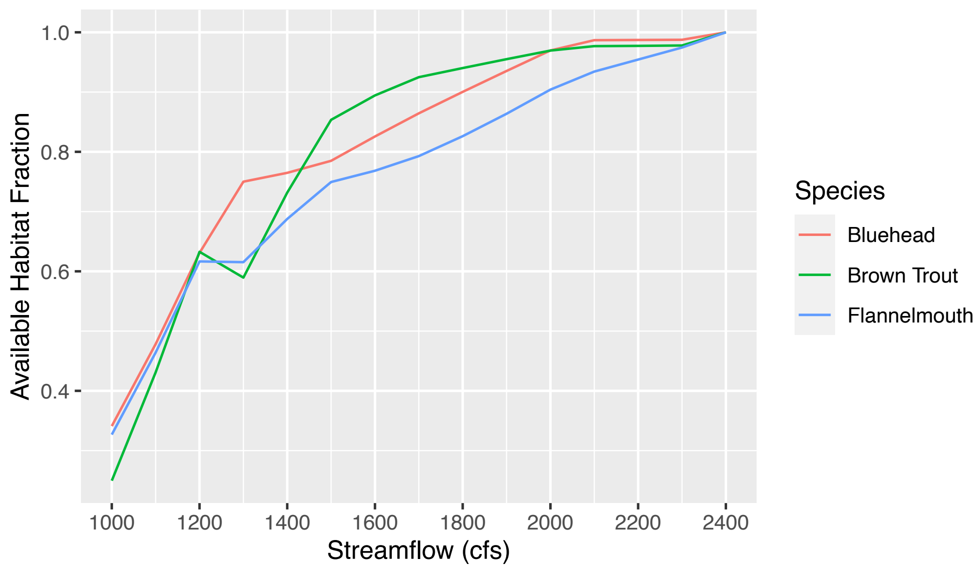

Figure 15. Fractional habitat suitability at Parachute computed by comparing WUA computed over a range of streamflows to the WUA value computed for naturalized mean August minimum flows.

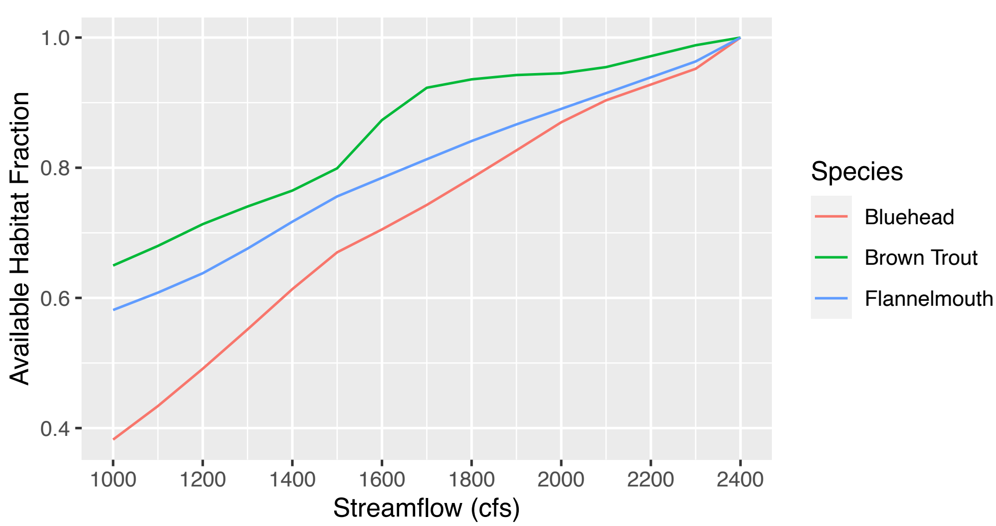

Figure 16. Fractional habitat suitability at Rifle computed by comparing WUA computed over a range of streamflows to the WUA value computed for naturalized mean August minimum flows.

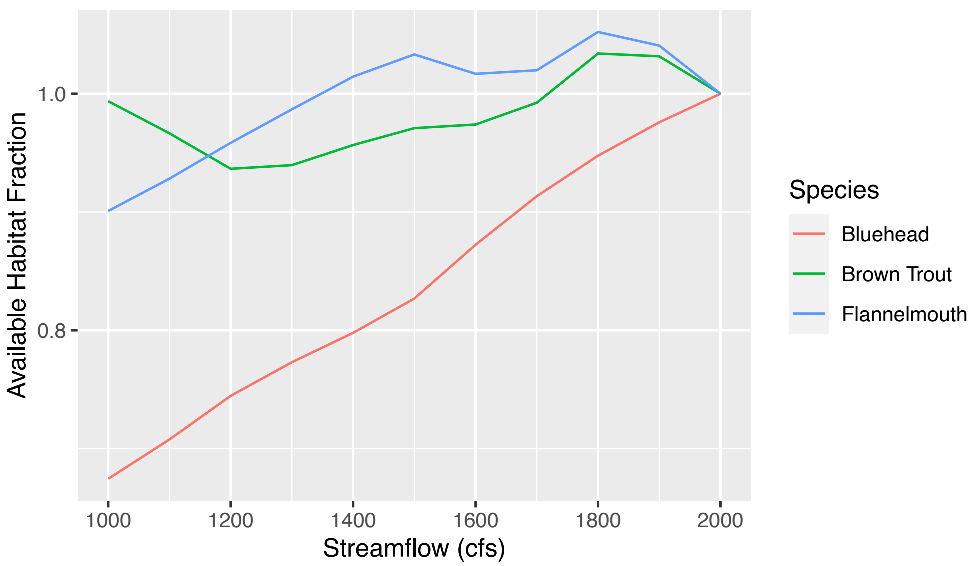

Figure 17. Fractional habitat suitability at New Castle computed by comparing WUA computed over a range of streamflows to the WUA value computed for naturalized mean September minimum flows. Note the vertical axis scale is different from the figure above.

2.4.9.3 Disease

Whirling disease, caused by the *Myxobolus cerebralis* metazoan parasite, significantly impacts Rainbow Trout populations. Wild recruitment is now rare except where CPW has introduced whirling disease-resistant Rainbow Trout populations from carefully cultivated hatchery stocks. If whirling disease is able to impact streams containing Cutthroat populations, they are likely to be extirpated. Brook Trout are heavily susceptible to high infection rates as well, though extirpation is less likely. Furunculosis, a persistent skin infection caused by *Aeromonas salmonicida* bacteria, has been a problem in the Eagle River near the Colorado River confluence in the past, causing localized high fish mortality. Through downstream migration of disease-carrying individuals, it could be a potential issue in the Middle Colorado Watershed in the future when water levels drop in summer and coldwater fish become concentrated in warmer waters.

2.4.10 Future Low Flow Events

The various planning scenarios considered under this planning effort indicate the potential for changes in the frequency, magnitude and duration of late summer low flow events. The characteristics of low flow events where July-September flows fall below the naturalized mean September minimum flow were computed. These calculations gave an indication of how events relevant to habitat suitability for various fish species in the Colorado River mainstem might change in the future (Table 9). The effect of upstream reservoir operations on late summer flows is apparent in these results. Average flow deficits computed under the Naturalized scenario are larger than for Baseline, Scenario A, or Scenario B. Scenarios D and E show an increasing event duration and severity as measured by total flow deficit when compared to either the Naturalized or Baseline scenario (Figure 18).

The section of the Colorado River that flows through the Middle Colorado Watershed tends to benefit from coordinated management activities intended to protect the fishery in the 15-mile reach. Water deliveries to the 15-mile reach aim to protect August through October flows at levels between 810-1,630 cfs, depending on the hydrological year type. Delivering this water past the various diversions to Grand Valley irrigators requires much more water to be delivered through the Middle Colorado reach. While the same benefits are expected in the future, more active participation by local stakeholders in those water management decision-making processes will help ensure that specific local needs are not overlooked as actions are taken to benefit downstream reaches. The habitat related benefits of delivering water to the reach of the mainstem Colorado River that flows through the Middle Colorado Watershed may also work to strengthen long-term protections for water deliveries to the 15-mile reach. The habitat modeling results presented above and discussed in further detail in Appendix F should provide useful supporting information in that context.

Critically, management actions focused on preserving or enhancing riparian health, sediment transport, and the dynamic characteristics of river channel discussed elsewhere in this document are as critical to maintaining high quality habitat for native and sport fish as maintenance of hydrological characteristics of the Middle Colorado River reach. Management of streamflows alone cannot be expected to stabilize and protect aquatic communities if, when and where significant degradation of riparian communities or channel complexity occurs.

Table 9. Low-flow event characteristics where flows fall below 2000 cfs for several planning scenarios. Top: computed low flow characteristics for several scenarios. Middle: percent change in various low-flow metrics under each scenario as compared to natural conditions. Bottom: computed change in low flow characteristics under each scenario as compared to baseline conditions.

			Simulation Results				
Metric	**Naturalized**	**Baseline**	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**	**Scenario E**
Average Event Start (Julian day)	231	212	213	211	214	209	213
Average Event Duration (days)	23	21	22	23	25	44	33
Average Minimum Event Flow (af)	1677	1696	1676	1659	1643	1514	1609
Average Flow Deficit (af)	24284	18577	20065	21254	18568	44510	31408

			Change from Natural Conditions				
Metric	**Naturalized**	**Baseline**	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**	**Scenario E**
Average Event Start (Julian day)	-	-8%	-8%	-8%	-7%	-9%	-8%
Average Event Duration (days)	-	-9%	-6%	-3%	9%	90%	42%
Average Minimum Event Flow (af)	-	1%	0%	-1%	-2%	-10%	-4%
Average Flow Deficit (af)	-	-23%	-17%	-12%	-24%	83%	29%

			Change from Baseline Conditions				
Metric	**Naturalized**	**Baseline**	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**	**Scenario E**
Average Event Start (Julian day)	-	-	0%	0%	1%	-1%	0%
Average Event Duration (days)	-	-	3%	8%	20%	110%	56%
Average Minimum Event Flow (af)	-	-	-1%	-2%	-3%	-11%	-5%
Average Flow Deficit (af)	-	-	8%	14%	0%	140%	69%

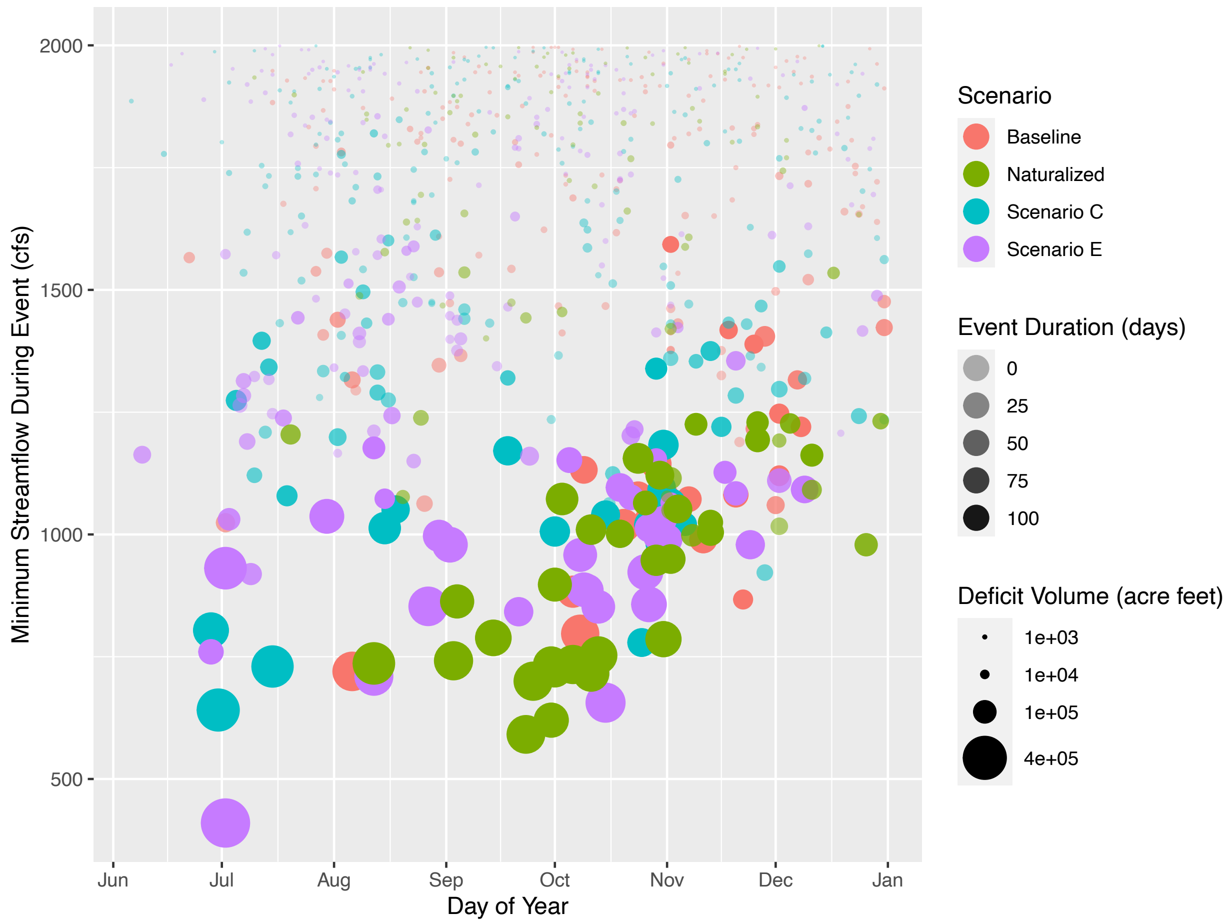

Figure 18. Low-flow event characteristics where flows fall below 2000 cfs over a 38-year period for a subset of the planning scenarios. Scenarios C and E show a shift toward high-severity low-flow events occurring earlier in the year.

2.4.10.1 Competition and Predation

Escapement of white suckers, bass, bullfrogs, and other species from private ponds and gravel pits presents an ongoing challenge for effective management of native aquatic biota in the Middle Colorado Watershed. Reducing impacts of invasive aquatic and amphibian species on aquatic biota may require targeted community education campaigns about what constitutes illegal stocking and why it should be avoided, signage around public ponds and river access points regarding invasive species control and illegal stocking, and physical modification of abandoned gravel pit ponds. Abandoned and reclaimed gravel pits exist in floodplains and low terraces throughout the planning area. Some of these pits contain invasive fish species and several, like the Mamm pits, are documented historical sources of invasive species to the Colorado River.[126] Escapement of fish from gravel pits and private ponds is most likely in cases where hydrological connections between

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[126] CPW, BLM, and USFS biologists, pers. comm., December 2018 and March 2019

those water bodies and the river do not include mechanical barriers to passage, maintenance to existing barriers is deferred or decreases over time, or when/where a levee or other barrier is breached by the river during a high flow event. See Section 2.11 for an expanded discussion of this issue.

2.5 Agricultural Production

Agriculture is the largest water user in the Middle Colorado River Watershed, putting the State's most precious resource to beneficial use for the production of food and fiber we all rely upon. The 2017 Census of Agriculture, conducted by the USDA National Agricultural Statistics Service found 475,166 acres of land in farms in Garfield County with 51,961 acres in irrigation (11% of land in farms). Of this land, the vast majority is in pastureland or in production of grain and feedstocks that support livestock, poultry and associated products. The same report found the market value of products sold in Garfield county to be $35.8 million with a net cash farm income of $4.7 million. Within this region, water is mainly put to use growing alfalfa or pasture grass to support cow-calf operations. For the purposes of quantification, irrigated acreage has been assessed by DWR Water District (**Error! Reference source not found.**). These districts are formed by DWR for the purposes of water administration and define the jurisdiction of various water commissioners. The vast majority of agricultural activities in the MCRW takes place in Water Districts: 39, 45 and 70. Water District 39 generally encompasses the area north of the Colorado River, District 45 encompasses areas south of the Colorado River and District 70 generally encompasses the Roan Creek drainage.

The three local Conservation Districts, Bookcliff, Southside, and Mount Sopris, were integral in conducting an agricultural infrastructure assessment as part of the Planning effort. The mission of the Conservation Districts is to provide leadership, encourage wise resource decisions, set standards, encourage stewardship and education cooperators, agencies, land users, and youth to conserve, improve and sustain our natural resources and the environment. The goals of the inventory were to assess the condition of diversion structures, main ditch, measuring devices, lateral headgates, culverts, and any other infrastructure present on the ditch. This assessment identified potential points of failure as well as providing any information to aid the landowner regarding efficiently diverting water and putting it to beneficial use in order to protect their water rights. GPS points were taken to identify the path of the ditch as well as key points along the ditch (culverts, headgates, siphons, etc.) In addition to the assessment, each water right owner was provided with a variety of publicly available information related to their water rights including: water court decrees, structure summary reports, diversion records, irrigated acreage assessment, and other information pertinent to their water rights. As of this writing, 55 structures and nearly 200 miles of ditch were inventoried for this effort. The agricultural infrastructure inventory is further detailed in Appendix H.

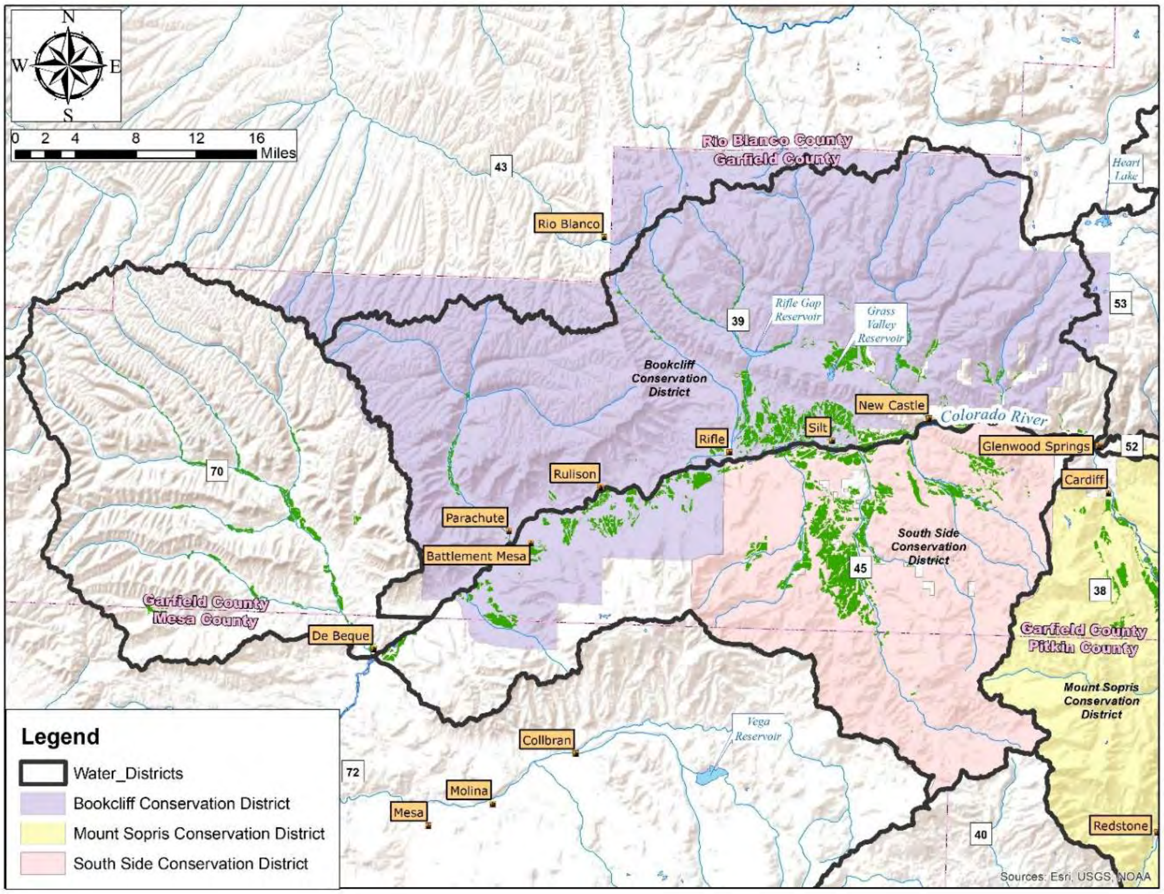

Figure 19. DWR Districts, Soil Conservation Districts, and locations of irrigated acreage within the study area.

Agricultural water diversions within the Middle Colorado Watershed are primarily located on the tributaries to the Colorado River. Many tributary water rights are pre-Compact (i.e., pre-1922, when Congress ratified the Colorado River Compact) and senior to the Cameo call, but are administered locally on the tributary. This results in much larger shortages due to limited local supplies and the resulting water administration. In a dry year, some tributary calls can become active as early as mid-April and remain in effect for the entire irrigation season, while a Cameo call is not likely until mid-July in some of the driest years and mid- to late-August in average years. Because of the relative seniority of tributary water rights, these users are curtailed in most years as the physical supply is dependent upon local snowpack conditions which are highly variable from year to year.

Irrigated acreage mapping and classification of agricultural production by crop types were created by the DWR using aerial imagery from 2015. Water District 39 has a total of 14,175 irrigated acres. Approximately 78% of these acres are defined as alfalfa under flood and sprinkler irrigation. Grass pasture represents approximately 16% of the acreage mainly under flood irrigation. Other minor crops include bluegrass and orchard. Water District 45 has a total of 26,062 irrigated acres. Approximately 69% of these acres are defined as alfalfa under mainly flood irrigation (57%) with some acres identified under sprinkler irrigation (12%). Approximately 22% of the acreage is defined as grass pasture mainly under flood irrigation. Other minor crops include: orchard, corn, bluegrass and grapes. Water District 70 has a total of 3,370 irrigated acres. Approximately 65% of the acreage is classified as alfalfa under mainly flood irrigation (63%) with a small amount under sprinkler or furrow irrigation. Approximately 35% of the acreage is identified as grass pasture under flood irrigation.

The main irrigation type across all water districts is flood irrigation. This method of irrigation does not have the high infrastructure costs which are typically associated with other forms of surface irrigation. Under flood irrigation water is turned out from the delivery structure and is run across the land. Flood irrigation has a typical efficiency of about 50%, this means that approximately 50% of the water diverted is available to the crops. The other 50% is lost to surface runoff or deep percolation into groundwater. Historically, these "losses" have contributed to local aquifer recharge and late season return flows that accrue back to the stream. As lands transition to sprinkler irrigation, application efficiencies generally increase which reduces the amount of aquifer recharge and late season return flows resulting from irrigation, but also reduces the amount of water that is required to be diverted to meet the crop demands. The majority of sprinkler irrigation in this area uses side roll, big guns or center pivot systems.

Transitioning to more efficient irrigation practices can cost in the thousands to tens of thousands of dollars. This amount of capital requires the producer to get a return on the investment, which is accomplished through increased production. As will be illustrated in later sections of this report, some areas are extremely water short and only receive water for a few days or weeks a year which results in only one cutting of hay/alfalfa. The lack of a reliable water supply does not justify the high infrastructure cost for many producers in our area. Producers that can rely on the Silt Project, where water is stored during the winter for release during the irrigation season, can more easily justify the cost of infrastructure upgrades based on a more dependable water supply. Similarly, basins such as Elk Creek and Canyon Creek have a more dependable supply from year to year. Producers on Silt Mesa have also benefited from the Salinity Control program conducted through the Natural Resources Conservation Service (NRCS) which provides cost share dollars to increase efficiencies in order to reduce salinity loading to the Colorado River.

2.5.1 Role of the Silt Project

Authorized by federal legislation in 1956, the Silt Project was built to supply new irrigation water to 2,416 acres and supplemental irrigation to another 4,628 acres around Rifle and Silt. BOR and the Silt Water Conservancy District manage the project and its two main pieces of infrastructure: Rifle Gap Reservoir and Silt Pump Plant. Rifle Gap Reservoir sits at the confluence of East and West Rifle Creeks at Rifle Gap. The reservoir has a capacity of 13,602 acre-feet and begins filling in November. The operators are required to bypass winter flow below the dam at either 5 cfs or inflow, whichever is less. Come the irrigation season, the reservoir makes deliveries directly into Davie Ditch for use on Davie Mesa and by exchange for use on lands under the Grass Valley Canal out of East Rifle Creek.[127] The Silt Pump Plant sits on the mainstem of the Colorado two miles east of the Town of Silt. The pump can lift 36 cfs into the Silt Pump Canal to irrigate

[127] Basin Information, supra note 15, at 2-65 - 66

1,950 acres. The Silt Project retained 5,000 acre-feet of water in Green Mountain Reservoir as augmentation supply to allow the Silt Pump to run even when it would be curtailed by senior calling water rights.[128]

2.5.2 Role of Harvey Gap Reservoir

Harvey Gap Reservoir (a.k.a., Grass Valley Reservoir) sits at Harvey Gap just north of the Town of Silt. The reservoir is privately owned but recreational access is secured for the public by CPW. Its capacity is around 5,920 acre-feet and is filled from the Grass Valley Canal. Although not technically a part of the Silt Project, water from Rifle Gap Reservoir does provide water to lands served by Harvey Gap Reservoir by exchange – diversions from East Rifle Creek are made upstream at the Grass Valley Canal and an equal amount is released from Rifle Gap Reservoir into Rifle Creek to satisfy downstream calling water rights.[129]

2.5.3 Risks for Diminished Agricultural Production

This section utilizes results from the 2019 Colorado Water Plan Technical Update scenario planning models by Water District to understand localized risks to the agriculture sector in the Middle Colorado River. Under the various planning scenarios, all basins experience additional shortages under scenarios C, D, and E, but usually less than 15% increase overall from existing shortage problems in the Baseline scenario. Within Water District 39, Rifle Creek is expected to see the greatest change in water availability under all scenarios, while other drainages like Elk Creek only see significant shortages under scenarios C and E. Water District 45 already sees significant shortages and is likely to see more under some scenarios. These shortages are the result of the less dependable water supply south of the Colorado River. These basins do not have very high elevations which can provide a more dependable winter snowpack.

The datasets from the Technical Update were parsed and used to derive outputs more representative of local conditions. The modeling results considered include total agricultural use demands, total supplies and total water shortages experienced at select individual structures known as explicit structures, and various aggregate structures. Because historical data are lacking for many structures in the planning area, the State relies on "explicitly" modeled structures in the scenario planning models. These structures have the data necessary to complete a consumptive use analysis. For each tributary with an explicit structure, the total demands, supplies and shortages were analyzed. The total demands, supplies, and shortages for the explicit structures were summed and divided by the irrigated area represented by these explicit structures. This provides an overall demand/supply/shortage normalized into units of "feet". Using the total irrigated area within the tributary the demands, supplies and shortages were scaled up to represent the whole tributary. This method was selected over the CWCB method of using "aggregate" structures because those demands, supplies and shortages are aggregated to a node on the Colorado River and the aggregates can include structures from different drainages. For this analysis it was desirable to assess each tributary independently based on their explicitly modeled structures and scaling those results to the total irrigated area under each source (Table 10). Generally, these structures are representative of the basin, however, some smaller drainages are lacking good

[128] Id.

[129] Basin Information, supra note

representation. Clear Creek in District 70 and Mamm Creek in District 45 have the poorest acreage representation by explicit structures.

In Water District 39, explicitly modeled structures were included on Elk Creek, Canyon Creek, Rifle Creek and Parachute Creek. Results are provided for the Baseline dataset as well as the five planning scenarios described previously.

Elk Creek included the following explicit structures: Coryell Ditch, Coryell Joint Stock Irrigating Ditch, Pierson and Harris Ditch, Thompkins Ditch, Ware and Hinds Ditch, and Red Rock Ditch. These structures represent a total irrigated area of 1,342 acres in the Baseline dataset. The total irrigated acreage in the Elk Creek drainage is 2,607 acres. In each of the planning scenarios, the acreage under the Coryell, Coryell Joint Stock Irrigating Ditch and Ware and Hinds was decreased by 24.7 acres, 64.4 acres and 7.5 acres, respectively. The assumption is that these acres are transitioned from irrigated agriculture to urban areas given their proximity to the Town of New Castle.

Canyon Creek included the following explicit structures: DeWeese Ditch and Williams Canal. These structures represent a total irrigated area of 449 acres in the Baseline dataset. The total irrigated acreage in the Canyon Creek drainage is 805 acres. There was no reduction to irrigated acreage under the planning scenarios.

Table 10: Total irrigated area represented by explicitly modeled structures.

Water District	Drainage	Area represented by explicit structures
39	Elk Creek	51%
39	Canyon Creek	56%
39	Rifle	79%
39	Parachute	64%
70	Roan	86%
70	Clear	4%
70	Carr	29%
45	Battlement	58%
45	Baldy	40%
45	Cache	36%
45	Garfield	73%
45	Mamm	19%
45	Divide Creek	82%
45	Beaver	38%
45	Colorado River	57%

Rifle Creek included the following explicit structures: Davie Ditch, Grass Valley Canal, Grand Tunnel Ditch, Hibschle Benbow Ditch, Rifle Creek Canon Ditch and West Lateral Rifle Creek Canon Ditch. These structures represent a total irrigated area of 2,830 acres under the Baseline dataset. The total irrigated acreage in the Rifle Creek drainage is 8,850 acres, which includes the acreage under the Silt Project which is supplied by diversions from Rifle Creek. In each of the planning scenarios, the acreage served by the Grand Tunnel

Ditch and Rifle Creek Canon Ditch was decreased by 215.1 acres and 249.4 acres, respectively. The assumption is that these acres are transitioned from irrigated agriculture to urban areas given their proximity to the City of Rifle.

Parachute Creek included the following explicit structures: Granlee Ditch, Jangle Ditch, Low Cost Ditch and Parachute Ditch. These structures represent a total irrigated area of 412 acres in the Baseline dataset. The total irrigated acreage in the Parachute Creek drainage is 648 acres. There was no reduction to irrigated acreage under the planning scenarios.

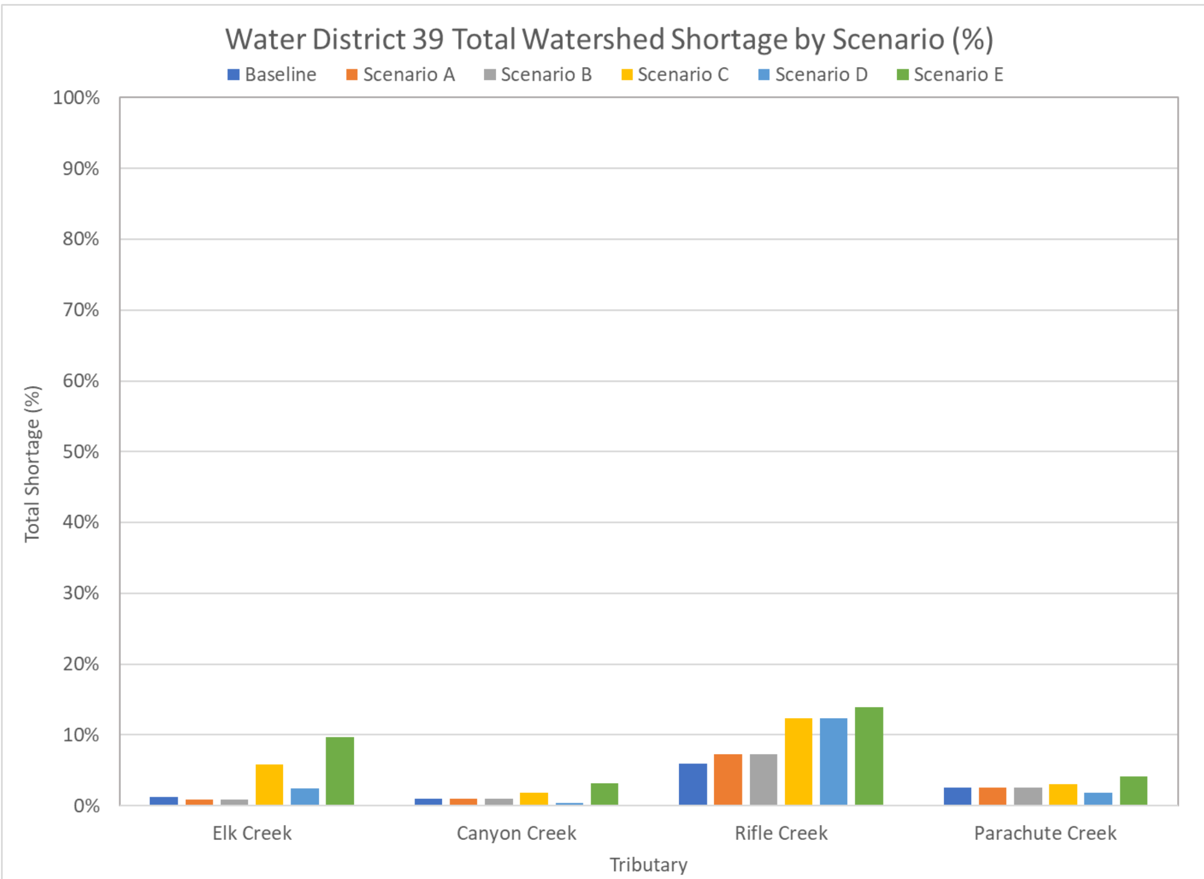

Figure 20: Water District 39 percentage short by tributary.

The total diversion shortage results by tributary in Water District 39 were computed as a percentage of the total watershed demand (various aspects of results displayed in Figure 20, Figure 21, Figure 22). On average, the Rifle Creek drainage suffers the largest shortages across the planning scenarios, but are less than 15% short. The largest shortage was modeled under Scenario E – Hot Growth. Results did not vary much from the Baseline dataset for Scenarios A-B, however, shortages increased for most tributaries in Scenarios C and E. Scenario D actually shows a decrease in the shortages on Elk Creek, Canyon Creek, and Parachute Creek which are more in line with the Baseline dataset. Scenario D is the Adaptive Innovation scenario which balances higher temperatures and populations with less water intensive crops and higher system efficiencies. Elk Creek, Canyon Creek and Parachute Creek have relatively lower shortages in all Scenarios which are generally less than 10%.

In Water District 45, explicitly modeled structures were included on Garfield Creek, Baldy Creek, Divide Creek, Mamm Creek, Beaver Creek, Cache Creek, Battlement Creek, and the Colorado River. Results are provided for the Baseline dataset as well as the five planning scenarios described above.

- Garfield Creek included the following explicit structures: Hudson and Sullivan Ditch, Roderick Ditch, and Sykes and Alvord Ditch. These structures represent a total irrigated area of 1,206 acres in the Baseline dataset. The total irrigated area in the Garfield Creek drainage is 1,653 acres. There was no reduction to irrigated acreage under the planning scenarios.
- Baldy Creek included the following explicit structures: Dow Ditch, Joe Taylor Ditch, and Murray and Yule Ditch. These structures represent a total irrigated area of 493 acres in the Baseline dataset. The total irrigated area in the Baldy Creek drainage is 1,227 acres. There was no reduction to irrigated acreage under the planning scenarios.
- Divide Creek included the following explicit structures: East Divide Creek Ditch, Tallmadge and Gibson Ditch, Ward and Reynolds Ditch, Louis Reynolds Ditch, Mineota Diversion System, Multa-Trina Ditch, Divide Creek Highline Ditch, Porter Ditch, and West Divide Creek Ditch. These structures represent a total irrigated acreage of 9,716 acres. The total irrigated area in the Divide Creek drainage is 11,816 acres. There was no reduction to irrigated acreage under the planning scenarios.
- Mamm Creek included the following explicit structures: Mamm Creek Ditch. This structure represents a total irrigated area of 366 acres. The total irrigated area in the Mamm Creek drainage is 1,893 acres. There was no reduction to irrigated acreage under the planning scenarios.
- Beaver Creek included the following explicit structure: Taughenbaugh Ditch. This structure represents a total irrigated area of 432 acres. The total irrigated area in the Beaver Creek drainage is 1,126 acres. There was no reduction to irrigated acreage under the planning scenarios.
- Cache Creek included the following explicit structures: H and S Ditch, and Holmes Diversion System. These structures represent a total irrigated area of 532 acres. The total irrigated area in the Cache Creek drainage is 1,497 acres. There was no reduction to irrigated acreage under the planning scenarios.
- Battlement Creek included the following explicit structures: Battlement Ditch, and Huntley Ditch. These structures represent a total irrigated area of 532 acres. The total irrigated area in the Battlement Creek drainage is 971 acres. There was no reduction to irrigated acreage under the planning scenarios.
- The Colorado River included the following explicit structures: Rising Sun Ditch, Last Chance Ditch, Larkin Ditch and Bluestone Valley Ditch. These structures represent a total irrigated area of 2,243 acres. The total irrigated area irrigated with water directly from the Colorado River is 3,909 acres. The Rising Sun, Last Chance and Bluestone Valley Ditch acreages were reduced by 42 acres, 114 acres and 646 acres, respectively across the planning scenarios. The assumption is that these acres are transitioned from irrigated agriculture to urban areas given their proximity to the Town of Silt and the Town of De Beque.

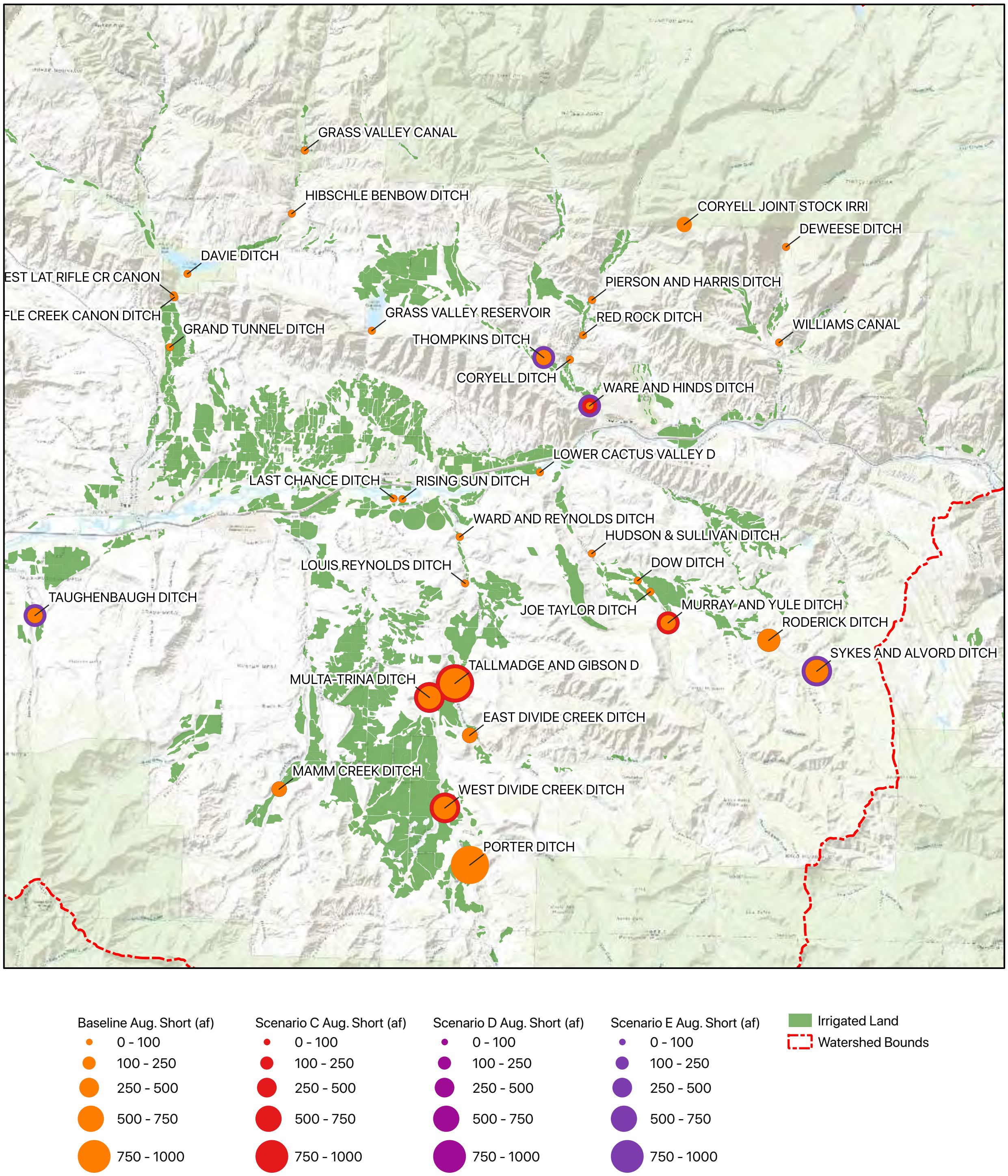

Figure 21. Relative magnitude of shortages experienced at surface water diversions in the Silt and Rifle area under baseline conditions and several of the evaluated planning scenarios.

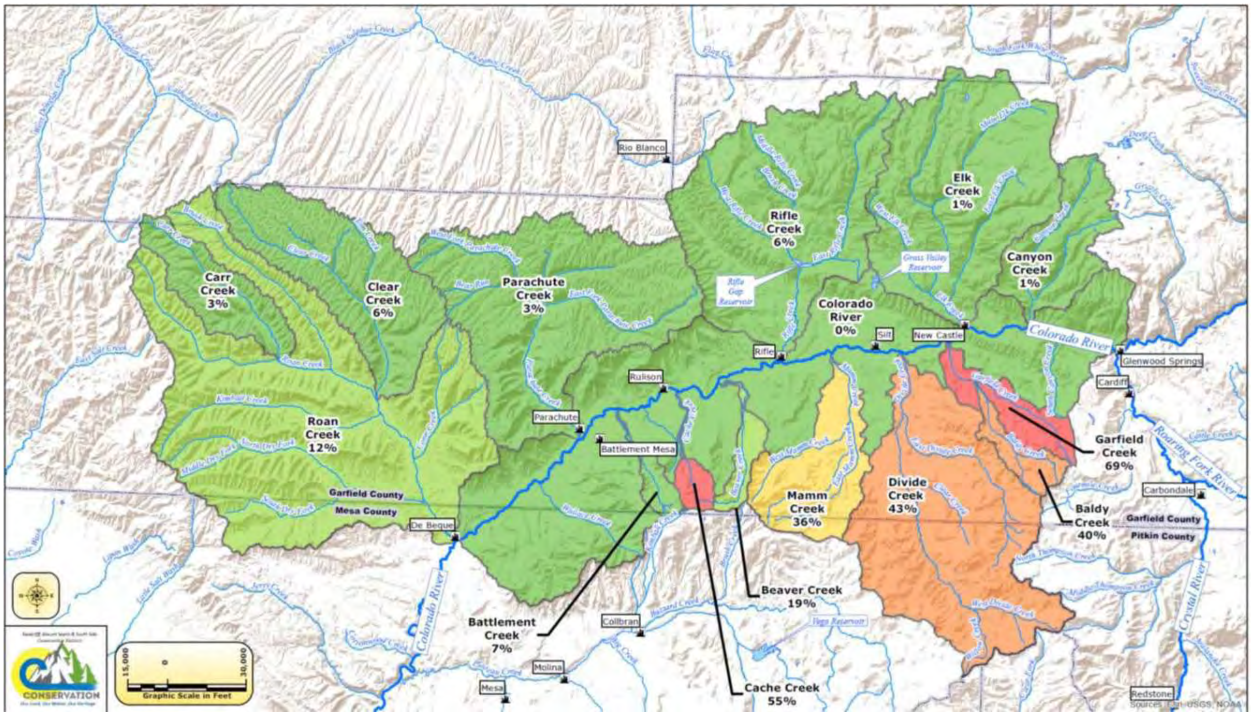

Figure 22. Magnitude of shortages experienced in each tributary basin under Baseline conditions. Results for all planning scenarios are included in Appendix H.

The total shortage results by tributary in Water District 45 were calculated as a percentage of the total watershed demand (Figure 22, Figure 23). On a percentage of demand basis, the Garfield Creek drainage suffers the largest shortages across the planning scenarios, and are upwards of 70-80% short. The majority of southwest tributaries in District 45 experience shortages in excess of 30% across baseline and future planning scenarios. Again, results are consistent from the Baseline through Scenarios A and B, with increases in shortages in Scenarios C-D. Scenario E has the highest shortages as it represents the hot growth scenario. Scenario D again balances higher temperatures and populations with less water intensive crops and higher system efficiencies which results in varying shortages by tributary. These shortages are the result of the less dependable water supply south of the Colorado River. These basins do not have very high elevations which can provide a more dependable winter snowpack. This area also does not have storage projects that could firm up the water supply situation, storing excess water in wet years for carry-over into drier years. The Colorado River structures experience very low water shortages given the more dependable water supply.

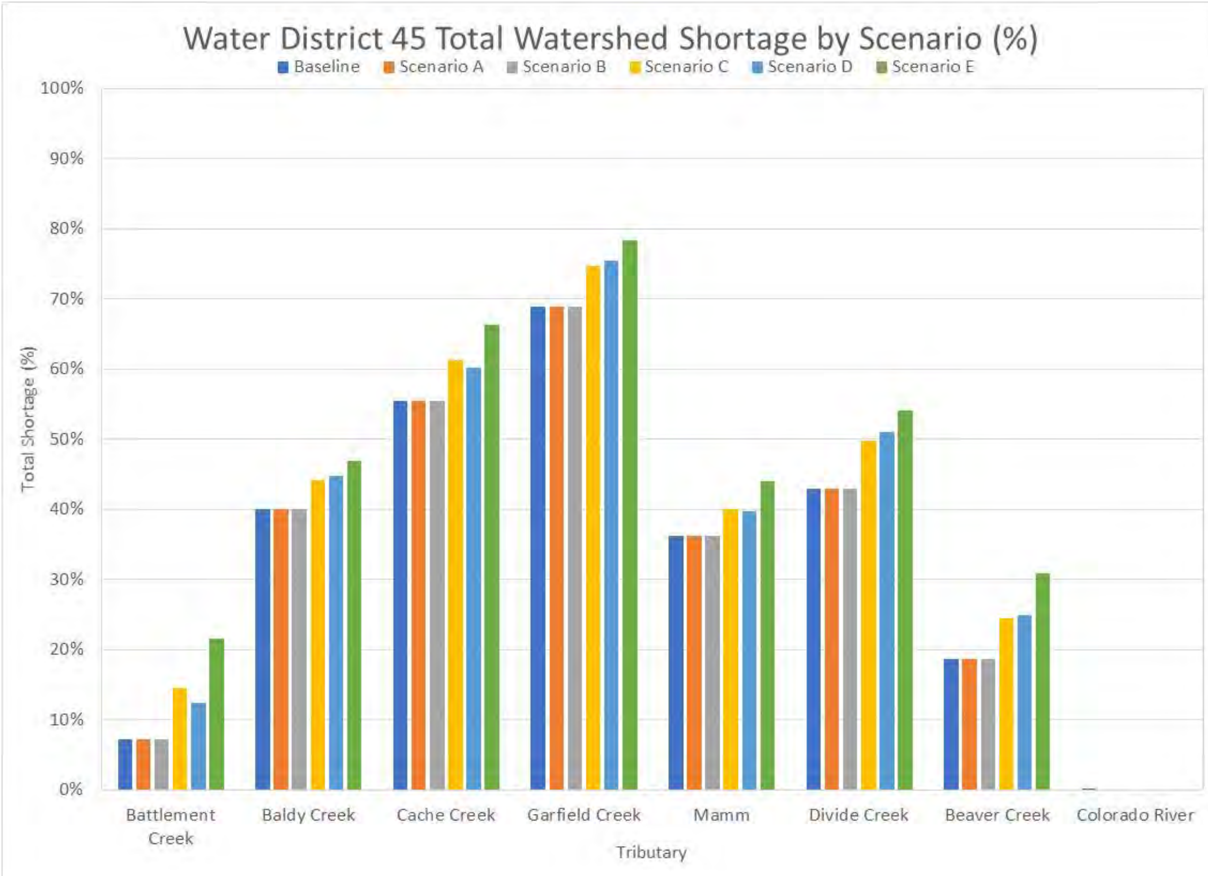

Figure 23. Water District 45 percentage short by tributary.

In Water District 70, explicitly modeled structures were included on: Roan Creek, Clear Creek and Carr Creek. Results are provided for the Baseline dataset as well as the five planning scenarios described above.

- Roan Creek included the following explicit structures: Creek and Newman Ditch, HVC and S Ditch, New Hobo Ditch, Reservoir Ditch, Roan Creek No. 2 Diversion system and Roan Creek No. 3 Ditch. These structures represent a total irrigated area of 1,430 acres. The total irrigated area in the Roan Creek drainage is 1,730 acres. There was no reduction in irrigated areas under the planning scenarios.
- Clear Creek included the following explicit structure: Clear Creek Ditch. This structure represents a total irrigated area of 38 acres. The total irrigated area in the Clear Creek drainage is 935 acres. There was no reduction in irrigated areas under the planning scenarios.
- Carr Creek included the following explicit structure: Upper Roan Creek Ditch. This structure represents a total irrigated area of 114 acres. The total irrigated area in the Carr Creek drainage is 395 acres. There was no reduction in irrigated areas under the planning scenarios.

In Water District 70, the Roan Creek drainage experiences the highest shortages which are on the order of 10-20%. Clear Creek and Carr Creek have shortages mainly less than 10%, with the exception of Scenario E.

Similar to the other Water Districts, results did not vary much between the Baseline through Scenarios A and B. For District 70, Scenario C experienced larger shortages than Scenario D on all tributaries. Scenario E, hot growth, again shows the largest shortages (Figure 24).

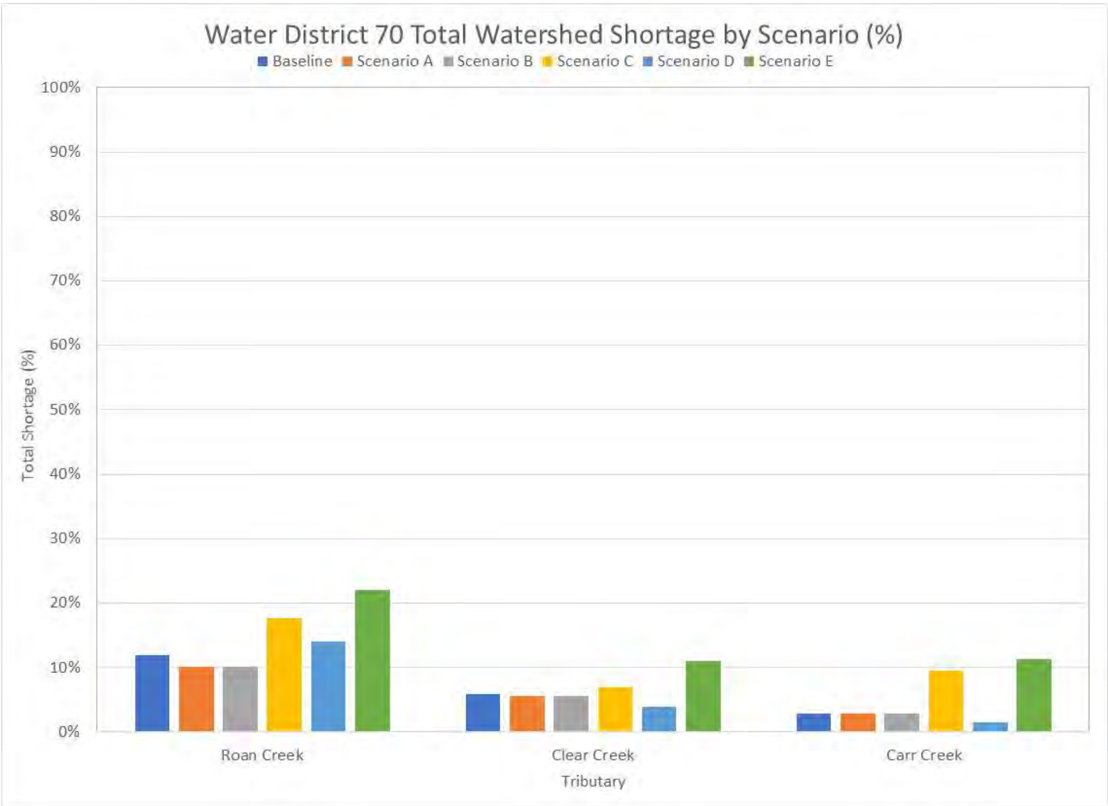

Figure 24. Water District 70 Percentage Short by Tributary.

The Water Plan Technical Update provides both baseline and future planning scenario data to assess agriculture diversion shortages across the State. These data were broken down to understand the water demands, supplies, and shortages for tributaries in the Middle Colorado Watershed, which is where the majority of irrigated lands source their supplies. It is clear from the results that Water District 45 experiences the largest shortages in the basin and is the most susceptible to increased shortages under future planning scenarios. This is mainly due to the lack of dependable snowpack which limits physical and legal water availability during the irrigation season. This area also does not benefit from storage which allows for more flexibility in managing water resources. Figure 25 shows an example of the monthly total supplies available and total demands in the Garfield Creek drainage. The supplies peak in May and quickly drop off while demands far exceed the available supply from May - October. The benefit of storage is to allow runoff to be re-timed and aligned to better meet irrigation demands.

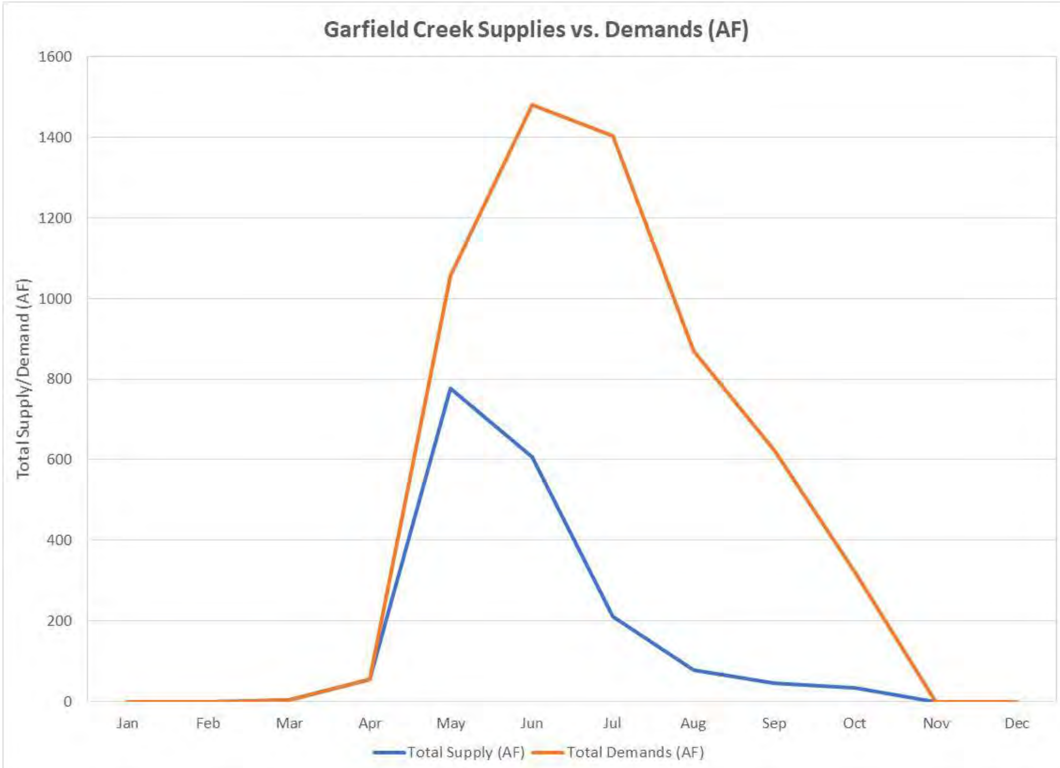

Figure 25. Water supply and consumptive use demand curves computed for Garfield Creek.

2.6 Municipal Water Supply

Municipal supplies in the Middle Colorado come from tributaries and the mainstem of the Colorado River. Each municipality has their own water supply portfolios which rely on the mainstem Colorado River to some degree, either as the main supply or as a supplemental drought year supply. The water portfolios of each municipality are described in the following sections.

2.6.1 City of Rifle

The State Demographers Office (DOLA-SDO) lists the current population of Rifle as 9,500 people. The City has been active in developing and protecting water suppliers with a Water Conservation Plan, a Water Efficiency Plan and a Source Water Protection Plan. These documents were utilized to understand the supplies available to the City. The City has a Green Mountain Protected HUP water right from the Colorado River in the amount of 10.1 cfs that can be diverted for municipal uses. The City has historical water rights on Beaver Creek that are known to be unreliable in drought years, which include 1.0 cfs of a senior right and 1.0 cfs of a junior priority. This water has been used to serve municipal demands south of the Colorado River; however, with the recent construction of a new water treatment facility in 2017, the Beaver Creek and Graham Mesa plants have been decommissioned by the City. The City decreed a plan for augmentation in

Case No. 83CW110 which changed various water rights from Rifle Creek. This change of use resulted in 616.5 AF/year with 33.5 AF/year of non-irrigation season return flow requirements. In addition to these water rights, the City also has a contract for 350 AF from Ruedi Reservoir. The City's water conservation plan (2008) indicated that without conservation measures additional supplies would be needed over the planning horizon which extended to 2027. With conservation measures and a new water treatment plant, it was found that the City had adequate supplies over the planning horizon. Because the City requires dedication of water rights for planned developments, the City has additional irrigation rights that have not yet been changed for municipal or augmentation uses. The draft 2019 water efficiency plan indicates that on average, indoor municipal use is 866 AF/year and outdoor (including raw irrigation water for parks) is 845 AF/year. The demands included in the water plan technical update models exceed these values. Even for the baseline scenario model, indoor demands were modeled at 1,308 AF and outdoor demands were 994 AF/year.

The construction of a new $27 million water treatment plant in 2017 now diverts the majority of City water from the Colorado River and conveys it through a large pre-sedimentation pond where it is then pumped to the water treatment facility. This new facility replaced both the Graham Mesa and Beaver Creek water treatment plants. During the summer peak demands, the plant produces an average of 4 million gallons per day with a maximum capacity of 8 million gallons per day. This is compared to the previous system which had a combined capacity of 5 million gallons per day (4.5 mgpd from Graham Mesa WTP and 0.5 mgpd from Beaver Creek WTP).

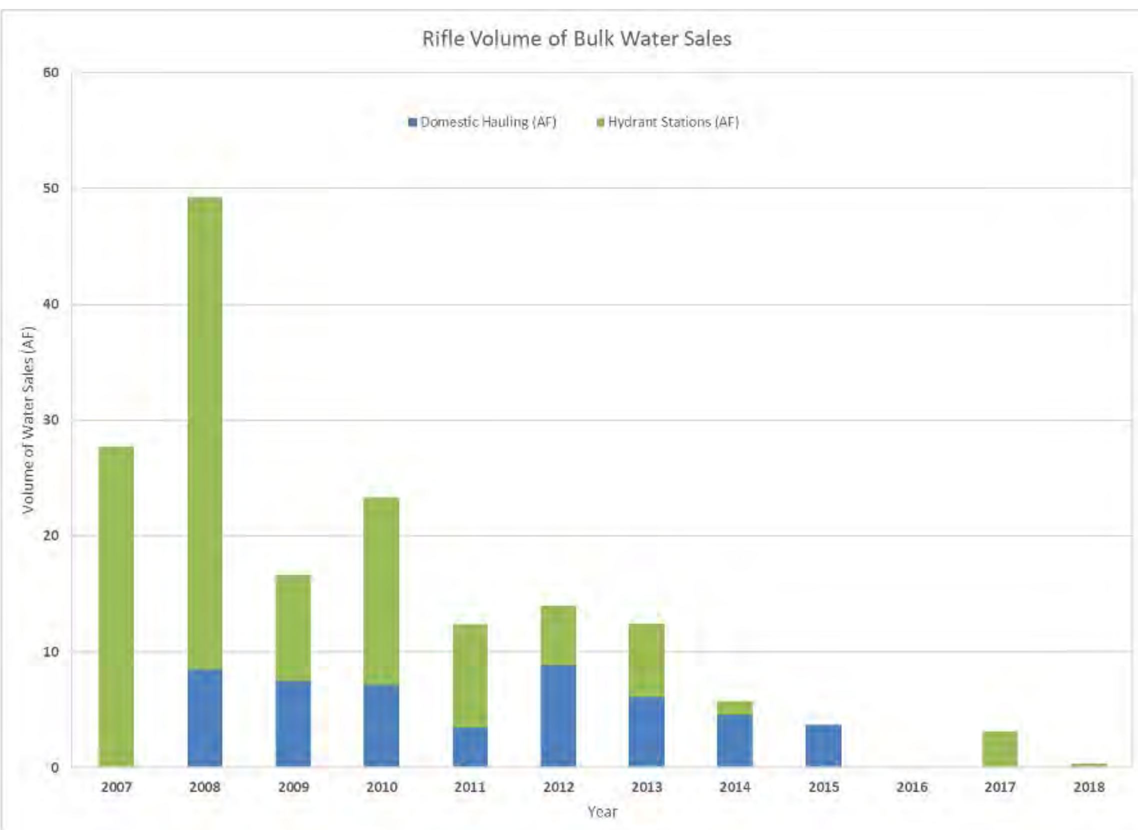

Figure 26: Rifle volume of bulk water sales 2007-2018.

The City of Rifle has a bulk water hauling stations for out of service area domestic users as well as a hydrant facility mainly used for construction. Data for the domestic station were analyzed for 2008-2015, on average 6.2 AF are utilized from this station. Data for the hydrant station were analyzed from 2007-2014 and 2017-2018, on average 11.9 AF of water was utilized through the hydrant stations (Figure 26).

2.6.2 Glenwood Springs

The State Demographers Office (DOLA-SDO) lists the current population of Glenwood Springs as 9,962 people. The City has both a Source Water Protection Plan (2014) and Municipal Water Efficiency Plan (2015) in place. The main source of water for the City is diverted from No Name and Grizzly Creeks located mainly within public lands in Glenwood Canyon. The No Name diversion is decreed for 12 cfs while the Grizzly Creek diversion is decreed for 11 cfs. Grizzly Creek is also an alternate point of diversion for the No Name 12 cfs water right. Both of these water rights are HUP protected by Green Mountain Reservoir. These water rights are diverted from the tributaries and delivered through a series of pipelines, aqueducts and storage tanks as the water is delivered across the Colorado and Roaring Fork rivers and up to the Red Mountain Treatment Plant. The City also has a backup emergency pump station on the Roaring Fork River that can divert under free river conditions or in the event of an Administrative Call on the Colorado River, the 500 acre-feet the City contracts in Ruedi Reservoir. The pump capacity is reportedly 7.75 cfs. The Grizzly/No Name and Roaring Fork emergency pump station cannot be operated simultaneously. Even with the emergency pump station, the City understands that if the No Name and Grizzly creek supplies are compromised for any reason (mainly wildfire), they may not be able to meet daily demands if two sources were to go down. In addition, the water treatment facility may not be able to adequately treat some contaminants. The source water protection plan was implemented to mitigate impacts to the water supply from wildfire, outdoor recreation, tampering with infrastructure, commercial/industrial operations, septic systems, storage tanks, and runoff. In 2020, these drainages were impacted by the Grizzly Creek fire which burned 32,631 acres in Glenwood Canyon. The City temporarily shut down the No Name and Grizzly supply and relied solely on the Roaring Fork River pump which necessitated outdoor watering restrictions in order to have sufficient supplies for domestic demands.

The City's supplies have an average year yield of 10,026 AF and a dry year yield of 7,525 AF. The Red Mountain water treatment plant has a capacity of 8.65 mgpd. This is compared to the maximum forecast demand of 3,544 AF in 2050.

2.6.3 New Castle

The DOLA-SDO lists the current population of New Castle as 5,198 people. The Town of New Castle mainly derives its water supply from East Elk Creek and the Colorado River. The Town has ownership in more than 10 water rights on East Elk Creek; however, the most critical are the Coryell ditch (which is decreed for use in Castle Valley Ranch), the New Castle Water Works System and Pipeline (NCWWSP), and the New Castle augmentation station (Colorado River). The NCWWSP is senior to the Cameo call, but it can be called out locally on Elk Creek by the Ware and Hinds ditch. It is augmented with consumptive use credits from the Coryell and Red Rock ditches. The Town also has a contract for 400 AF of water in Ruedi Reservoir which can augment diversions from the New Castle augmentation station on the mainstem Colorado. The station is a pump limited to 3 cfs and is mainly used for raw water irrigation (1 cfs to Lakota, 2 cfs to the Town). This pump could be utilized for potable water but would likely encounter treatment and delivery issues. In 2017/2018 the town received a grant from DOLA (Department of Local Affairs) to upgrade the potable water treatment system. The treatment capacity has increased to 4.1 mgpd, enough to meet the demand of the town for the next 20 years. The new equipment selected is much more capable of treating water from the augmentation station on the Colorado River and also much more capable of treating high turbidity levels from Elk Creek.

The Town of New Castle received a grant to provide bulk water services as other local municipalities do. This station is currently under construction and is anticipated to be online in September 2020. The station includes a 2-inch dispenser for domestic users and a 3-inch dispenser for commercial users.

2.6.4 Silt

The DOLA-SDO lists the current population of Silt as 3,193 people. The Town of Silt provides domestic and irrigation water through separate systems. The Town produced a Water, Wastewater and Irrigation Master Plan in 2019. The Town's domestic supply is mainly from Colorado River direct diversions and through a series of municipal wells. The Silt Pipeline has a 1.5 cfs water right with an enlargement right of 8.5 cfs. In addition, the town has 4 wells which pump water from the Colorado River alluvium. Silt Well #1 is decreed for 0.385 cfs and wells 2-4 are all decreed for 1 cfs per well. The river diversions for domestic uses are augmented with a 217 AF contract in Ruedi Reservoir and 130 AF of consumptive use credits from the Last Chance Ditch. Because of the reliance on the river and its alluvium, the Town recognizes the need for additional wells to be drilled further from the river in order to have a backup supply that is not as influenced by the river in the event river water could not be diverted.

The water treatment system has a capacity of 1 mgpd and utilizes microfiltration. Four storage tanks totaling 1.8 million gallons are also utilized in the water system. The Town's municipal code requires any new development to dedicate water rights to the Town or pay a fee in lieu of water rights. The Master Plan indicates that the Town should begin planning for additional augmentation of the Colorado River water rights, drill additional wells in strategic locations and begin to negotiate with other water right owners (Harvey Gap, Ware and Hinds) to provide an emergency source of water in case there were a catastrophic event affecting the Colorado River. The current domestic wells are influenced by river levels. The Master Plan sets a goal of expanding the water treatment plant by 2024 with no specific capacity. The Town is included in the Garfield County Source Water Protection Plan.

Silt is one of few towns in Colorado that have a raw water irrigation system delivered through the Town. The Town's irrigation water rights consist of the following: 13 shares of Farmer's irrigation company water (3.5 gpm/share), 1.5 shares on the Giancinta Ditch (50 gpm/share), 24.56 shares of the Lower Cactus Valley Ditch (88 gpm/share), 201 shares of the Last Chance Ditch, 58.5 shares of the Ware and Hinds Ditch, 15 shares of the Silt Pump Canal (3.5 gpm/share) and direct flow from the Rising Sun Ditch which was acquired with the Silt River Preserve totaling 4.3 cfs over three priorities.

In addition to in-town residential uses, the Town has three bulk water hauling stations which provide water to out-of-town residential users as well as industrial/commercial users. On average, the Town sells 28 AF/year through the bulk hauling station (Figure 27).

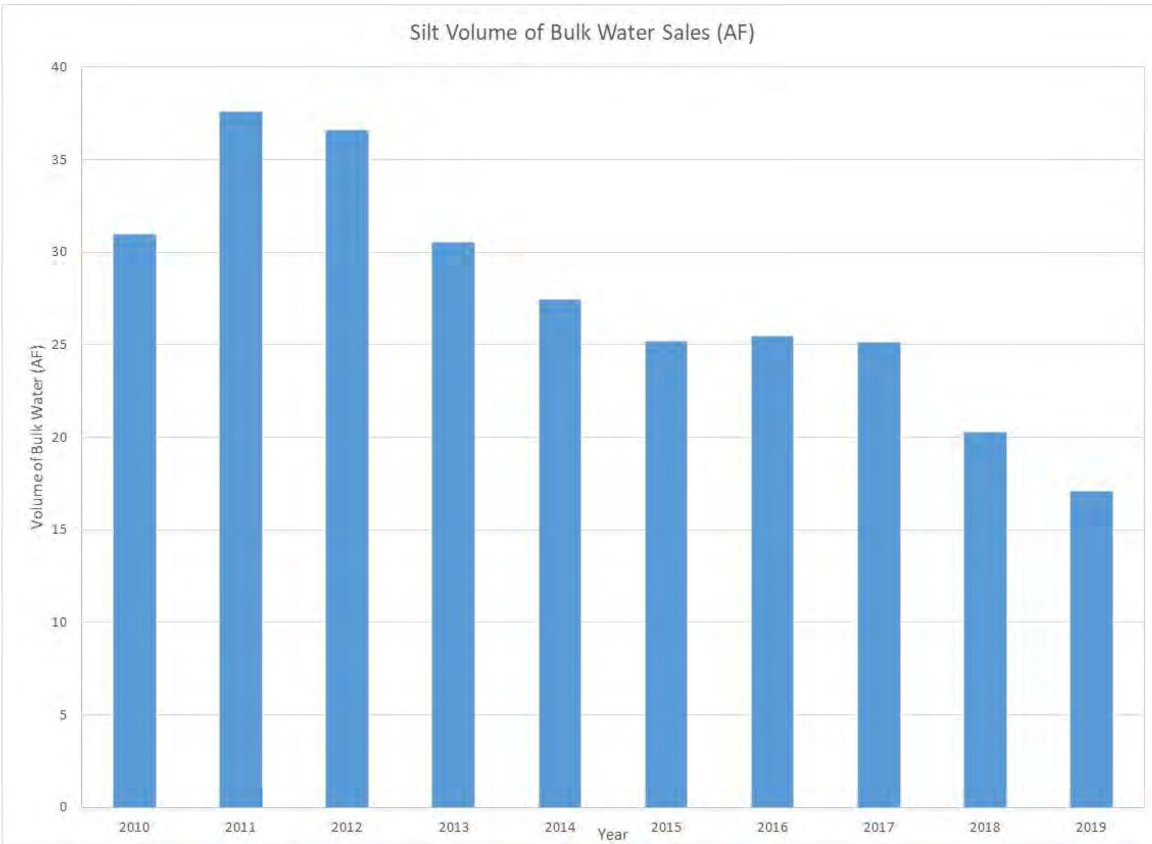

Figure 27: Silt volume of bulk water sales 2010-2019.

2.6.5 Parachute

The DOLA-SDO lists the current population of Parachute as 1,218 people. Parachute mainly relies on the Colorado River for its water supply. The Town has a 0.24 cfs water right for the Parachute Pumping Plant located on the Colorado River which is decreed as an alternate point of diversion to the Diamond Ditch. The Grand Valley Pipeline is decreed absolute for 0.78 cfs with 29.22 cfs remaining conditional. The Grand Valley Water Supply Pipeline is decreed for 2 cfs, with 1 cfs having a source of ABC, O'Toole and Revel Springs and 1 cfs having a source from Springs 1-6 which is considered the first enlargement of the Pipeline right. Parachute also utilizes Battlement Mesa Inc intakes 1-3 which are decreed as alternate points of diversion to various water rights in the plan for augmentation in the amount of 2.24 cfs over three priorities. The plan for augmentation was decreed in Case No. 83CW35. The augmentation supply included changed irrigation rights on the Daisy, Diamond and Cornell ditches that yielded 280.4 acre-feet of consumptive use credits which can be stored in a variety of reservoirs. In addition to these credits, the plan also included 75 acre-feet of Ruedi Reservoir water to cover non-irrigation season depletions.

Irrigation supplies are diverted from Parachute Creek through the Diamond Ditch; these supplies were not included in the plan for augmentation. The Town changed the place of use for 0.24 cfs of the Diamond Ditch rights in Case No. 83CW52 for the irrigation of 12 acres within the Town. The Garfield County source water protection plan indicates that Parachute's average summertime demand is 325,000 – 375,000 gallons per day. Wintertime demands are 200,000- 250,000 gallons per day. Parachute sells water through a bulk water hauling station. Records obtained show that from 2015-2019, the town sold 11.7 acre-feet on average (Figure 28).

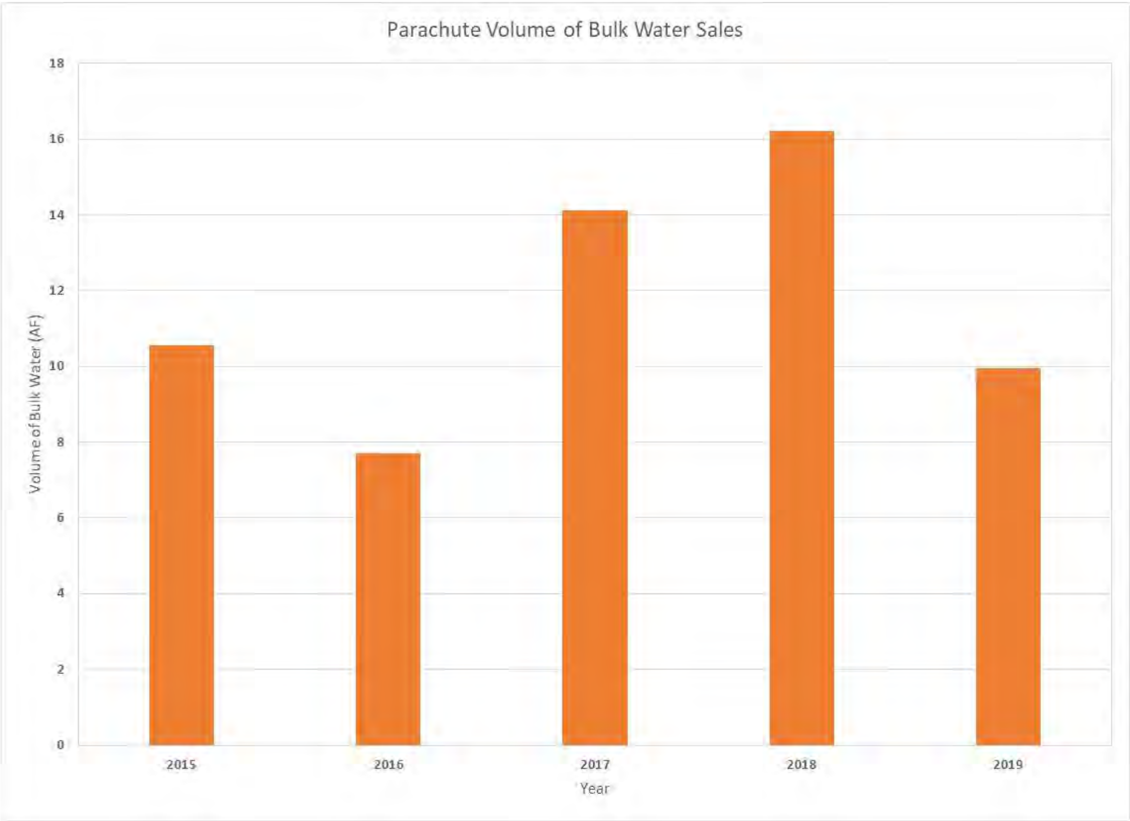

Figure 28: Parachute volume of bulk water sales 2015-2019

2.6.6 Battlement Mesa

Battlement Mesa provides municipal water from a pump station on the Colorado River and surface diversion from Monument Gulch to a raw water reservoir. The pump has a capacity of 9 mgpd and the reservoir capacity is 40 AF. The reservoir allows domestic deliveries to continue in the event of contamination in the Colorado River which might prevent pumping. The sources from the Colorado River are decreed absolute for 10.69 cfs and the Monument Gulch supply is decreed absolute for 1.5 cfs. A series of wells are also decreed for use by the Town which are alternate points of diversion for the DOW pump and pipeline. The majority of water rights owned by Battlement Mesa are junior to Shoshone and are augmented with a 1,250 AF contract in Ruedi Reservoir.

2.6.7 De Beque

The State Demographers Office (DOLA-SDO) lists the current population of De Beque as 508 people. The Town of De Beque utilizes a pump in the Colorado River which is decreed as an alternate point of diversion for the Kobe Pump and Pipeline for municipal and irrigation uses. A plan for augmentation was decreed in Case No. 03CW312 which includes the 1.7 cfs from the Kobe pump and pipeline alternate point, the De Beque water works pump and pipeline (DWWPPL) decreed for 0.46 cfs (HUP protected) and the first enlargement of the DWWPPL of 0.75 cfs. The augmentation sources include 62.3 AF from Green Mountain Reservoir HUP pool which covers the historical depletions of the water rights and a 100 AF Ruedi Reservoir contract.

2.6.8 Risks to Municipal Water Supplies

Projected future water demands were calculated by adjusting the Baseline water usage values (gallons per capita per day) for future demand drivers. Municipal use was broken into five demand categories: residential indoor, non-residential indoor, residential outdoor, non-residential outdoor, and non-revenue. Non-revenue refers to water that is treated by the municipality but not metered for use, essentially a loss to the municipal system. The following demand drivers were considered in the municipal demand projections:

- Changes in Urban Land Use
- Technology
- Regulations
- Social Values

The medium population growth used in Scenario A is based on the State Demographers Office projection to 2050. Additional growth scenarios were developed for the Technical Update for the low and high growth used in Scenarios B and E. The "adjusted" medium and high growth projections used in Scenarios C and D reflect the movement to mountain resort and urban areas, as described in the Colorado Water Plan which reflects urban land use driver influences.

The Water Plan technical update results indicated that the City of Rifle experiences water shortages even in the Baseline scenario (Figure 29), however; there appears to be a disconnect between the City's planning and the Technical Update modeling. Conversations with the consulting firms responsible feel there are a few reasons for the modeled shortages: Green Mountain HUP water was not correctly identified for Rifle and the Ruedi contract was also not assigned. The model also did not represent the augmentation plan decreed to Rifle in Case No. 83CW110. The model also does not represent the raw irrigation supplies from Rifle Creek utilized for watering parks. The CBRT should work with the CWCB to get these issues resolved within the StateMod representations. The 2019 draft water efficiency plan states that the City appears to have twice the water supply necessary to support its current population and indicates the current system can likely support

20,000 people which would be sufficient until 2042 assuming a 3% growth rate. The City has seen demands decrease by 13% (239 AF/year) between 2010 and 2017 which is attributed to water saving measures including:

- 2011 - Water appliance rebate program initiated.
- 2013 – The City implemented a tiered rate structure, increasing from 2 tiers to 4.
- 2014-2018 – The City implemented 5% rate increases.
- 2017 – Rifle Regional Water Purification Facility commissioned
    - Lowered unrecovered water losses
- 2019 – Water loss audit conducted to identify priority action items.

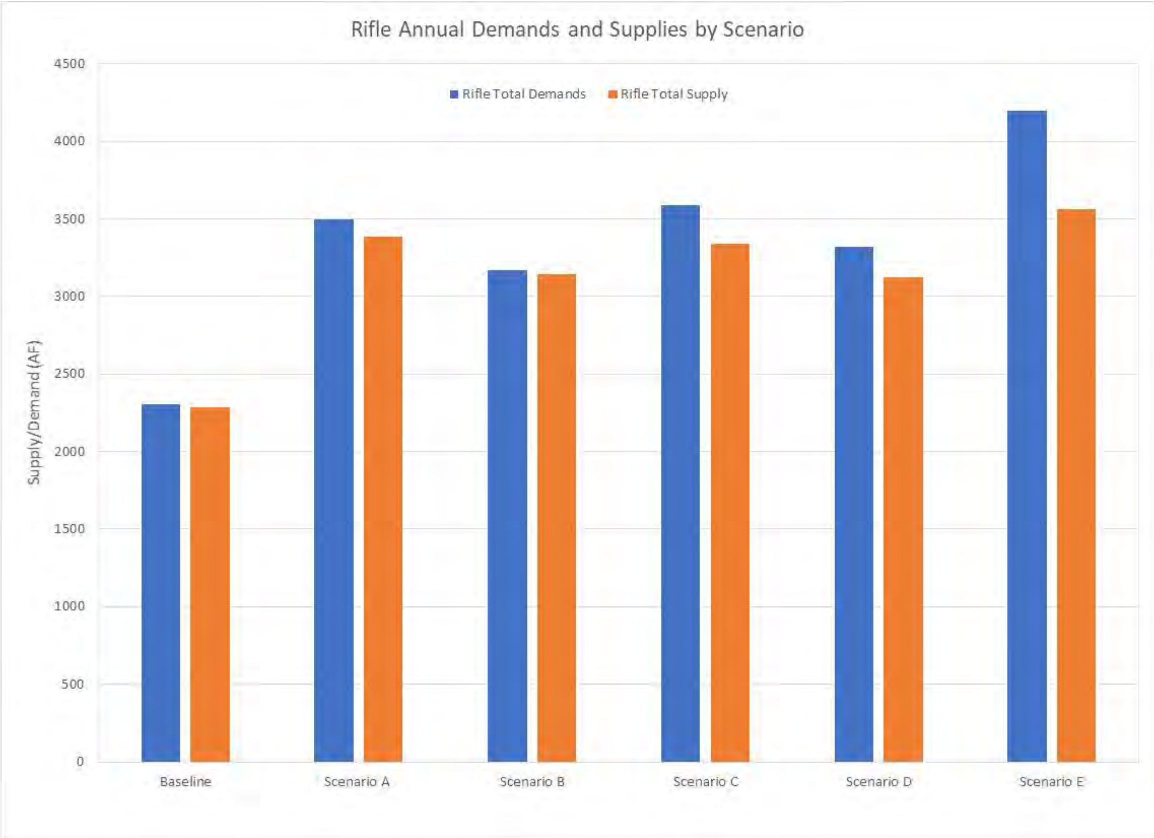

Figure 29: City of Rifle Annual Supplies and Demands from the Water Plan Technical Update

The City of Glenwood Springs was the only other municipal entity explicitly modeled in the Water Plan technical update. The results from the Water Plan technical update agree with the City planning documents and show no shortages to indoor or outdoor usage over the planning scenarios (Figure 30).

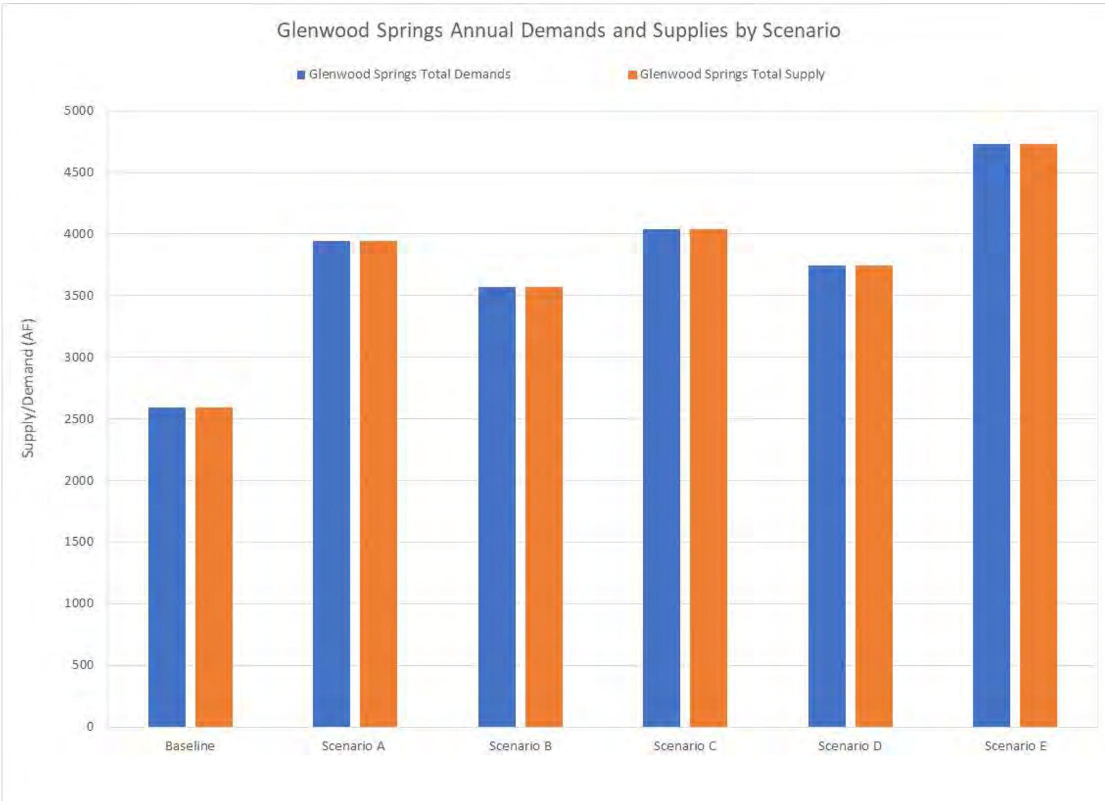

Figure 30: City of Glenwood Springs Supplies and Demands from Water Plan Technical Update.

New Castle was included in the Water Plan technical update as a municipal aggregate in Water District 39 which showed no shortages over the scenario planning. Because of the reliance on East Elk Creek, firming of Colorado River supplies and treatment was a priority for New Castle. New Castle is part of the Garfield county source water protection plan.

Silt was included in the Water Plan technical update in a municipal aggregate for Water District 39. No shortages to indoor or outdoor usage were modeled over the planning scenarios.

Parachute was included in the Water Plan technical update in a municipal aggregate for Water District 39 and/or 45. No shortages to indoor or outdoor usage were modeled over the planning scenarios. A 2015 Parachute infrastructure master plan indicated that the Town has no issues with water supply for current and future demands.

Battlement Mesa was included in the Water Plan technical update in a municipal aggregate for Water District 45. No shortages to indoor or outdoor usage were modeled over the planning scenarios.

De Beque was included in the Water Plan technical update in a municipal aggregate for water district 70. No shortages to indoor or outdoor usage were modeled over the planning scenarios.

2.6.9 Rural Groundwater Supplies

In addition to municipal water providers, many domestic water users in the planning area rely on wells for their water supply. In order to understand the availability of groundwater for domestic users, well production data available through the CDSS were analyzed for wells constructed since 2000. The wells were broken into categories based on the yield reported in gallons per minute (gpm). 54% of the wells analyzed had a yield in the range of 10-25 gpm. Only 5% of the wells had yields higher than 25 gpm and 41% had yields less than 10 gpm. The yields are shown spatially in Figure 34. Not surprisingly, the highest yield wells are located in the Colorado River alluvial aquifer. These high-capacity wells are typically associated with commercial or industrial uses. The lowest yield wells are concentrated in the Silt Mesa area where wells producing less than 10 gpm are common. This is also the case in areas farther from streams, such as Grass Mesa and Dry Hollow areas. While these wells are low yield, they typically can support the demands associated with domestic uses. The yield requirement to serve 1 home, 2,000 ft^2 of irrigation and 4 head of livestock is less than 1 gpm. It is important to note that the yield data are based on a pump test that is typically conducted for less than 4 hours and may not continually sustain these production rates. These same low yield areas have many domestic users who haul from local municipality bulk water stations. This further suggests the yields are not sustainable and are likely lowest during the winter months when irrigation practices are not occurring and contributing to groundwater.

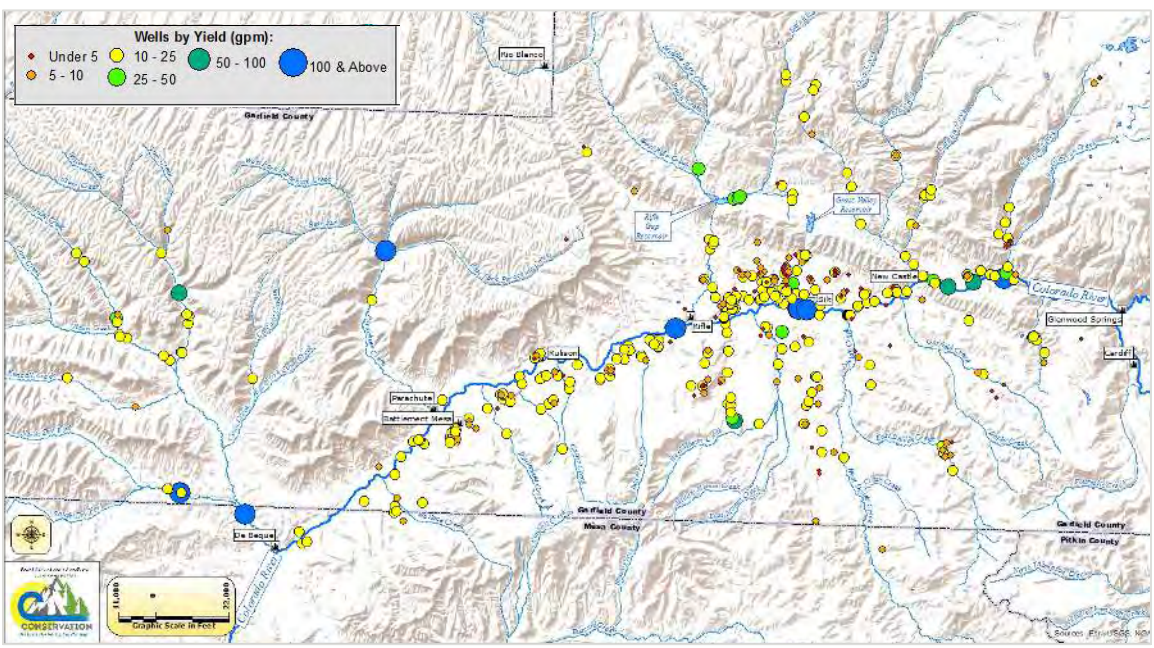

Figure 31: Reported yields of wells constructed since 2000.

2.7 Industrial Processing and Resource Extraction

Industrial water uses in the Middle Colorado Watershed mainly include water for oil and gas extraction activities and gravel operations, among other smaller scale industrial activities. The CDSS was queried to identify all industrial water rights in Water Districts 39, 45 and 70 (Table 11). Many industrial water rights were originally decreed for oil shale development and are being changed to include gas extraction activities. Industrial water rights have also been moved to alternate points of diversion/exchange points as future planning for oil and gas is continually changing depending on market forces. In addition to water rights decreed for industrial uses, irrigation water rights have also been acquired, quantified, and changed to use historical consumptive use credits for industrial uses, not only for oil and gas, but also gravel operations. In some cases, these water rights have been acquired and changed and are leased back for agricultural uses until the water supply is needed operationally. The source of changed water rights are mainly the Colorado River, Parachute Creek and Roan Creek.

Table 11. Direct flow and storage rights decreed absolute and conditional for industrial uses (among other uses).

Units	Direct Flow (cfs)		Storage (AF)	
WD	Absolute	Conditional	Absolute	Conditional
39	336	896	13,045	146,172
45	88	1,189	282	72,024
70	17	478	14	168,301
Total	**440**	**2,562**	**13,342**	**386,497**

Plans of augmentation have also been developed for industrial uses. For instance, Exxon Mobile holds a Ruedi Reservoir contract in the amount of 6,000 AF which is used to augment various water rights from the Colorado River that can also be used in the Piceance Basin. Water uses for industrial activities is often considered to be 100% consumptive, meaning that replacements are made according to the amount of water that is diverted for the various uses. Gravel operations utilize historical consumptive use credits and reservoir releases to augment ongoing evaporative losses created by the open surface areas created by on-channel gravel pits exposing groundwater.

In order to understand the future uses of the oil and gas industry, a 2014 report[130] (aka Phase III study) commissioned by the Colorado and Yampa/White Roundtables was relied upon. This study quantified the water demands of both oil shale and oil and gas extraction from wells. However, it is worthy of note that as of 2011 both Chevron and Shell have ceased their oil shale development research in Colorado.

[130] AMEC Environment and Infrastructure and Canyon Water Resources, LLC (2014) Energy Development Water Needs Assessment Update, Phase III, Final Report.

2.7.1 Oil Shale Development

The Phase III study quantified the demands for both in-situ and above ground oil shale development. It also quantified both direct (site development, operations, production processes, refining processes, and electric energy generation) and indirect (workforce and population) water demands. The Phase III study utilized production estimates from the National Oil Shale Association (NOSA) which had decreased by 2/3rds from the Phase II study. Phase III considered a production level of 500,000 barrels of oil per day, while the Phase II study considered a production level of 1.5 million barrels of oil per day. The results for the Colorado Basin indicated a direct water demand of 13,000-18,000 acre-feet per year which is associated with the Colorado basin portion of production of 275,000 barrels of oil per day. The indirect water demands associated with this production level were quantified to be 6,000 acre-feet per year.

2.7.2 Oil and Natural Gas Extraction

The Phase III study quantified the demands of gas production wells. For the Colorado River, water demands of 1 acre-foot per year per well were utilized to quantify the total demands. This per well demand is lower than other basins because of water reuse activities taking place in the Colorado Basin. The peak drilling year was found to be 2008 when 1,100 wells were drilled in the basin. The direct water use was quantified for a low well start number of 1,100 and a high well start number of 1,500 wells. The direct demand ranged from a low of 1,100 to a high of 1,500 acre-feet per year. The indirect water demands were quantified to be 8,200-11,400 acre-feet per year; however, this was not broken down by basin. The Colorado Basin included 50% of the peak year production; therefore, 50% of the indirect demands can be attributed to the Colorado Basin and would range from 4,100 – 5,700 acre-feet per year.

2.7.3 Gravel Pits

A high-level assessment of the surface area of exposed water related to gravel operations was conducted using Google Earth imagery, water right, and property ownership records. Approximately 326 acres of open water surface was quantified to be associated with gravel operations. Free surface water evaporation in this area is roughly 45 inches (3.75 feet) per year[131]. This amount of exposed surface water equates to about 1,220 acre-feet of evaporative losses per year. The evaporative atlas has not been updated since 1982, and it is reasonable to expect with rising temperatures that these demands will continue to increase with increasing temperatures.

2.8 Water Quality and Regulatory Compliance

The role that healthy ecosystems play in promoting regulatory compliance is an often-overlooked aspect of water and land use management. We conducted analyses targeting a number of water quality indicators in the basin. These included a water quality report card to assess compliance of current available monitoring data for the mainstem Colorado River and tributary watersheds with state standards, review of trends in

[131] 1982, U.S. Dept of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. NOAA Technical Report NWS 33: Evaporation Atlas for the Contiguous 48 United States.

instream water temperatures of the mainstem Colorado River, and review of trends in major components of salinity for the mainstem Colorado River. Due to the extensive nature of reporting results for the numerous individual stream segments in the Middle Colorado River region, full reports of monitoring data and water quality report card standards reviews are included in the IWMP appendices.

Water quality characteristics of the Middle Colorado River are described in detail elsewhere.[132, 133] This planning effort builds on those studies to provide additional information to support decision-making.

2.8.1 Regulatory Background

The Colorado Department of Health and Environment (CDPHE) Water Quality Control Division (WQCD) implements the Clean Water Act by regulating pollutant effluent primarily generated by industry or municipal wastewater treatment. Regulation takes the form of surface water standards for water quality and a permitting process that places limitations on pollutant dischargers. The purpose of regulation is to ensure that surface waters continue to support a diversity of uses.

Rivers and streams serve as a natural transport, distribution, and attenuation system for natural and human-sourced additions to the water column. These additions include metals from mines; nutrients from agriculture and wastewater treatment; and other constituents from residential, commercial, or industrial land uses. Where water quality conditions are degraded, the ability for local communities to use a stream as a source for drinking water or as a diluent for effluent discharges may be reduced. Furthermore, non-compliance with water quality regulations may lead to costly capital expenditures on wastewater treatment plant upgrades. For example: low flows can affect regulatory compliance by reducing the ability of a stream to dilute pollutants in discharges, which in turn can affect permitted discharge limits.[134] National Pollutant Discharge Elimination System permits are held by all the major municipalities, metro districts, water utilities, and numerous commercial/industrial businesses in the watershed and include:

- Battlement Mesa
- De Beque
- Glenwood Springs
- Glenwood Hot Springs
- Iron Mountain Hot Springs
- New Castle

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132 https://static1.squarespace.com/static/582a05f020099e61757374f5/t/5ada37d12b6a2817c1d619e6/1524250631447/FINAL+MCWC+Surface+Water+Quality+Data+Analysis+3-25-15.pdf

133 Thomas, J. C., Moore, J. L., Schaffrath, K. R., Dupree, J. A., Williams, C. A., & Leib, K. J. (2013). Characterization and Data-gap Analysis of Surface-water Quality in the Piceance Study Area, Western Colorado, 1959-2009. US Department of the Interior, US Geological Survey.

134 https://www.colorado.gov/pacific/cdphe/news/water-quality-permits

- Rifle
- Silt

While most streams in the watershed do not indicate any level of water quality impairment (Figure 32, Table 13), existing regulatory listings indicate several streams in the Middle Colorado River have concerns for municipal water supply quality that include chloride, manganese, sulfate, and arsenic concentrations. Regulatory listings related to aquatic life protection result from elevated concentrations of nutrients, arsenic, and selenium in several areas. Local concerns about salinity arise from regional commitments by multiple states to reduce salinity loading to the mainstem Colorado River as prescribed in the federal Colorado River Basin Salinity Control Act.

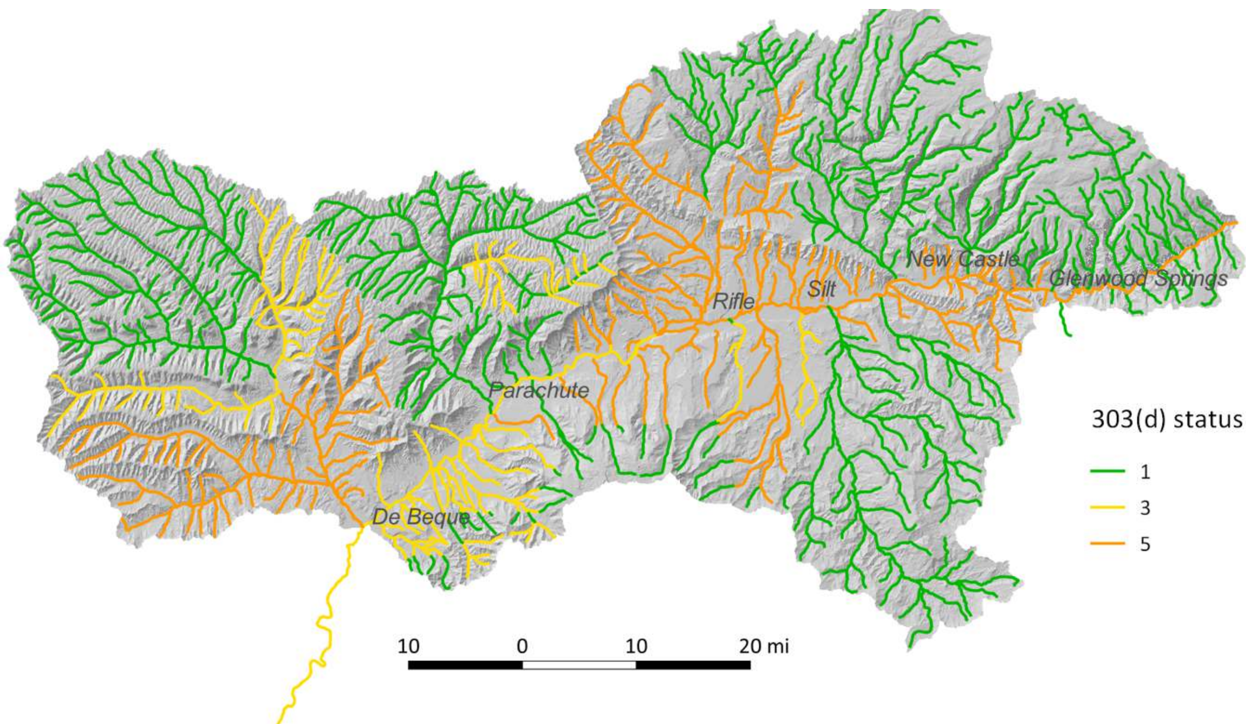


Figure 32. Current Regulation 93 stream status (2018 303(d) category status. 2018 segmentation spatial data provided by CDPHE WQCD.

Table 12. Regulation 93 stream status summarized by stream miles.

303(d) classification	Miles
1 – Supporting all uses	1344

3 – Monitoring and Evaluation, 1 or more analytes	165
5 – Water Quality Impaired, 1 or more analytes	16
5 + 3 – Water Quality Impaired *and* M&E for *at least* one analyte in each category	577

2.8.2 Salinity Trends

Water quality trends analysis can help identify emerging water quality issues and provide quantitative assessment of progress on current water quality improvement efforts. Trends analyses were conducted across the Middle Colorado Watershed where data was sufficient in temporal coverage and coincided reasonably with stream flow measuring locations. The parameters selected for trends analysis included those classified with a use protection rating of either 'poor' or 'concern' in the water quality report card (Appendix G), currently 303(d)-listed parameters, or specific parameters of interest in the basin (e.g., salinity). Analysis was carried out using a Weighted Regression of Time, Discharge, and Season (WRTDS). This approach estimates time trend relationships for water quality constituents by removing the influence of intra- and inter-annual changes in streamflow. Where datasets were insufficiently long for WRTDS, data were investigated visually using simple time series plots with statistical smoothing overlays. Existing reports and literature on water quality trends in the Middle Colorado Watershed were compared against analysis results produced by this effort.

2.8.2.1 Total Dissolved Solids

Total dissolved solids (TDS) is a measure of all the dissolved organic and inorganic content in water. It is frequently defined as the fraction of substances that will pass through a 0.45 micron filter. Although many substances contribute to TDS levels, the measure is principally comprised of inorganic salts of calcium, magnesium, potassium, sodium, bicarbonate, chloride, and sulfate. Even though additional substances are included in a TDS measurement, it is typical to use it a standard proxy for quantifying salinity. TDS loads to streams in the Middle Colorado River are released from a variety of sources including chemical and physical weathering of surficial geologic formations and soils, runoff from roads, irrigated agriculture and oil/gas drilling pads, saline groundwater springs, and urban and transportation runoff. Unlike many other water quality parameters like trace metals or nutrients, TDS is regularly measured at several sites in the project area, producing a robust dataset for statistical analysis. However, spatial coverage is low. The sites with the largest data records bracket the upstream (Colorado River at No Name, Colorado River below Glenwood Springs) and downstream (Colorado River at Cameo) end of the Colorado River in the Middle Colorado River region. TDS is commonly reported at other sites by USGS, CDPHE and River Watch, but the temporal and spatial coverage is insufficient for estimating loads and/or trends.

The analysis presented here incorporated a total of 304 observations from the Colorado River at No Name, 75 observations for the Colorado River below Glenwood Springs, and 508 observations for the Colorado River at Cameo. Compared to other salinity analytes, the number of available observations for TDS at No Name and Cameo created high confidence in WRTDS model outputs and, by extension, inferences about changing water quality conditions based on these models. Results showed decreasing load trends in the 1980s and 1990s, with a more stationary (no trend) condition in the last two decades; the majority of salinity at the mouth of the watershed is sourced upstream of South Canyon (Figure 33, Figure 34, Figure 35). Annual load estimates also compare favorably to previous work conducted by USGS. Mean TDS loads estimated for 2008-2018 were within 5% of published USGS work that utilized the Spatially Referenced Regression on Watershed Attributes (SPARROW) method (Figure 36).[135]

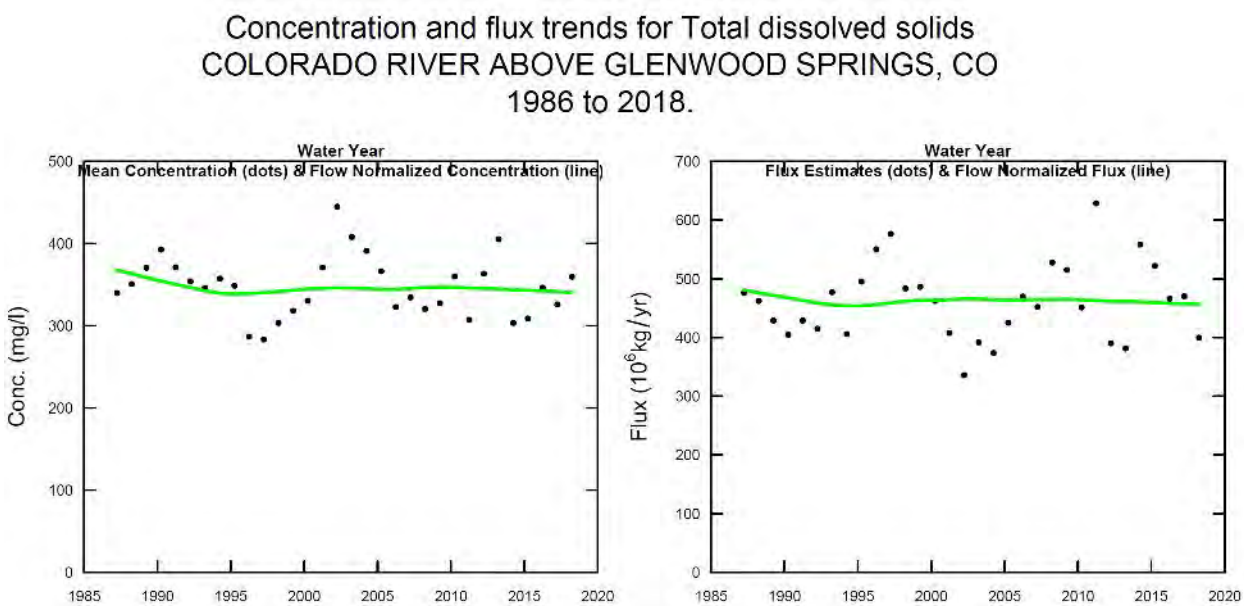


Figure 33. Above Glenwood Springs, annual concentrations and fluxes (loads) decreased slightly in the very beginning of the data record, but overall remained stationary, indicating little change in salinity loads in this portion of the watershed.

135 Miller, M.P., Buto, S.G., Lambert, P.M., and Rumsey, C.A., 2017, Enhanced and updated spatially referenced statistical assessment of dissolved-solids load sources and transport in streams of the Upper Colorado River Basin: U.S. Geological Survey Scientific Investigations Report 2017–5009, 23 p., https://doi.org/10.3133/sir20175009.

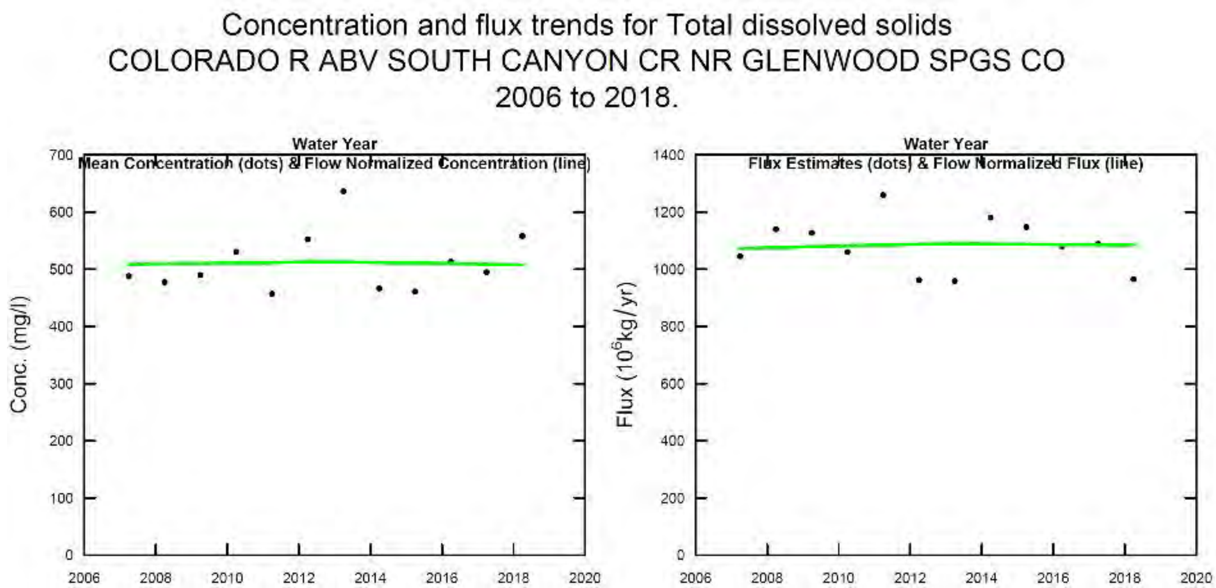


Figure 34. Mean annual concentrations and loads remained relatively steady in the last decade below Glenwood Springs. A shorter time period of data availability decreases the WRTDS model descriptive power at this location, however the stationary trend slope agrees with conditions downstream at Cameo and upstream of Glenwood springs for the same time period.

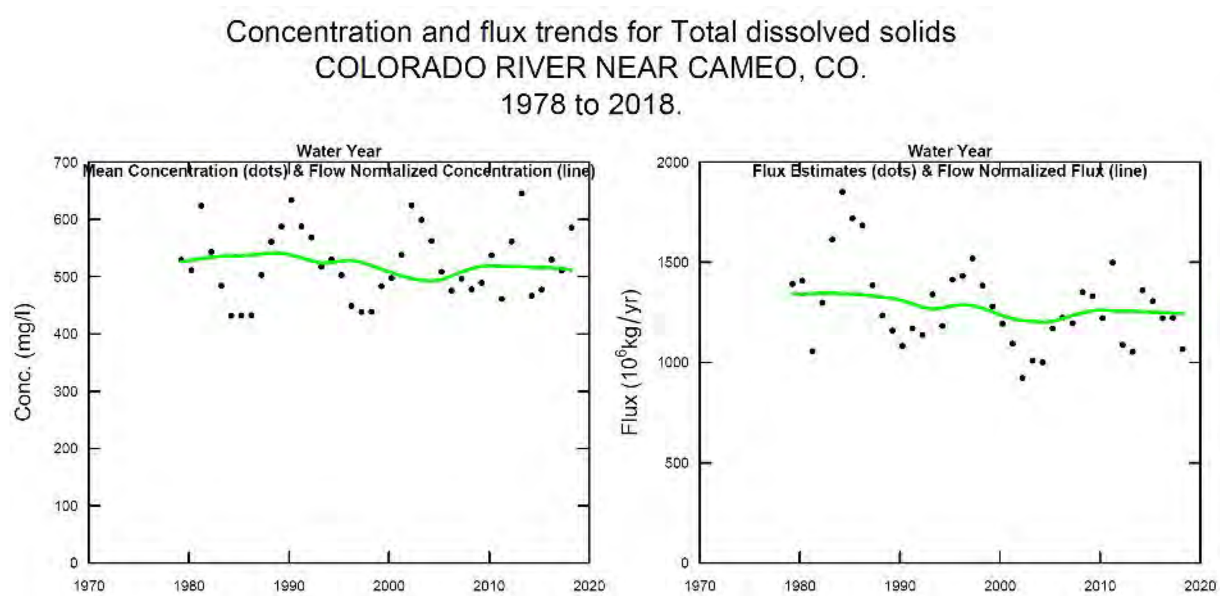


Figure 35. TDS flux (load) decreased steadily at Cameo in the late 1980s until mid-2000s, before leveling more recently. Parallel but smaller decreases in annual mean concentrations indicate that this decrease may partly be due decreasing streamflows in addition to reduced source loads.

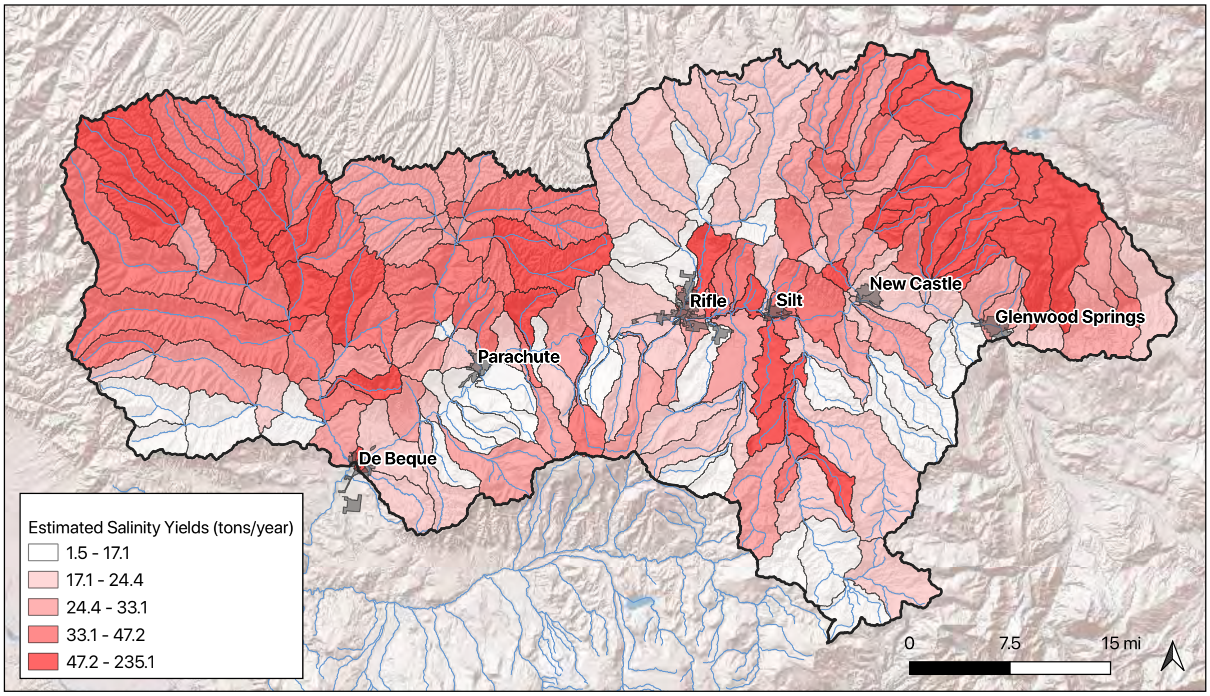


Figure 36. USGS SPARROW modeling results[136] estimating contributions of TDS to the Colorado River from various subwatersheds and drainages. Highest yields are evident in the Elk Creek, Divide Creek, Parachute Creek and the Roan Creek drainages.

Recent research efforts characterized longitudinal changes in load on the Colorado River mainstem through the Middle Colorado Watershed.[137] Real-time data and periodic volumetric water samples were collected from a floating platform along the reach under three different flow conditions in 2018 (low runoff), 2019 (high runoff), and 2020 (typical/dry runoff). Results of this effort indicated a significant influx of salinity in the vicinity of the Roaring Fork River confluence (Figure 37). The resolution of the data does not support assigning fractions of this load to either the geothermal springs or the Roaring Fork River. However, both sources probably contribute. Below Glenwood Springs, salinity load profiles appear fairly stable, especially during below average (2019) and low flow conditions (2018). A vertical discontinuity in the load profile from 2020 in the vicinity of Rifle was due to changing discharge conditions that occurred over a short delay in sampling activities and does not seem to indicate salinity loading from Rifle Creek. These results generally support the idea that salinity loading to the Colorado River from tributaries in the Middle Colorado Watershed is incremental and that the salinity loads carried to the river in dry periods in-between precipitation events are insignificant in comparison to the load carried by the Colorado River. A similar longitudinal sampling effort conducted during a wet-weather event—when rainfall carries salts from exposed soils produces to nearby streams—may yield different results.

[136] https://www.sciencebase.gov/catalog/item/5be0b9bce4b0b3fc5cf34277

[137] Hensley, RT, *MJ Spangler, LF DeVito, PH Decker, MJ Cohen, and MN Gooseff. 2020. Evaluating spatiotemporal variation in water chemistry of the upper Colorado River using longitudinal profiling. Hydrological Processes, 34(8):1782-1793.

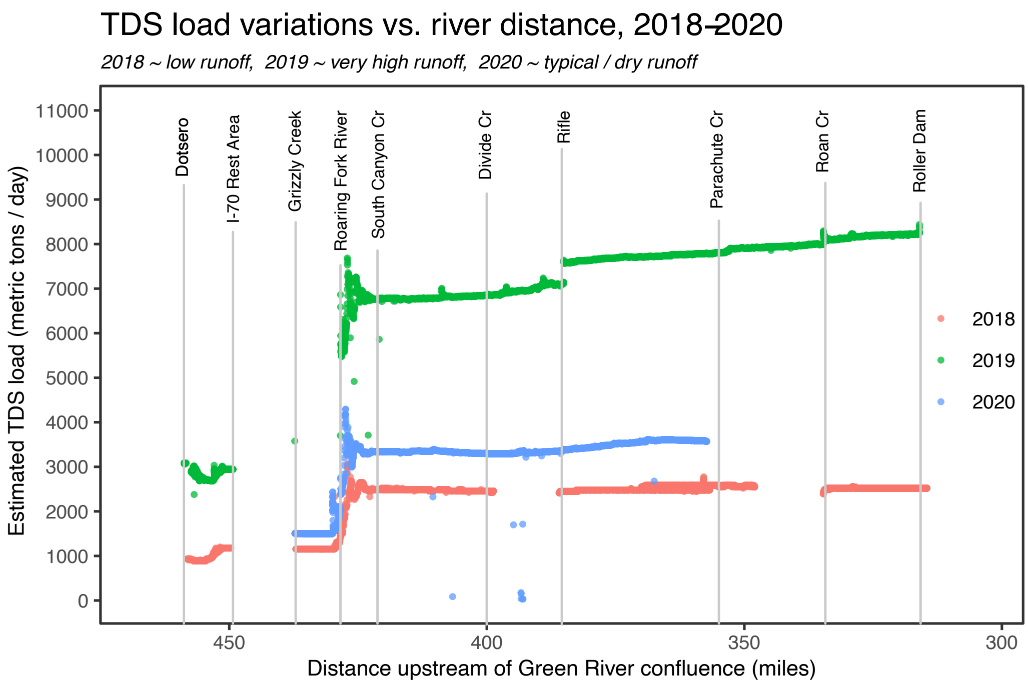


Figure 37. Longitudinal profiles of TDS along the Colorado River mainstem between Dotsero and Cameo, collected in a high-water year (green), a typical water year (blue), and a low water year (red). The vertical discontinuity apparent in Rifle during 2019 is an artifact of changing discharge across the days when the survey was completed.

2.8.2.2 Chloride

Chloride is common major component of salinity in the Colorado Basin. It may source from natural geologic formations and soils derived from marine sedimentary formations, from saline hot springs, or may have an anthropogenic component tied to maintenance of road surfaces in urban environments and highway corridors adjoining the river. Counter to the overall trend of TDS and other components of TDS such as sulfate and calcium/magnesium, chloride displays a steadily increasing trend in the river above Glenwood Springs since 1995, a generally flat trend at South Canyon for the most recent decade in which data was available, and a flat trend at Cameo from 1980 to the early 2000s with an increasing trend in the last decade (Figure 38).

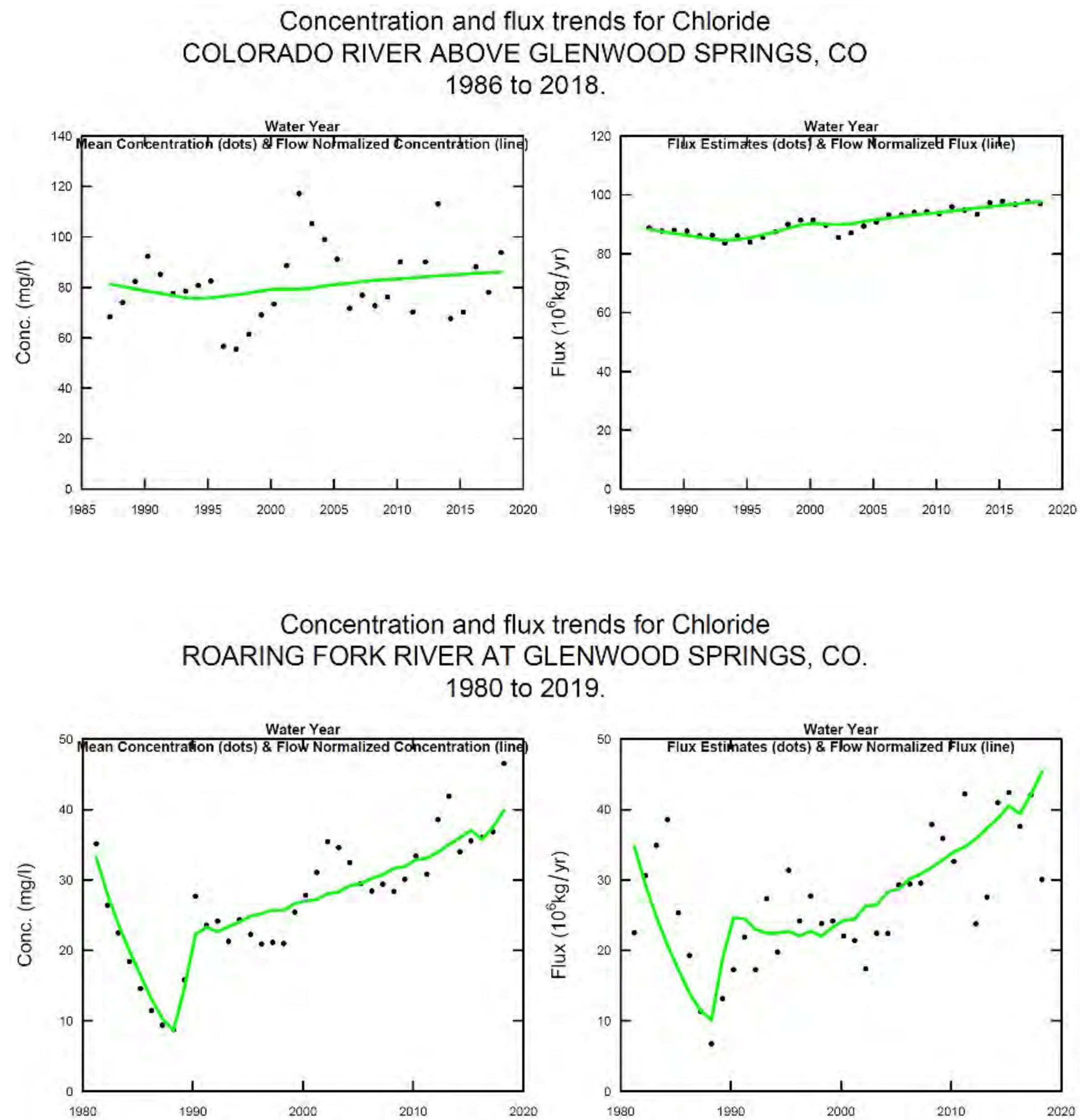


Figure 38. Concentration and load time series of chloride for the Colorado River above Glenwood Springs (top) and the Roaring Fork River at Glenwood Springs (bottom). The apparent increase in flow normalized concentration (green line) on the Roaring Fork in 1990 is an artifact of the way the data smoothing methodology and not likely a reliable indication of a step change in concentrations at this time. Flow normalized concentration lines are only included to facilitate visual assessment of trends over the 2000-2020 period.

In the most recent decade from 2008 to 2018, estimated loads in South Canyon and Cameo are similar, between 300-310 x 10^6 kg/yr, indicating very little additional chloride load to the mainstem Colorado River occurs downstream of South Canyon. Looking further upstream, loads in Glenwood Canyon and at the mouth of the Roaring Fork River both display an increasing trend since the early 2000's, but a back-of-envelope addition of these two sources accounts for approximately 135 x 10^6 kg/yr, falling far short of the total load measured in South Canyon below Glenwood Springs. Presumably salinity from thermal springs is a large component of this addition, with urban runoff from downtown Glenwood possibly providing a lesser but still important fraction. The slight but steadily increasing loading trend in Glenwood Canyon since the 1990's are coincident with the shift towards increasing applications of liquid deicer agents during this time period by CDOT, but may also reflect a consistent discharge over time from saline springs near Dotsero that has received less dilution in the last decade due to declining annual flow volumes from the upper river basin during baseflow periods. Chloride loads from the Roaring Fork, while constituting slightly more than 10% of the total load entering the Middle Colorado Watershed, display a much sharper increase since the 1990's; although the WRTDS model was produced with a much shorter calibration record and fewer data points in recent years.

2.8.2.3 Sulfate

Sulfate is a major component of salinity in the Colorado Basin. It is commonly released to surface waters in dispersed non-point landscape locations from natural geologic formations and soils derived from marine sedimentary environments. Saline thermal springs between Dotsero and South Canyon may also be important point source contributors of sulfate to the Colorado mainstem. Similar to the overall trend of TDS and other components of salinity like calcium/magnesium (but counter to chloride), sulfate displays a steadily decreasing trend in the river above Glenwood Springs since 1995, a generally flat trend at South Canyon for the most recent decade in which data was available, and a steadily decreasing trend at Cameo from 1980 to the early 2000s with a flat or very slightly decreasing trend continuing in the last decade (Figure 39).

In the most recent decade from 2008 to 2018, combined loads from Glenwood Canyon and the Roaring Fork River, roughly 100 x 10^6 kg/yr each, account for nearly the entire load observable just downstream in South Canyon. This indicates that the saline hot springs in the Glenwood Springs area do not provide the same influence on overall sulfate loads as they do for chloride; more sulfate may be sourcing watershed-wide rather than locally. Downstream of South Canyon, an additional 50 x 10^6 kg/yr of sulfate load is added to the river in the Middle Colorado Watershed prior to Cameo. After decreasing significantly by 80-100 x 10^6 kg/yr from the late 1980s until the mid-2000s, this amount has remained static in the most recent decade. The time of decrease is also coincident with decreasing trends noted by USGS authors for the Upper Colorado Basin Salinity Control Unit Region 4 (between Cameo and Glenwood Springs).[138] Those authors reported significant decrease to salinity loads in the early 1990s and flat or stationary trends moving into the early 2000s. The authors also reported significant downward trends in Ca, Mg, Na, and SO_4^- at monitoring stations in Glenwood, Cameo, and the State Line, but found no trend in chloride. They considered changes to channel evolution (declining rates of arroyo development in tributary watersheds due to better range

[138] Miller, M.P., Buto, S.G., Lambert, P.M., and Rumsey, C.A., 2017, Enhanced and updated spatially referenced statistical assessment of dissolved-solids load sources and transport in streams of the Upper Colorado River Basin: U.S. Geological Survey Scientific Investigations Report 2017–5009, 23 p., https://doi.org/10.3133/sir20175009.

practices, phreatophyte colonization—including invasive species, equilibrium between channels and irrigation return flows, and large-scale hydrologic patterns changes), groundwater inflows (conversion to more efficient irrigation systems reduced deep percolation and thus reduced mobilization of salts into base flows), and land use change.

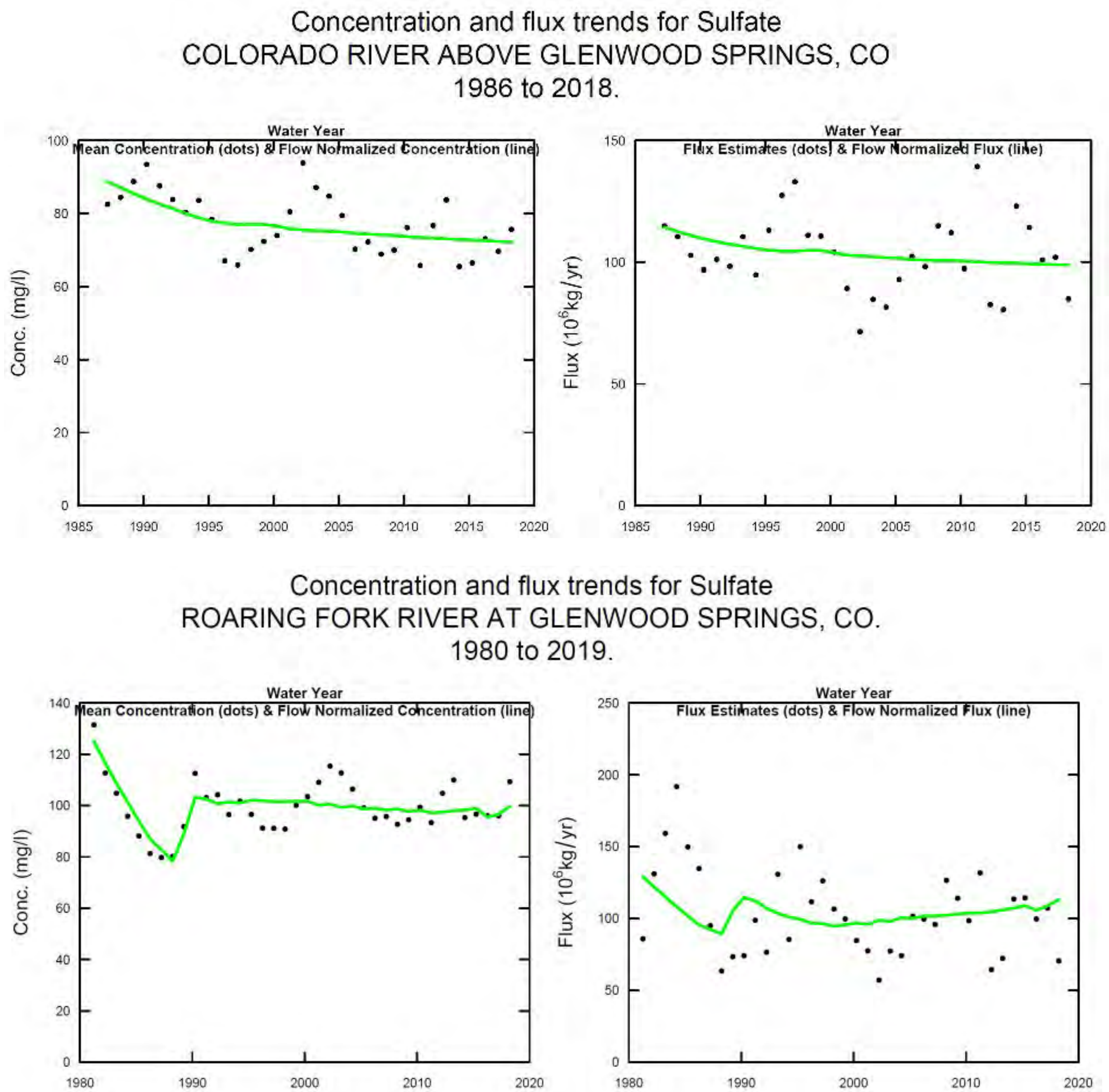


Figure 39. Concentration and load time series of sulfate for the Colorado River above Glenwood Springs (top) and the Roaring Fork River at Glenwood Springs (bottom). The apparent increase in flow normalized concentration (green line) on the Roaring Fork in 1990 is an artifact of the way the data smoothing methodology and not likely a reliable indication of a step change in concentrations at this time. Flow normalized concentration lines are only included to facilitate visual assessment of trends over the 2000-2020 period.

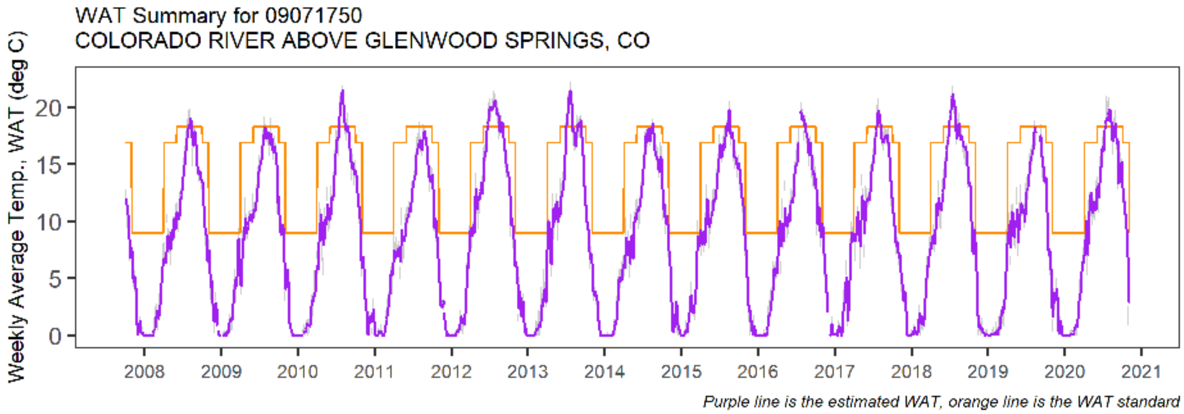
2.8.3 Water Temperature

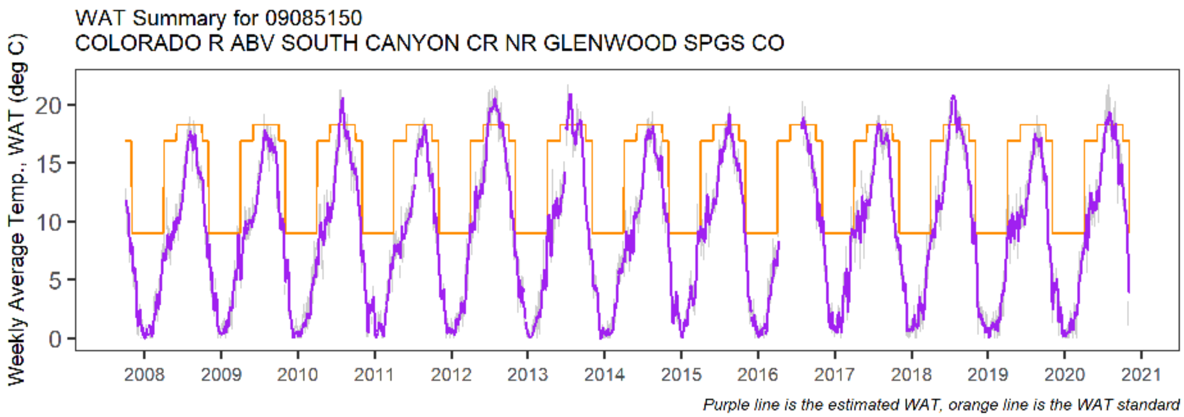
Instream temperature remains a prominent issue in Colorado watersheds, as thermal regime shifts in streams systems are driven by altered or declining flows, riparian change, watershed urbanization, and climate warming. Contemporary monitoring data for portions of the Colorado River in lower Glenwood Canyon and below Glenwood Springs identify exceedances of instream weekly average temperature standards for cold water fisheries in the majority of data years available. These issues may result from a poor match in the regulatory standards overlay for the Colorado River relative to the natural temperature regimes present in the region. However, water management activities may exacerbate these issues in some years.

The Middle Colorado River Watershed straddles a transitionary geography between cool, high elevation mountain headwaters, and the warmer arid lands and canyon country of the Colorado Plateau. The most-upstream portions of the project area in Glenwood and South Canyons are both classified Cold Stream 2 (CS2) in state regulatory processes in order to remain protective of the cold-water salmonid fisheries present. Classification shifts to Warm Stream I (WS I) below Rifle Creek for the remainder of the project area to Roan Creek and De Beque Canyon.

Unlike the discrete shifts in water quality standard thresholds applied to segmented regulatory reaches, the Colorado River experiences a gradual transition from cool water fisheries on the upstream end of the watershed to warm water conditions on the downstream end. Depending on the time of year and flow conditions, both warm and cool species may travel throughout the reach to utilize habitats, find adequate food sources, and access tributaries well above and beyond the regulatory boundaries that reflect the presumed range for their respective populations. It is likely that, prior to upstream reservoir development and augmentation of late season flows through the Middle Colorado, late summer and early fall temperatures were warmer than observed over recent history. This is due to the relationship between streamflow and the thermal inertia of stream/river water. High streamflows tend to dampen the relative impact of shortwave/longwave radiation and air temperature on water temperature in a given reach. It can be presumed, therefore, that thermal boundaries for historical ranges of warm-water fish were probably larger that today. The inverse was likely true for cold water fish.

Water temperature data collected at three locations on the Colorado River through the Middle Colorado Watershed indicate existing issues with regulatory compliance (Figure 40). The two sites near Glenwood experience regular exceedances of the chronic water temperature standard for aquatic life use protection. These exceedances tend to occur in the late summer or early fall when air temperatures are still high but streamflows are low. Similar exceedances are not observed at Cameo due to the change in regulatory classification and elevated water temperature standards. The pattern of water quality exceedances observed on the Colorado River above and below Glenwood Springs is likely an artifact of regulatory stream segmentation and assignment of water quality standards. These exceedances do not appear related to a specific land or water management activity.





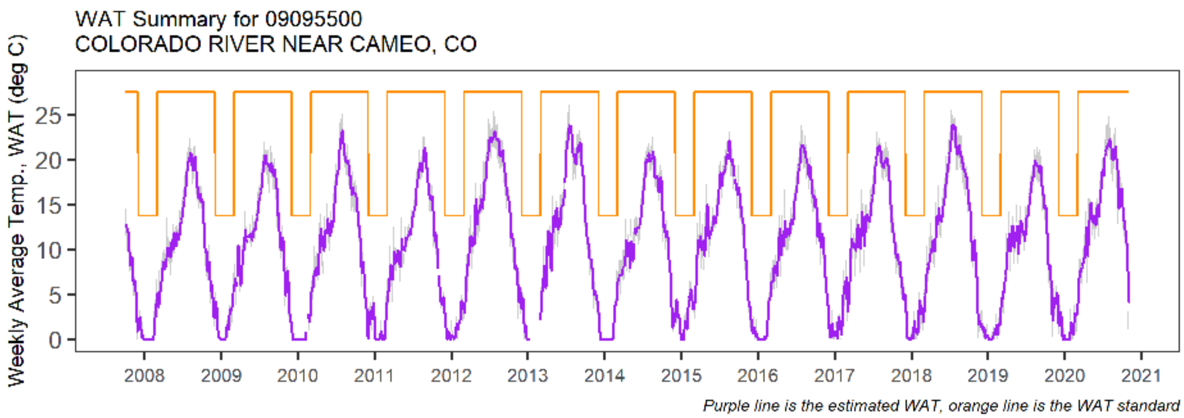


Figure 40. Measured temperature time series (purple lines) compared against Weekly Average Temperature (WAT) water quality standards (orange lines) for the Colorado River above Glenwood Springs (top), the Colorado River below Glenwood Springs (middle) and the Colorado River at Cameo (bottom). Periods where the purple line fall above the orange line indicate an exceedance of the chronic water quality standard for aquatic life use protection.

2.8.4 Risks to Water Quality Regulatory Compliance

Risks to water quality regulatory compliance in the Middle Colorado River can be divided into three categories for further consideration: water quality monitoring, salinity control, and water temperature. Each topic is discussed below.

2.8.4.1 Water Quality Monitoring

Many of the potential risks to water quality regulatory compliance in the Middle Colorado Watershed stem from the relative dearth of monitoring data across the watershed. This circumstance makes it difficult to detect emerging water quality issues and/or identify the potential source of an issue observed at one of the few long-term monitoring locations. Mainstem monitoring location data gaps do not allow bracketing of influences from urban growth centers and major tributaries. There are no consistent long-term ambient monitoring sites between New Castle, Silt, Rifle, Parachute, and De Beque. This data gap might be filled in several ways. Additional water quality data related to energy development activities may exist. Formal requests for data publication may by possible through the Garfield and Mesa County's oil and gas permitting authorities. Alternatively, this objective may be met through cooperation and dialog between and among oil and gas producers and other local stakeholders. Coordinating permitted wastewater discharges conducting Regulation 85 nutrient sampling upstream/downstream of their discharge locations to collect and submit additional water samples analysis of major ions, metals, and other parameters can leverage existing data collection efforts at these locations. The MCWC also recently proposed a plan for ambient water quality at locations throughout the watershed. Securing funding for the implementation of this program would provide a consistent long-term basis for evaluating conditions and trends, enabling local stakeholders to take corrective action before an observed issue produces a burdensome regulatory listing or discharge permit limitation.

2.8.4.2 Salinity Control

Salinity loading is a regulatory issue of regional importance that will likely persist into the future. Compared to the Grand Valley and Gunnison basins, the Middle Colorado River has less irrigated agriculture but still contains large land areas of erosive geologies and soils. Much of the salinity and suspended sediment load to the Colorado River may mainly derive from natural sources. Unfortunately, other than the mainstem river sites that bracket the study area, existing data collection locations and frequency make finer characterization of spatial and temporal patterns of salinity loading within the watershed difficult. Therefore, targeting high-priority drainages for implementation of salinity control measures remains a challenge. Real time monitoring of proxy variables such as conductivity and turbidity at several additional sites on the mainstem Colorado between South Canyon and Cameo could produce a better understanding of spatial and temporal trends in TDS source loading. Ambient monitoring sites that bracket both urban development in the valley floor and oil and gas activities upstream of the towns but downstream of the forested headwaters may provide better understanding of the salinity impacts associated with these activities on major perennial tributaries like Elk, Rifle, Parachute, Roan, Divide, and Mamm creeks.

USGS SPARROW modeling results indicate the highest salinity loads may come from Elk Creek, Divide Creek, and Roan Creek. Conducting targeted outreach in cooperation with NRCS to landowners in the drainages listed above about the opportunities for participation in salinity control programs is an important effort that should help reduce the reduce the incremental loading of salinity in the Middle Colorado Watershed (Figure 37). While these increases in loading do not appear to be an issue of local concern, they are an issue of regional concern.[139] Notably, increasing land disturbance from oil and gas activities and urban development may be increasing local salt and sediment loading to the Colorado River over time. Salinity control associated with these activities is best dealt with through local land use permitting and regulation.

2.8.4.3 Water Temperature

Water temperature exceedances are likely to persist into the future. Climate change and warming air temperatures are the main presumptive drivers of changing water temperatures in the region, but hydrologic modification and land use change remain important influences. These influences may either amplify or attenuate the climate warming signal in turn, depending on when in the season and where in the stream system they occur. Some diminishment of late summer high temperatures on the Colorado River below Glenwood Springs may accrue from coordinated releases out of Ruedi Reservoir intended to have the same effect on the lower reaches of the Roaring Fork River.[140] Continued water temperature exceedances in the Colorado River through the Middle Colorado Watershed may result in some additional discharge permit limitations for wastewater providers in the watershed. A focused evaluation of: 1) the water quality use classes and segmentation schemes applied to reaches of the Colorado River through the Middle Colorado Watershed and 2) the potential sources of water temperature degradation of the segments of river above and below Glenwood Springs may help clarify whether a coordinated effort to secure site-specific standards or re-segmentation through the regulatory review process should be pursued by local stakeholders.

2.9 Groundwater Recharge

Groundwater recharge is an important consideration for water management in the Middle Colorado Watershed. The primary mechanisms for such recharge in the project area include: 1) overbanking flows on floodplains and low terraces, and 2) delivery and application of agricultural irrigation water. Both types of recharge may produce elevated baseflows in area streams and the Colorado River in the late summer, fall, and winter months. Agricultural irrigation, specifically, flood irrigation in upland areas, is also expected to support the supply of water to numerous domestic drinking water wells. The causal linkages between overbanking flows and/or application of irrigation water to fields and measures of stream baseflow behavior or well production are difficult to measure directly. Instead, anecdotal observations and numerical models are regularly employed to understand those effects.

[139] https://www.usbr.gov/uc/progact/salinity/

[140] The Roaring Fork Conservancy and Ruedi Water and Power Authority recently completed a study about the effectiveness of late summer Ruedi Reservoir releases on water temperatures in the Roaring Fork River at Glenwood Springs.

The CWCB's StateMod planning models for the Upper Colorado River Basin include a crude approximation of return flows generated by irrigated agriculture in the Middle Colorado Watershed. Unfortunately, no work exists characterizing those impacts at a high spatial resolution or using site-specific information. Neither are estimates available for understanding the impact of overbanking flow events on baseflow behavior in the alluvial reaches of the Colorado River or its tributaries. Anecdotal evidence relating the dry up of irrigated agriculture or the transition to more efficient irrigation applications (i.e., flood to center pivot) to reduced production in domestic water wells and reduction to late season return flows is available in the vicinity of Rifle and Silt. No additional investigations into groundwater recharge were included under this planning effort.

2.9.1 Risks to Groundwater Recharge

Future impacts to groundwater recharge may result from regional changes in hydrological behavior produced by climate change, reductions in peak flows produced by reservoir operation and water use, and/or shifts in the timing and rate of water application on irrigated parcels across the Middle Colorado Watershed. Changes in peak flow recurrence intervals on the Colorado River mainstem predicted under planning scenarios C, D and E may be expected to reduce late season groundwater contributions to flows in the river below Rifle, requiring delivery of additional water from upstream reservoirs through the Middle Colorado Watershed to meet demands below Cameo.

Water efficiency and water conservation measures enacted on agricultural parcels may have unintended consequences for domestic well production or late season flows in small tributary streams. These effects cannot be anticipated easily without careful consideration of field-level physical characteristics and site-specific historical management activities. Site-specific water balance modeling efforts will, therefore, be beneficial to any process evaluating the relative prioritization and potential costs/benefits of proposals to implement irrigation water conveyance/application efficiencies.

2.10 Flood Regulation and Erosion Control

Although river corridors provide many benefits to their surrounding communities, they can also present hazards that impact floodplain residents and infrastructure. These hazards include, but are not limited to: flooding, bank erosion, slope failure, and sediment transport. Traditionally, quantification of fluvial hazards is based on floodplain mapping by the Federal Emergency Management Agency or other entities. While this approach provides helpful guidance on potential for inundation for various flood levels and their estimated recurrence intervals (e.g., "the 100-year flood"), traditional floodplain mapping overlooks the many other hazards present in river corridors and can lead to misconceptions within the community about the wisdom or longevity of certain long-term land uses in river-impacted landscape localities.

The alluvial sections of the Colorado River below South Canyon are active geomorphological response zones. Overbanking flow conditions still regularly occur during high spring snowmelt flows and channel form and location is prone to incremental and, sometimes, abrupt lateral movement. The close proximity of floodplains and low terraces to the river made them attractive locations for agricultural production over the last century and a half. The gently sloping floodplain surfaces in these areas made them particularly attractive for development of transportation infrastructure. Over time, infrastructure (roads, bridges, water diversions/conveyances, houses, utility lines, etc.) was placed in the 100-year and 500-year floodplains along the Colorado River between Silt and De Beque. This infrastructure is at elevated risk for impact due to flooding and natural channel erosion.

2.10.1 Risk of Flood and Erosion Impacts

Reducing risks for flooding and erosion in these areas can be best achieved *not* through further structural modification of the floodplain (e.g., construction of dikes or placement of rip-rap along streambanks) but through long-term passive management and regulation of the river corridor that works to modify the characteristics and limit the amount of infrastructure or active land use in regularly-inundated areas. Removing infrastructure from harm's way or modifying it to be more resilient to floods or changes channel alignment is a more sustainable approach to floodplain management than an approach that attempts to control the dynamic character of the river at the expense of riparian and aquatic attributes.

To this end, the CWCB recently released new guidance to local communities for mapping potential hazards in river corridors as Fluvial Hazard Zones (FHZs).[141] FHZ mapping incorporates the latest research on river dynamics to provide a more informative, flexible, and locally applicable framework for providing information to communities about fluvial hazards. FHZ mapping is not a regulatory tool, nor does it influence insurance rate determination. Delineations of FHZ components are intended to inform river corridor planning efforts for infrastructure risk and flood hazards, but also provide secondary benefits in emphasizing the value of riparian communities and overall river corridor health (Figure 41).

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[141] https://www.coloradofhz.com

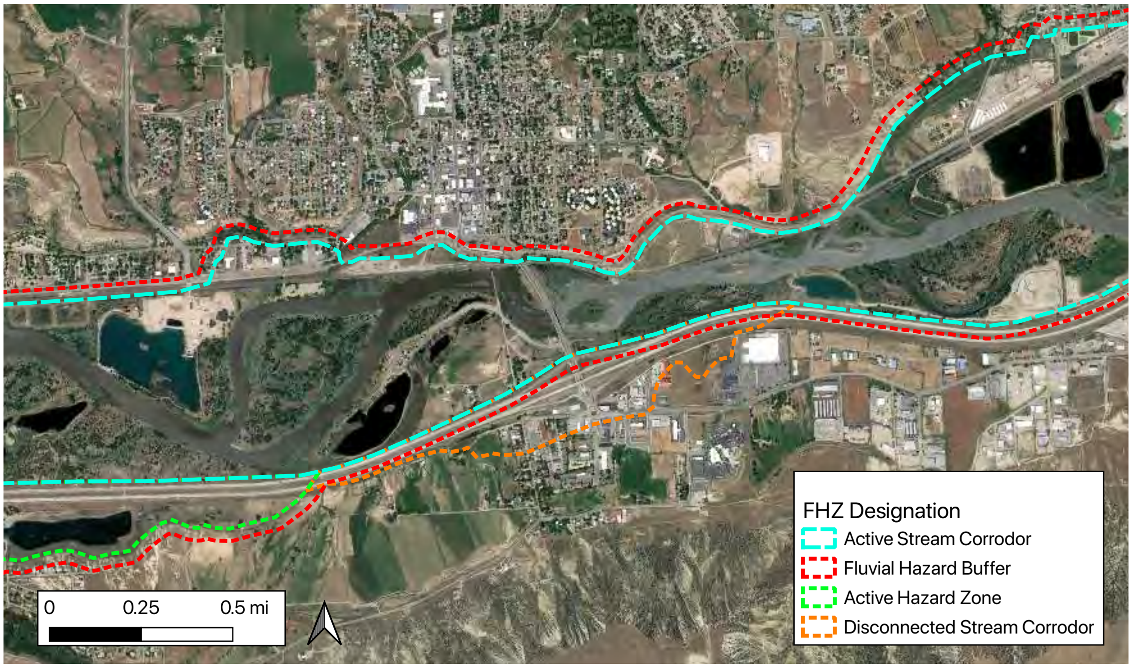

Figure 41. Fluvial Hazard Zone mapping completed for the Colorado River in the vicinity of Rifle

The FHZ maps provided through this project (Appendix B) are available to municipalities, county governments, and land/business owners to help understand potential risks to infrastructure and contemplate long-term strategies to reduce those risks. However, use of these maps is caveated because they have not been peer-reviewed or officially approved by planning officials at this time. These maps may be useful in (re)development permitting and approval processes or in the creation of hazards zoning overlays.

2.11 Pest Regulation

The pest species of particular interest to local stakeholders include invasive woody riparian plants (e.g., tamarisk and Russian Olive), invasive herbaceous riparian plants (e.g., Russian Knapweed), invasive fish (e.g., White Suckers, Smallmouth Bass), and other invasive aquatic and amphibian species (e.g., bullfrogs). The issues associated with these species were presented previously (see Section 2.3 and 2.4). This section will not endeavor to replicate those discussions. Instead, this space will be used to clarify the interconnected nature of land/water management and requirements for ongoing interventions to control pests.

In many cases, the rapid spread of invasive species in riparian and aquatic ecosystems is aided where hydrological modifications to the stream network or land use/land cover changes in the riparian corridor are severe. These changes alter the bio-geophysical template upon which native species evolved and are most equipped to thrive in. Human land and water management activities can, thus, create novel ecosystems where invasive species exhibit significant competitive advantages over native species.

2.11.1 Invasive Riparian Plants

Like much of the western United States, invasive riparian woody and herbaceous plants took hold following more than a century of land cover change and land management practices. Hydrological modification, particularly reductions in springtime peak flows, are expected to reduce the overall width of the riparian corridor in the Middle Colorado Watershed and make it more difficult for native woody species to successfully recruit on scoured surfaces. Grazing, riparian deforestation, and bisection of floodplains by transportation corridors and other infrastructure further disrupts native plant community dynamics and provides an altered setting where invasive plants can take hold and thrive.

The areas with the greatest need and opportunity for invasive plant control exist between Silt and Rifle, in the reaches upstream of Parachute, and in the Colorado River and Roan Creek floodplains near De Beque (Figure 42). From Silt to De Beque, Colorado Headwaters Invasives Partnership (CHIP) recommended biological treatment as the primary treatment method. Between Glenwood Springs to Silt, Russian olive is more abundant than tamarisk, and CHIP recommended cut stump with herbicide for treatment. Building enclosures can also protect rare plants, help sustain the broadleaf plant community, and support the regeneration of native grasses and forbs. Appendices B and E include maps of high priority areas for invasive species control to help target and coordinate those efforts in the reaches between New Castle and De Beque.

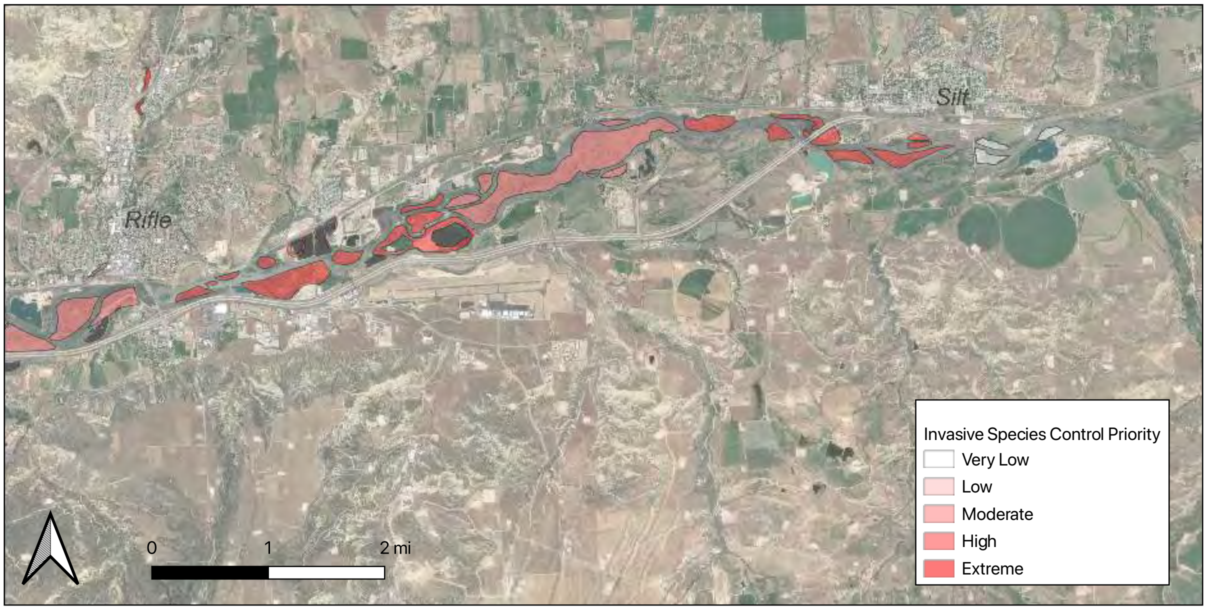

Figure 42. Mapped invasive species control priorities in the reach between Silt and Rifle according to site access, invasive species density, and the condition of adjacent riparian communities.

2.11.2 *Gravel Pits and Fish Escapement*

The same alterations and management actions that can impact native riparian communities are also expected to impact aquatic communities. Altered hydrology and/or sediment regimes in the Colorado River may reduce habitat complexity and produce conditions more favorable non-native species. Modification of floodplain and channel structure (e.g., through construction of gravel pits or elimination of side channels and backwaters) and intentional stocking of non-native species were highlighted previously as high-priority issues.

Invasive fish and amphibians are known to inhabit gravel pits in the Middle Colorado Watershed. Escapement of fish from gravel pits and private ponds is most likely in cases where hydrological connections between those water bodies and the river do not include mechanical barriers to passage or when/where a levee or other barrier is breached by the river during a high flow event. Risk levels for the latter event type were characterized for gravel pits between Silt and De Beque. Risk levels were delineated based on the distance between each pit and the river, the difference in water surface elevations between each pit and the river using LiDAR and inundation model data, and the relative height of the levee or other barrier between the pit and the river (Figure 43). The resultant risk map provides a coarse prioritization for completing projects to reduce the probability of a hydrological connection with the river during high flow events.

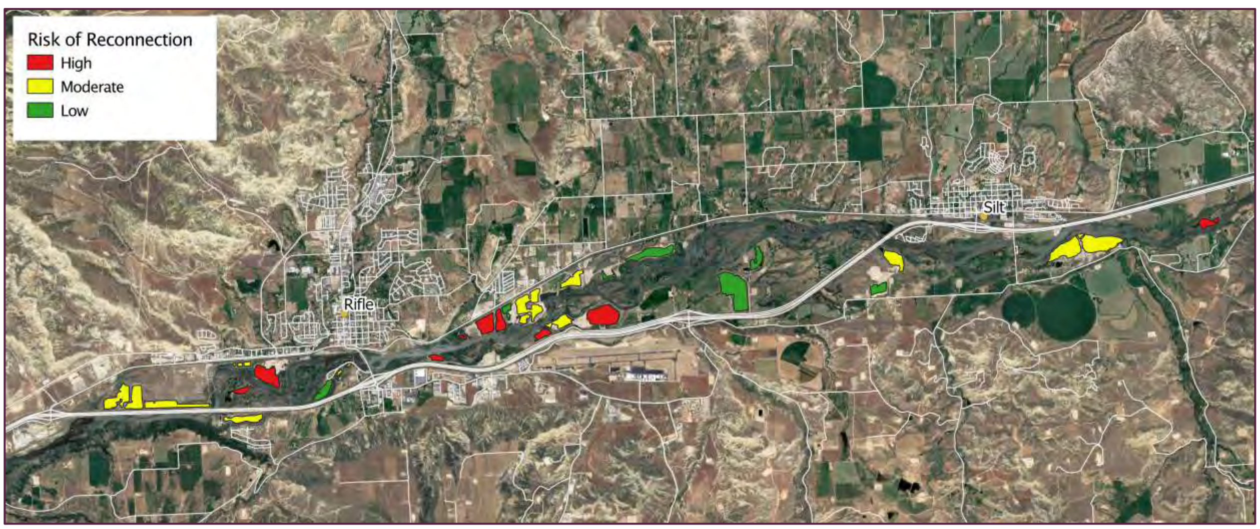

Figure 43. Risk of hydraulic reconnection of gravel pits to the Colorado River during flood events in floodplains in the Silt and Rifle area.

Reducing the propensity for hydrological connections between abandoned gravel pits and the river is only one part of a multi-pronged effort likely needed to reduce or eliminate the invasive species impacts associated with those pits. Increased signage and public education regarding the illegality and ecological risks associated with moving or stocking non-native species in gravel pits without CPW stocking permits is also prudent. Efforts to remove or prevent escapement of illegally introduced invasive species within gravel pits will be required into the future. Over the long-term the invasive species impacts associated with gravel pits may be most effectively addressed through revision of permitting and reclamation requirements for gravel mining operations. Local stakeholders may also want to consider the value of a pilot project to improve the reclaimed condition of a single abandoned gravel pit. A pilot project could be used to demonstrate best practices for fish migration barriers. An effort could be made to improve the riparian values (and enhance opportunities for colonization by native plants) at the reclaimed site by extending the vegetated fringe around the pit. This may be accomplished by placing fill in near bank areas or excavating additional material around the edges of the pit to create a greater acreage of low-lying and/or shallow-submerged areas.

2.12 Recreational Use of the Colorado River

The recreational value of streams and rivers in the Middle Colorado Watershed is recognized widely by local stakeholders. This is reflected in numerous efforts by local municipalities to provide or expand access to and use of the river. Glenwood Springs, New Castle, Silt, Rifle, Parachute, and De Beque each boast a boat ramp that provides access to the river. Several municipalities continue to explore how increased recreational use opportunities on the Colorado River might help diversify local economies.

The evaluation of recreational use opportunities throughout the planning area focused on boating and angling on the mainstem Colorado River from Glenwood Canyon to De Beque Canyon, ending at the Roller Dam. This section of river receives relatively little use below Silt, while upstream sections see heavy use at different times of the year. Recreational use preferences are notoriously difficult to quantify, especially in areas that don't receive heavy recreational traffic. In many water planning settings, efforts to describe relationships between water management and recreational use focus on streamflows.[142] This approach was deemed inappropriate for the Middle Colorado through consultation with local stakeholders Instead, a web survey was distributed to the local community in 2019 regarding the dominant types of recreational use activities, the most/least appreciated characteristics of the recreational experience, and opportunities for expanding or enhancing those experiences.

Respondents to the community survey (n = 66) were, overwhelmingly, citizens from municipalities within the Middle Colorado Watershed. Most indicated that they were private recreators. Of the total respondents, 40% indicated they recreated on the section of the Colorado River that flows through the planning area 1-5 times per year, 33% indicated they recreated 5-20 times per year, and 25% indicated they visited the river more than 20 times per year. Non-motorized floating activities dominated the typical use categories (Figure 44). Recreators indicated being drawn to this section of the Colorado River by opportunities for solitude and an experience in nature (Figure 45). River access and flow levels topped the list of factors most affecting the ability to effectively use the river (Figure 46).

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[142] https://www.americanwhitewater.org/content/Wiki/stewardship:whitewater_flow_studies?

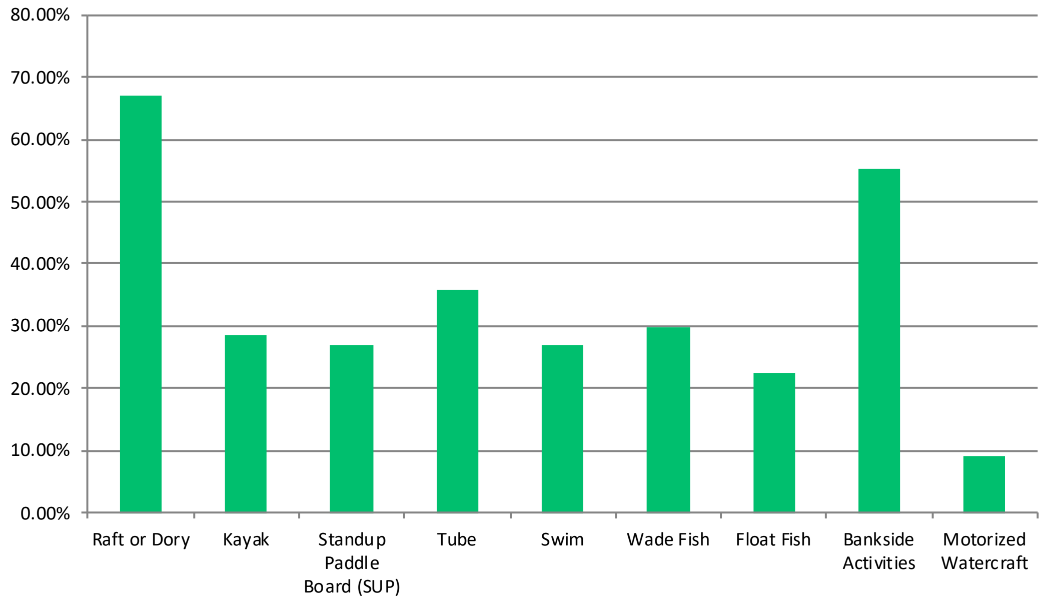

Figure 44. Distribution of community responses to survey question regarding typical uses of the Colorado River through the planning area. Individual survey respondents may be represented in several use categories.

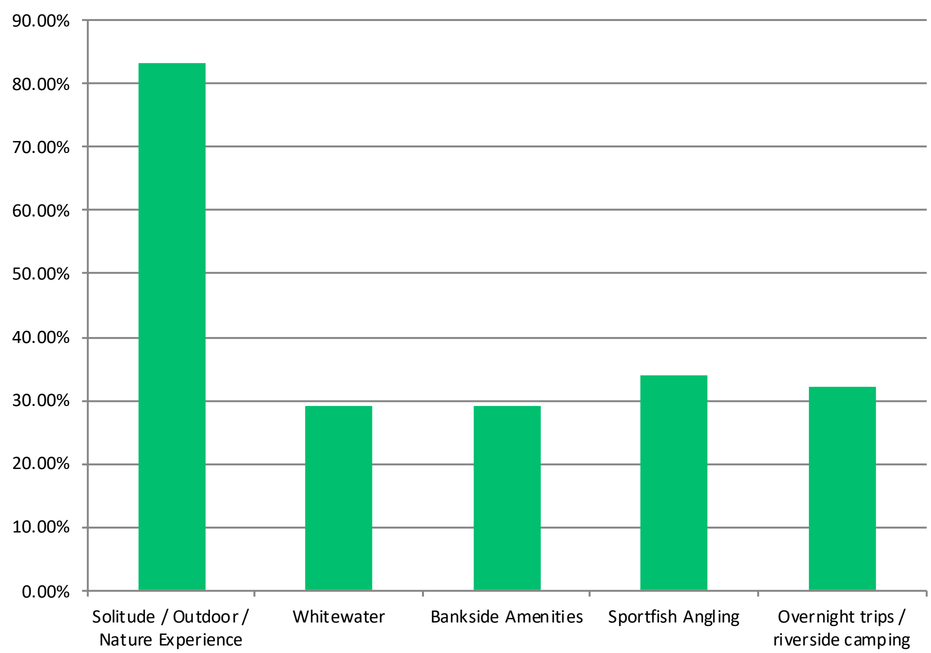

Figure 45. Distribution of community responses to survey question regarding the things that users look for in a recreational experience on the Colorado River through the planning area.

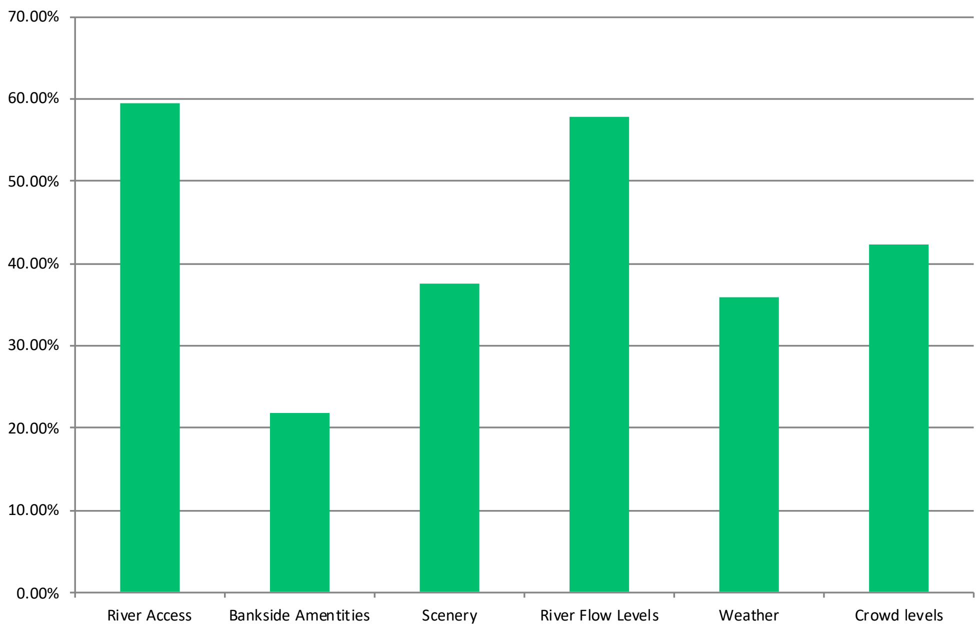

Figure 46. Distribution of community responses to survey question regarding the factors that most greatly affect recreational experiences on the Colorado River through the planning area.

A common perspective articulated by stakeholders to the planning process was that lack of knowledge about the characteristics of the river combined with a limited number of access points on the Colorado River below Rifle represent significant barriers to recreational visitation. As noted above, boat ramps in lower river segments are located at Rifle, Parachute, and De Beque. However, the spacing of those ramps is generally too great for visitors to travel between them over the course of a half-day trip. A limited amount of public land for picnicking and other activities (and a lack of knowledge or signage about the existing public land) further discourages visitation. Stakeholders identified the need for a ramp in the Rulison area, improvements to the ramp below Parachute at Una Bridge, and mapping and signage of public land between Silt and De Beque as high priorities for promoting and supporting recreational use of the Colorado River through the planning area.

2.12.1 Risks to Recreational Use Activities

Increasing levels of recreational use in the Middle Colorado Watershed are not without drawbacks. Too much use in locations with limited public land or where the primary draw for use is a “wilderness” experience can degrade the experience for many visitors or decrease wildlife habitat values. Some stakeholders to the planning process expressed exactly this concern for the Colorado River through the planning area. In an effort to prevent this scenario from unfolding, it will be important for federal resource management agencies, local municipalities and watershed organizations to regularly evaluate perceptions of recreational use among a growing recreator population. When and where visitors express strong preferences for limited use, permitting systems or other mechanisms for access control may be needed.

As use of the Colorado River increases, so too does the risk for conflict between recreational visitors and private landowners. Installing signage along public and privately-owned sections of streambank will help reduce this risk. Publication of a river map/guide that clearly identifies the location and extent of public property would benefit future users and lower risk for conflict with landowners.

A growing recreational user base will, over the course of several years, begin to understand how the recreational characteristics of the Colorado River change with changing flows. At some point in the future, it may be beneficial to conduct a Boatable Days assessment[143] to determine if/how operation of upstream reservoirs, expansion of upstream transmountain diversion, or the hydrological changes associated with any of the hydrological planning scenarios presented in this effort might degrade or improve recreational use opportunities.

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[143] https://www.americanwhitewater.org/content/Wiki/stewardship:whitewater_flow_studies?

3 PLANNING OBJECTIVES

Stakeholders helped articulate management goals for the Colorado River and its tributaries through the Middle Colorado River Watershed. These goals were used to guide the identification of objectives and the projects or management actions needed to meet those objectives.

3.1 Goal and Objective Setting

Surveys, group meetings, and one-on-one meetings were used to characterize local values related to water uses that support human communities and the environment. Those interactions helped describe a set of planning *Goals* that reflect high-priority issues warranting focused consideration in the planning area. Goals respond to the location, behavior, condition, and/or function of the primary attribute(s) of interest to local stakeholders. The goals identified by the Advisory Committee included the following:

- Foster a collaborative approach to water management through shared stewardship.
- Protect existing water uses and secure future water supplies.
- Maintain, or enhance where appropriate, healthy watersheds, rivers and streams.
- Enhance and promote responsible recreational use of local streams and rivers.
- Promote, preserve and protect agriculture.
- Increase resiliency in the regional water supply.
- Promote a resilient and diverse economy.
- Plan to adaptively meet impacts of a changing climate.

Planning goals provide a benchmark for evaluating progress toward or away from desired outcomes after some action is taken. However, goals tend to be fairly broad and high-level. *Objectives* are more focused and provide a better basis for identifying *Actions*. After the Goals were articulated by the Advisory Committee, each of the focus groups set to work identifying a set of Objectives that responded to both the Goals and the high-priority issues relevant to each topic area. The focus groups used mental models as a means for conceptualizing the multi-faceted nature of land and water management issues as they worked to formulate objectives. Mental models are a useful group brainstorming tools. They help communicate complex ideas and support the rational for a given course of action. The mental models employed in this planning effort took the form of directed acyclic graphs.[144] Participants identified key concepts and the nature of the relationships between them by connecting concepts with arrows and assigning each arrow a positive proportional effect or a negative effect. The mental models and the Objectives generated by each focus group are presented in the subsections below. The four mental models generated by each focus group were eventually aggregated into a

[144] https://en.wikipedia.org/wiki/Directed_acyclic_graph

single large structure (Appendix J). In addition to the advantages regarding clarification of complex interrelationships between variables, the directed acyclic graph mental models created here can be extended in the future to create Bayesian Belief Networks—a potentially useful approach for exploring outcomes associated with various climate/hydrological change or policy scenarios.[145]

3.1.1 Riparian Areas and Water Quality

Participants in the Riparian and Water Quality focus group meetings developed a mental model that outlined many (but not all) of the variables/issues relevant to decision-making intended to support riparian and water quality and the human uses that depend on them. This work resulted in the articulation of eight planning Objectives.

3.1.1.1 Mental Model

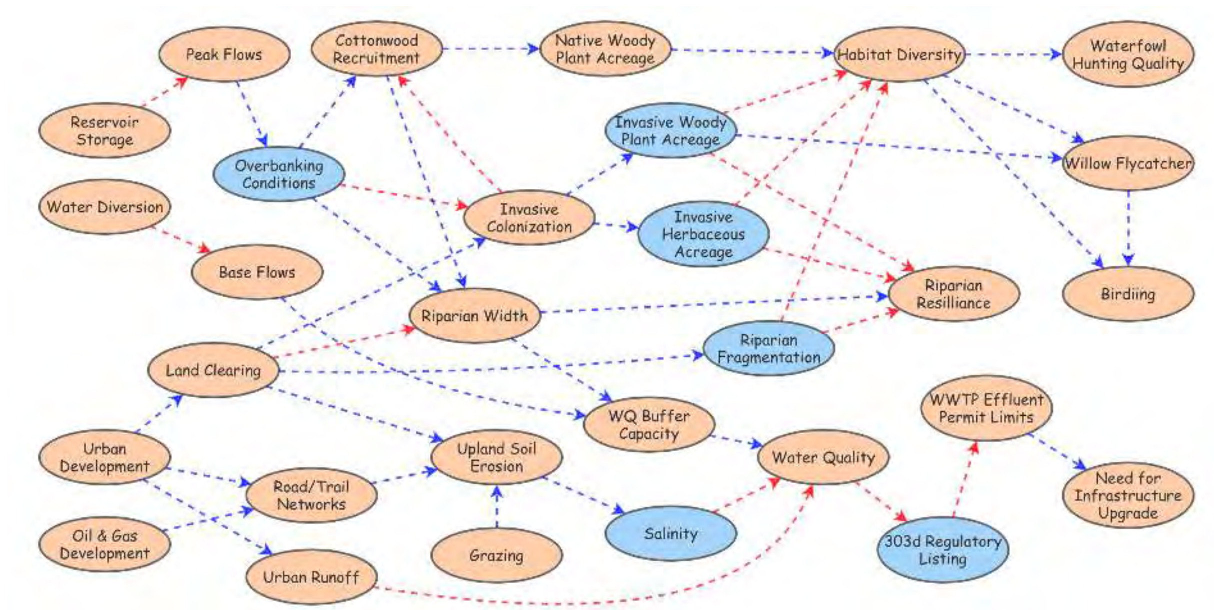

Figure 47. Directed acyclic graph mental model created by stakeholders that indicates interrelationships between riparian and water quality concepts in the Middle Colorado Watershed. Blue arrows indicate a linkage where one variable has a proportional effect on another (i.e., as variable A goes up or down, so does variable B). Red arrows indicate a linkage where one variable has an opposite effect on another (i.e., as variable A goes up, variable B goes down, and vice versa). Variables indicated in blue are issues of specific focus that resulted in articulation of one or more Objectives.

3.1.1.2 Defined Objectives

- Reduce the number of stream miles in the Middle Colorado Watershed that are included on the State of Colorado 303(d) list, and prevent future listings.

[145] Salliou, Nicolas & Barnaud, Cécile & Vialatte, Aude & Monteil, Claude. (2017). A participatory Bayesian Belief Network approach to explore ambiguity among stakeholders about socio-ecological systems. Environmental Modelling and Software. 96. 199-209. 10.1016/j.envsoft.2017.06.050.

- Reduce salinity loading to the Colorado River in the Middle Colorado Watershed.
- Reduce risk for municipal wastewater discharge permit violations (due to altered patterns of upstream water use/management or the impacts of climate change on water temperature and the hydrological regime).
- Protect areas of contiguous riparian habitat from future degradation or loss.
- Reduce acreage of riparian area functionally degraded by invasive plants.
- Increase the acreage of contiguous high-quality riparian habitat.
- Restore and preserve the connectivity between the river and the functional floodplain.
- Increase community awareness of the consequences of water management decision-making for human and natural systems.

3.1.2 Aquatic Biota

Participants in the Aquatic Biota focus group meetings developed a mental model that outlined many (but not all) of the variables/issues relevant to decision-making intended to support conditions for native aquatic species, sport fish, and the recreational activities that depend on them (Figure 48). This work resulted in the articulation of six planning Objectives.

3.1.2.1 Mental Model

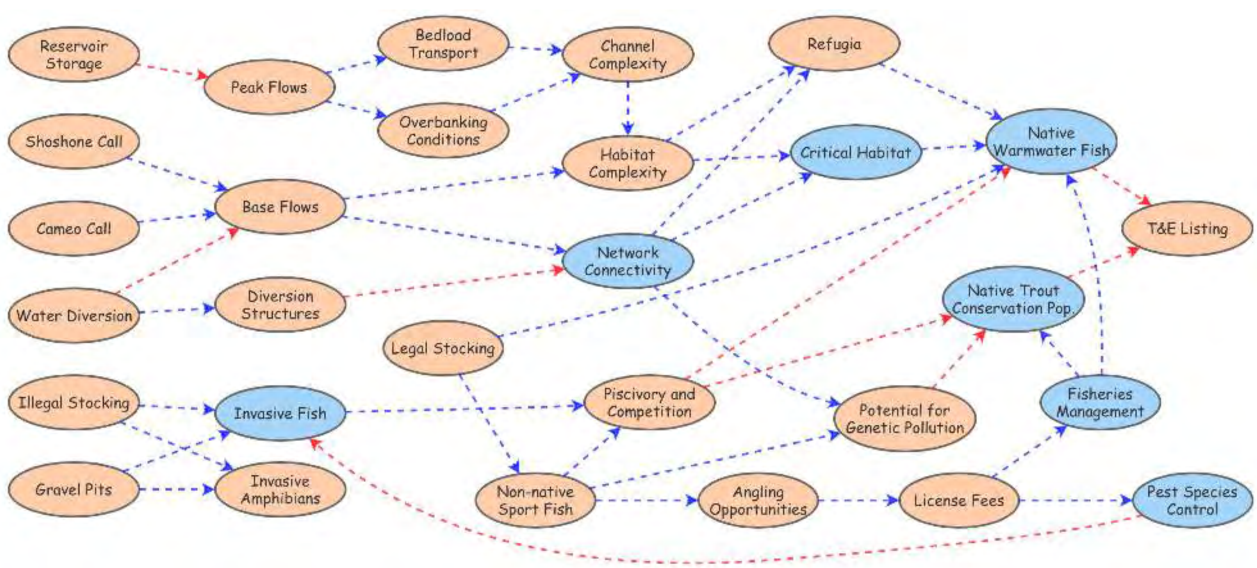

Figure 48. Directed acyclic graph mental model created by stakeholders that indicates interrelationships between aquatic biota concepts in the Middle Colorado Watershed. The meanings for arrow and variable coloration are consistent with the description provided in Figure 47.

3.1.2.2 Defined Objectives

- Maintain healthy, productive aquatic communities of native and other desirable species at viable population levels commensurate with the species' and habitats' potential.

- Restore stream network connectivity for native warmwater fish and cold-water sport fish along the mainstem Colorado River and lower segments of tributary streams.
- Conserve and/or recover ESA-listed species and the ecosystems on which they depend through on-going, conservation activities.
- Maintain or enhance special status species and their habitats to provide for on-going conservation and recovery.
- Reduce or eliminate threats to sensitive species to minimize the likelihood of and need for listing of these species under the ESA.
- Sustain ongoing monitoring and research efforts characterizing native fish and invasive fish abundance and range throughout the watershed.
- Enhance community awareness of state and federal fishery management objectives and the critical role that individuals can play in meeting those objectives.

3.1.3 Consumptive Use

Participants in the Consumptive Use focus group meetings developed a mental model that outlined many (but not all) of the variables/issues relevant to decision-making intended to support agricultural, municipal and industrial uses of water in the Middle Colorado Watershed (Figure 49). This work resulted in the articulation of seven planning Objectives.

3.1.3.1 Mental Model

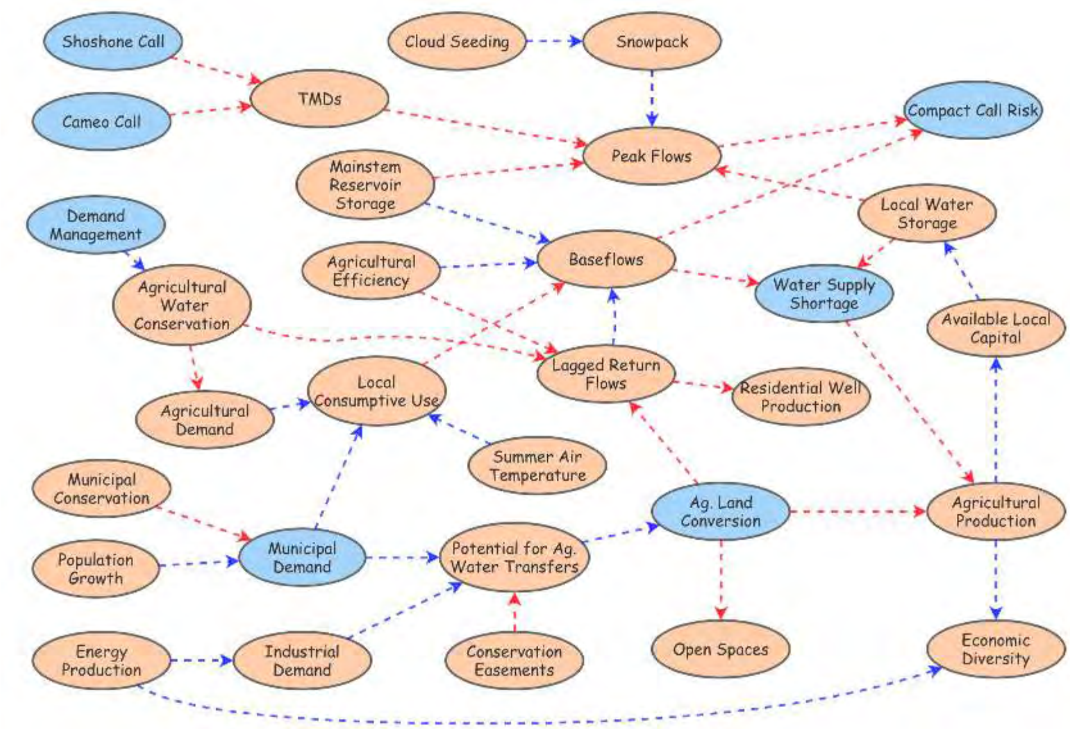

Figure 49. Directed acyclic graph mental model created by stakeholders that indicates interrelationships between consumptive water use concepts in the Middle Colorado Watershed. The meanings for arrow and variable coloration are consistent with the description provided in Figure 47.

3.1.3.2 Defined Objectives

- Enhance the security of the Shoshone water right to serve western Colorado.
- Limit the magnitude and frequency of water shortages experienced by agricultural producers on tributaries.
- Enhance market opportunities and flexibility for water use/management by agricultural producers.
- Incentivize actions that preserve agricultural lands, produce benefits for consumptive water users and/or achieve habitat protection and restoration objectives.
- Promote resiliency in local water supply in anticipation of future population growth, changes in industrial uses and/or climate change.
- Reduce risk of curtailment due to a Colorado Compact call.
- Enhance local understanding of administrative/legal/operational controls on water use.

3.1.4 Recreational Use

Participants in the Recreational Use focus group meetings developed a mental model that outlined many (but not all) of the variables/issues relevant to decision-making intended to recreational uses of the Colorado

River mainstem through the Middle Colorado Watershed (Figure 52). This work resulted in the articulation of seven planning Objectives.

3.1.4.1 Mental Model

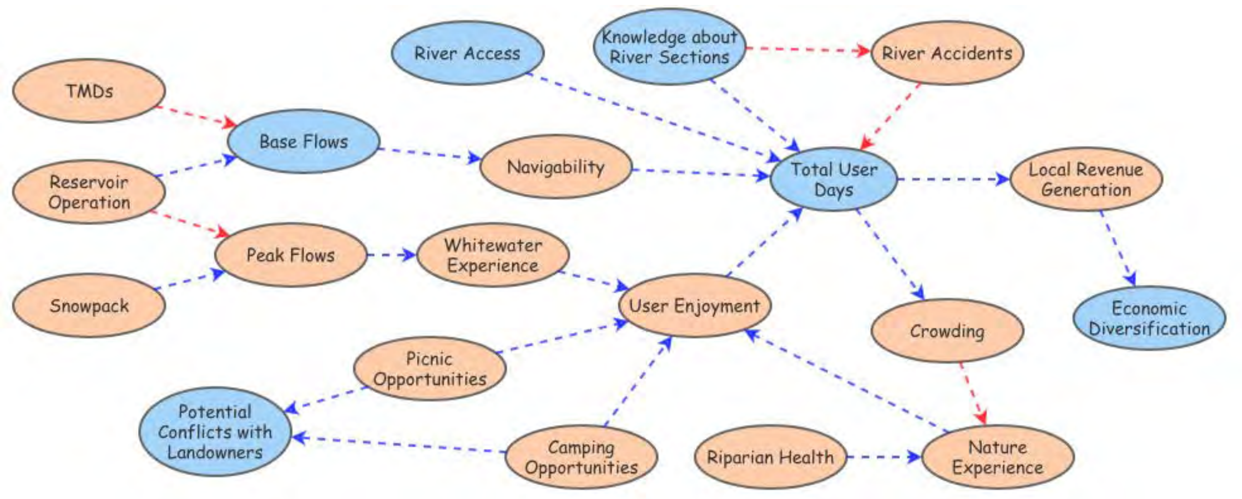

Figure 50. Directed acyclic graph mental model created by stakeholders that indicates interrelationships between consumptive water use concepts in the Middle Colorado Watershed. The meanings for arrow and variable coloration are consistent with the description provided in Figure 47.

3.1.4.2 Defined Objectives

- Understand present and future recreational visitor experiences and preferences
- Enhance opportunities for day and overnight floating activities.
- Enhance opportunities for non-boating recreation activities along the Middle Colorado River.
- Minimize conflicts among recreation visitors, between recreation visitors and other users of the river, and with private landowners.
- Limit recreational impacts on areas of significant cultural, historic, biological and conservation value.
- Limit impacts of low flow periods on recreational experiences in the Middle Colorado Reach.
- Add or maintain contributions to the local economy and support local businesses in the Middle Colorado River Reach.

4 RECOMMENDED ACTIONS

Water is a limited resource and balancing consumptive and non-consumptive use needs generally involves tradeoffs. The responses of physical and legal water demands to hydrological conditions determine the allocation of water among the various uses present in the system. For agricultural uses, the infrastructure used to convey water, the irrigation application method, and the distance of fields from stream systems all influence the timing and location of surface and groundwater return flows. Interaction between water availability and use efficiencies can conspire to create demand shortages at different locations over the course of a year. Understanding the location, magnitude, and frequency of water use shortages affecting environment, agriculture, municipal use, and recreation can be useful for identifying locations and times when opportunity exists for implementing cooperative measures. Understanding water use shortages affecting a diversity of users also assists in identifying those locations and times where and when water availability and other constraints may limit the feasibility or effectiveness of some identified potential action.

4.1 Action Identification and Prioritization

Stakeholders were engaged in a deliberative process to consider information generated by the targeted assessments, review stated objectives, brainstorm potential actions that might meet the objectives and, finally, discuss the relative merit and priority of each proposed action in light of expected costs, permitting difficulties, legal issues, popularity among the broader community, etc. The intersection of these issues was made explicit through the creation of Objective/Action prioritization matrices (Appendix K). These matrices helped the Advisory Committee and the Focus Groups reach consensus on the Actions that were elevated as recommendations to the Plan. To provide insight on the development of these concepts, two example actions and the factors considered by the stakeholders when evaluating their relative merits are discussed in detail below.

4.1.1 Example: Potential for Kendig Reservoir to Address Agricultural Shortages

Water District 45 clearly experiences the largest agricultural shortages in the Middle Colorado River region. Kendig Reservoir is a conditional water storage right held by West Divide Water Conservancy District (WDWCD) in the amount of 15,450 acre-feet and a first enlargement right of 2,610 acre-feet. Kendig Reservoir would obtain its main supply from West Divide Creek and provide water to West Divide and Divide Creek. Feasibility studies have found the various dam alignments being considered to range from 9,000 to 16,500 acre-feet of storage. In order to determine the amount of agricultural shortage that could be met by a Kendig Reservoir, the 16,500 acre-foot reservoir was modeled. The model was run for the Baseline and Planning Scenarios using the datasets available from the CWCB.

The model utilized the Technical Update data for the West Divide Creek near Raven streamflow as well as the watershed scaled demand and supply data, described in previous report sections. In the model, it was assumed that no water could be stored until all demands below the reservoir were met. The total demands were quantified from each of the planning scenario models. Excess water supply at the stream gage, beyond the total basin demand, was put into storage. This negates the need for a water right analysis as it assumes the reservoir is the most junior use and cannot store until all downstream demands are met. Storage was limited to 16,500 AF based on previous feasibility studies. The water in storage was then assessed evaporation and the amount was reduced accordingly. In months where shortages were experienced, releases from storage are made to satisfy all or portions of the shortages. If the available water supply could not be stored due to capacity limitations, it was quantified as a spill and was not accounted for in the reservoir operations. The amount of demand shortage that could be met with reservoir releases was quantified across all planning scenarios. The majority of water is stored during peak runoff in April and May (Figure 51). Even in the scenarios with the highest impacts from climate change, the peak runoff month is May. However, the availability of water supplies varies across the planning scenarios with Scenario E showing the lowest available yield to the reservoir.

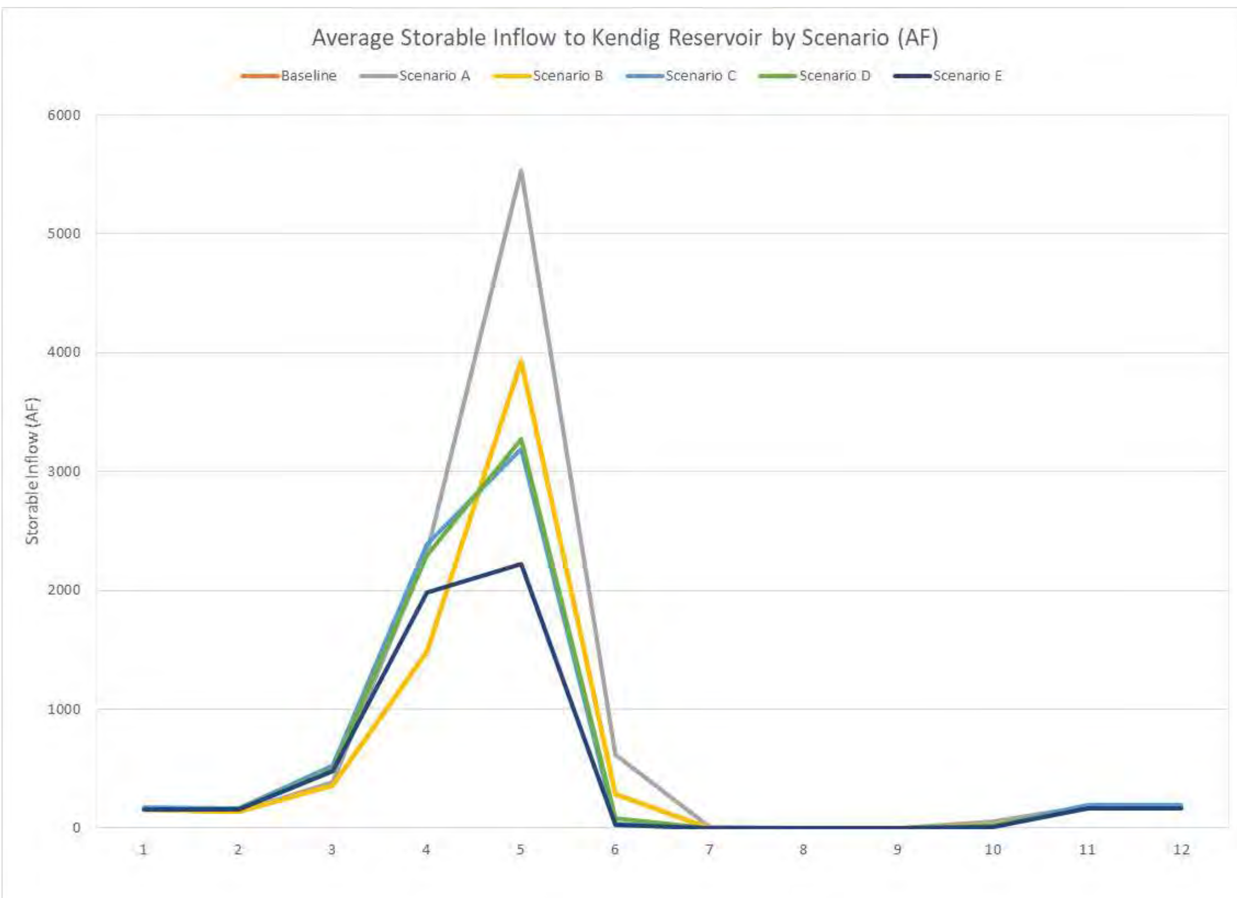

Figure 51. Storable inflow to Kendig Reservoir from West Divide Creek. Horizontal scale is time in months.

The results of the reservoir model are shown in Figure 52, below. Across all planning scenarios, the ability to store excess spring runoff and retime it with reservoir releases reduced the amount of shortage experienced by downstream agricultural water users. The reduction in water shortages varied from a low of 13% in Scenario E to a high of 56% in Scenario A. The Scenarios with the largest agricultural demand gaps also have the lowest reduction because the gaps are driven by the reduction in available streamflow. The reduction to the gap does not rely heavily on carryover storage, as it is not available in most years. While the available supply can be retimed to more align with the demands, the physical flow is not available to meet the seasonal demands. While Kendig Reservoir only addresses a fraction of the agricultural diversion gap, it can reduce the magnitude of shortage experienced by approximately 5,000- 9,000 acre-feet across the planning scenarios, on average.

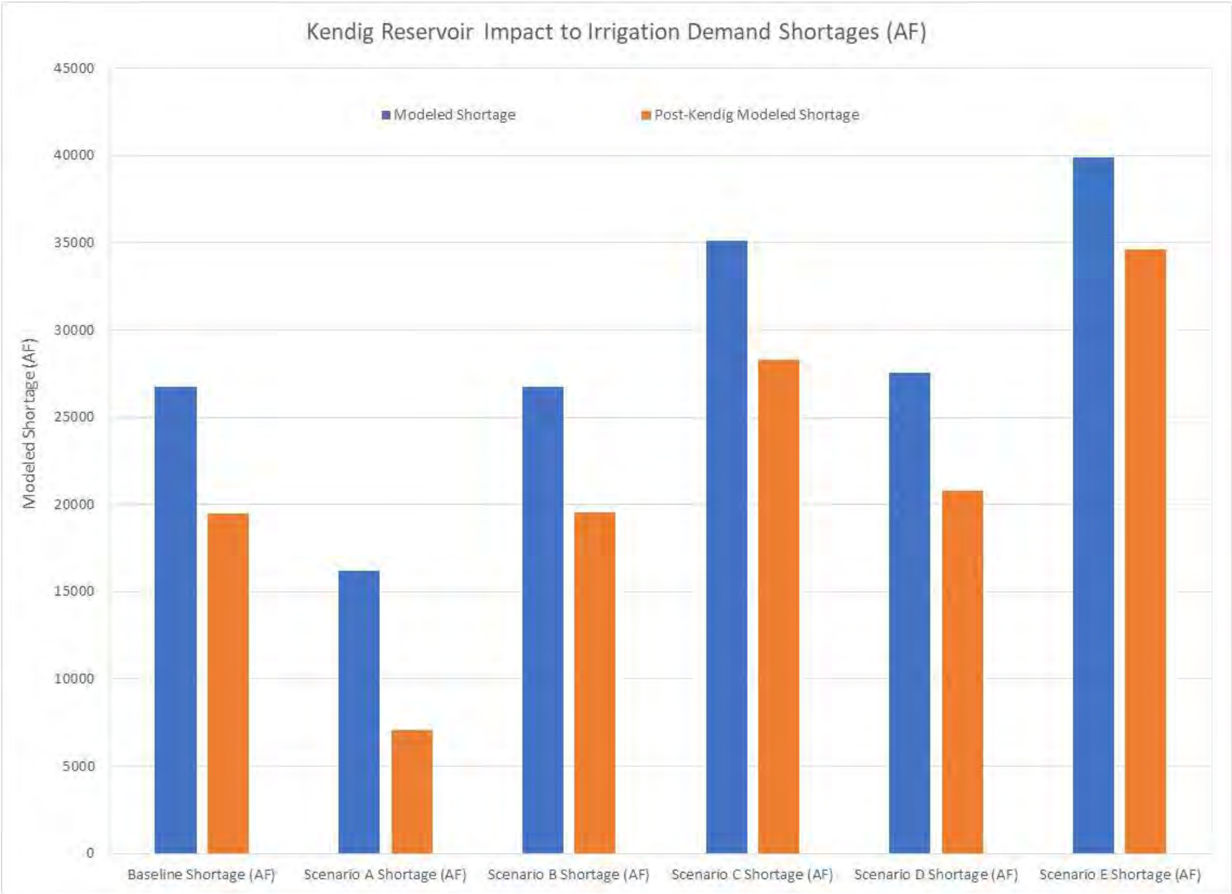

Figure 52. Agricultural water shortages evaluated without and with Kendig Reservoir.

4.1.2 Example: Opportunities for Streamflow Supplementation from Ruedi Reservoir

The Middle Colorado has not historically been a focus of streamflow restoration or supplementation because of its advantageous location: it benefits greatly from the routine administration of the Colorado River. It sits upstream of major administrative calls, downstream of major reservoirs, and sees the added benefit of water used to generate hydropower at Shoshone Power Plant. Because it sits in the heart of Colorado River administration, any attempts to supplement flows in the reach should be (and will necessarily be) closely coordinated with the CWCB, the CRD, BOR, and the DWR Division 5 engineer's office, among others.

Contracting for water out of Ruedi Reservoir is one of Colorado's simpler water transactions. The CRD has a pool of water available for contract,[146] and the agency recently established a rate of $67.25 per acre-foot for "in-channel uses".[147] In addition, contracts for Ruedi water have not required additional water court or division engineer approval for in-channel use, vastly reducing the transaction's cost and complexity.

However, Ruedi operations are complex. The reservoir is a vital piece of Colorado River administration, stores water for many entities, and its releases are constrained by the size of the Fryingpan River. The stakeholders should evaluate whether Ruedi water can be released at the times and flow rates desired. In addition, water is expensive, and flow increments of 10-15 cfs are difficult to measure in a river the Colorado's size. Stakeholders in the Middle Colorado should analyze whether contracting for additional streamflows will provide the outcomes they seek.

Several entities have recently used Ruedi water to bolster streamflows. In 2015, Ute Water Conservancy District approached the CWCB to lease 12,000 acre-feet of its contract water in Ruedi Reservoir at cost. The water supports the Recovery Program by helping meet the U.S. Fish and Wildlife Service's recommended flow rates in the 15-Mile Reach. Releases have been made again each year.

In 2018, the CWCB approved a one-year lease of 3,500 acre-feet with the CRD intended to increase winter streamflows in the lower Fryingpan. Winter temperatures and low flow conditions can conspire to create anchor ice – ice that forms on the bed of a stream and reduces macroinvertebrate habitat, thus limiting fish food supply.

To pursue similar water transfers, stakeholders may contact CRD, CWCB, or non-profit organizations like the Colorado Water Trust[148], Trout Unlimited[149], and The Nature Conservancy[150] that specialize in navigating contracting and approval processes. These organizations can also help with developing and deploying funding resources if necessary. For example, Yampa River Basin locals recently established the Yampa River

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146 https://www.coloradoriverdistrict.org/water-marketing/

147 Colorado River District, Water Marketing Policy of the Colorado River Water Conservation District's Colorado River Water Projects Enterprise (Jan. 15, 2019) https://www.coloradoriverdistrict.org/wp-content/uploads/2019/12/crwcd-2019-policy-colorado.pdf

148 https://coloradowatertrust.org/project/stagecoach-reservoir-yampa-river

149 https://www.watereducationcolorado.org/publications-and-radio/headwaters-magazine/fall-2017-can-colorado-save-its-farms/voices-from-the-field-jesse-kruthaupt/

150 https://www.yampariverfund.org/

Fund with the assistance of these organizations to fund a variety of river-related projects.[151] The CWCB also has funding for instream flow projects.

Other creative options exist as well. For example, stakeholders could identify a downstream farm in need of additional supply. Stakeholders and the producer might agree on a cost split and delivery schedule. Released water then would benefit the Middle Colorado on its way to the farm.

In another example, the Colorado Water Trust holds a contract with the GVWUA and Orchard Mesa Irrigation District to use available capacity within the Grand Valley Power Plant to deliver water to the 15-Mile Reach as discussed in section 2.1.2.3.[152] The Water Trust is actively looking for water supplies to deliver to the power plant. By supporting that project, stakeholders could improve flows in the Middle Colorado River and the 15-Mile Reach. Stakeholders are encouraged to consult with the Water Trust for further information.

Entities within the Middle Colorado might also benefit from consumptive use of releases. For example, the stakeholders might identify a water user who was willing to reduce diversions on a tributary in dry years in exchange for pumped Ruedi water from the Colorado River. Such a project would improve streamflows in the tributary while raising portions the Colorado River above the diversion.

Middle Colorado stakeholders might also explore the use of so-called municipal-recreational contracts. This is a contractual mechanism already used on the Colorado River to deliver water downstream, and would require the assistance of the CRD and a local municipality.[153]

Lastly, should the stakeholders pursue a recreational in-channel diversion, Ruedi water might be available for delivery to the RICD when its decreed flow rates were unmet.

4.2 Identified Action Cutsheets

The planning process yielded 55 different Actions (Table 13). Each Action is considered a high-priority as attested to by stakeholder consensus. Some Actions apply to a specific geographic location in the watershed while others are more generalized and can apply to the watershed as a whole.

[151] https://www.yampariverfund.org/

152 https://coloradowatertrust.org/project/15-mile-reach

153 https://co.grand.co.us/DocumentCenter/View/7049/WGFP-IGA---10--a-COOPERATIVE-WATER-LEASE-AGREEMENT

Table 13. List of identified planning Actions organized by topic area.

Code	Topic	Description
AQ1	Aquatic Biota	Reconfigure Barriers for Fish Passage
AQ2	Aquatic Biota	Install Fish Screens
AQ3	Aquatic Biota	Roan Creek Barrier
AQ4	Aquatic Biota	Process Based Restoration in Rifle Creek Basin
AQ5	Aquatic Biota	Educational Signage About Illegal Transport of Aquatic Species
AQ6	Aquatic Biota	Collaborative Post Fire Watershed Management
AQ7	Aquatic Biota	Participation in Flow Management Forums
AQ8	Aquatic Biota	Renewal of Upper Colorado River Recovery Program
AQ9	Aquatic Biota	Best Practices for Gravel Pit Reclamation
AQ10	Aquatic Biota	Landowner Outreach for Fishery Management Best Practices
AQ11	Aquatic Biota	Citizen Science to Track Invasives
AQ12	Aquatic Biota	Evaluate Fish Movement Above Cameo Diversion
AQ13	Aquatic Biota	Monitor Fish Entrainment in Mainstem Diversion Structures
REC1	Recreation	Recreational River Guide
REC2	Recreation	Improvements Silt Boat Ramp
REC3	Recreation	Rifle Whitewater Park and Recreational In-Channel Diversion
REC4	Recreation	Rulison Boat Ramp
REC5	Recreation	Una Bridge Boat Ramp Improvements
REC6	Recreation	De Beque Canyon Boat Ramp
REC7	Recreation	Riverside Camping Town of Parachute
REC8	Recreation	River Access Facility Improvements
REC9	Recreation	Property Ownership River Signage
REC10	Recreation	River Camping Opportunities
REC11	Recreation	Land Acquisition for River Access
REC12	Recreation	River Trail Planning
REC13	Recreation	Participation in Flow Management Forums
REC14	Recreation	Glenwood Recreational In-Channel Diversion
REC15	Recreation	Flow Preference Survey
REC16	Recreation	Track River Use, Needs, Contributions
WQR1	Water Quality	Water Quality Monitoring Strategy
WQR2	Water Quality	Site-Specific Temperature Standards
WQR3	Water Quality	Riparian Restoration and Invasives Control
WQR4	Water Quality	Pilot Gravel Pit Reclamation
WQR5	Water Quality	Interpretive Education at River Stop
WQR6	Water Quality	Securing Shoshone Water Right
WQR7	Water Quality	Contract Water for Environmental Support
WQR8	Water Quality	Participation in Flow Management Forums
WQR9	Water Quality	Targeted Outreach for Salinity Control
WQR10	Water Quality	Best Management Practices for Floodplain Uses
WQR11	Water Quality	Incentive Programs for River Habitat Protection
WQR12	Water Quality	Best Practices for Gravel Pit Reclamation
WQR13	Water Quality	Educational Programming to Protect Local Water Resources

Code	Topic	Description
CONS1	Consumptive Use	Agricultural Infrastructure Upgrades
CONS2	Consumptive Use	Streamflow Monitoring
CONS3	Consumptive Use	Kendig Reservoir
CONS4	Consumptive Use	Support Colorado River District
CONS5	Consumptive Use	Encourage Water Rights Owners
CONS6	Consumptive Use	Local Water Market
CONS7	Consumptive Use	Pilot Local Market for Agricultural Products
CONS8	Consumptive Use	Limit out of Basin Water Exports
CONS9	Consumptive Use	Connect Ag Producers with Funding
CONS10	Consumptive Use	Opportunities ATMs
CONS11	Consumptive Use	Multi-Benefit Water Storage
CONS12	Consumptive Use	Demand Management Investigations
CONS13	Consumptive Use	Irrigation Scheduling Study

One-page, conceptual descriptions of each of the 55 Actions are provided here. Some Actions are *Projects*, some are *Initiatives*, while others are *Studies*. In the following cutsheets, Actions are organized and color-coded by topic area and Action type for clarity (Table 14).

Table 14. Color coding for Action categories used on the cutsheets.

Action Category	Color Code
Project	
Initiative	
Study	

4.3 Success in Implementation

Stakeholders and project coordinators attempted to describe each Action in sufficient detail to ease the process of funding identification and future implementation. Each Action suggests an organizing entity and set of potential partners; this information is provided as a starting point for implementation discussions and is not meant to obligate or commit any entity in any way. Effort was also made to provide appropriate metadata for each Action so that it may be incorporated into the next CBRT BIP update.

Each Action also attempts to identify agencies that may: 1) play a regulatory role in Action implementation, 2) hold an Action-specific resource management/stewardship responsibility, and/or 3) be positioned to consult on a particular Action either through authorizing state statute or based upon the agencies' individual expertise and interest. The listing of agencies for each Action may not be fully complete but are, again, offered as a starting point for consideration. Colorado Parks and Wildlife has prepared a written statement regarding its consultation and stewardship roles and how those intersect with the Middle Colorado IWMP (see Appendix L).

Implementation of the Actions is intended to be voluntary and will only be successful with collaboration and cooperation among affected stakeholders and water right holders. The collection of suggested organizing entities and potential partners are varied and diverse; there is no single entity that will carry the torch. The IWMP Actions can be used as a roadmap for stakeholder entities to capitalize on when inspired to move a project, initiative, or study forward. As much support as we can provide each other should go a long way in seeing the IWMP come to fruition.

4.4 The Future of the IWMP Plan

The IWMP Plan can be viewed and used as a foundational and seminal piece of work developed through a community-driven process to guide projects in the Middle Colorado for decades. It establishes watershed goals based on currently understood issues and concerns and identifies actions to be undertaken by watershed stakeholders to secure a water future to the degree possible in the face of uncertainty. But uncertainty is certain and, with this understanding, the Plan should be regarded as a living document that will need to adapt to an ever-changing water landscape. Take, for example, the reality of two catastrophic fires that burned through the watershed as this Plan was under development.

Thought should be given as to how the Plan can continue to serve the community in a dynamic and responsive fashion where water challenges will continue to evolve. Is there an interest in continuing an established planning process with local stakeholder support to address future in-basin water challenges? Should a particular agency or collective of organizations be charged with the responsibility for facilitating adaptive planning and spearheading project implementation? Are there ways to raise monies locally to contribute to on-the-ground projects? How should progress toward meeting watershed goals be tracked, disseminated, and celebrated? The answers to these questions are important for the Middle Colorado communities as well as the State of Colorado and its citizens who endeavor to address both local and statewide water challenges while meeting the goals and objectives of the Colorado Water Plan.

<table>
<tr><td colspan="5">RECONFIGURE BARRIERS FOR FISH PASSAGE ON TRIBUTARIES</td><td>PROJECT AQ1</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Reconfigure existing barriers to fish passage on tributaries in the watershed including diversion structures and box culverts. Reconfiguration could include the addition of a ladder or modification and modernization of the entire structure, if needed and desired by the owner. Structures identified for reconfiguration are listed HERE. See related Project AQ2.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">AQ(a), AQ(b), AQ(c), AQ(d), AQ(e), AQ(g)</td></tr>
<tr><td>LOCATION OR AFFECTED AREA</td><td colspan="3">Various tributaries in watershed. See Table for structure-specific location information.</td><td>WATERSHED REGION</td><td>Upper, Mid, Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">MCWC, TU, USFS, BLM, or CPW (depending on structure ownership and location)</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">Private landowner or ditch company, Conservation Districts, TU</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">NRCS, BLM, USFS, CPW, U.S Army Corps of Engineers, county</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Physical barriers in streams and creeks can unintentionally inhibit the movement of fish as they migrate to and from the mainstem Colorado River into the tributaries each year to spawn and rear their young. Designs to retrofit and reconstruct these barriers need to consider the target species and their locomotive thresholds. Landowner consent is needed to form a project partnership. This type of work poses an excellent opportunity to incorporate updates to the physical structure and modernization of operation instrumentation on currently active water diversion structures without inhibiting yield or affecting existing water rights.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td colspan="2">Initiate 1+ years, 10-20 year completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Project sponsor(s) develop implementation phasing plans reflecting agreements with private landowners/ditch companies.
• Consult with CPW on design criteria to address specific species requirements. See published CPW research and design criteria HERE.
• Acquire funds for design/construction.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$25,000 to $200,000 per structure</td><td colspan="3">Varies widely depending upon structure design</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Observational evidence of fish movement through the structure on an annual basis or capture/release data documenting movement.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Ag, Muni, Industrial</td><td colspan="2">WATER SOURCE</td><td>Various</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>53, 39, 45, 70</td></tr>
</table>

<table>
<tr><th colspan="5">INSTALL FISH SCREENS TO MINIMIZE ENTRAINMENT</th><th>PROJECT AQ2</th></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Install fish screens or similar hardware to minimize entrainment of fish in open diversion structures on tributaries of the mainstem Colorado River. Design screens to address priority species and life stage. Consider the need for and feasibility of adding screens as part of fish passage projects described in Project AQ1. Initiate creation of a database on fish screen installation experiences for watershed target species.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">AQ(a), AQ(b), AQ(c), AQ(d), AQ(e), AQ(g)</td></tr>
<tr><td>LOCATION OR AFFECTED AREA</td><td colspan="3">Various</td><td>WATERSHED REGION</td><td>Upper, Mid, Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">MCWC, TU, USFS, BLM, CPW, Recovery Program (depending on structure ownership and location)</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">private landowner or ditch company, Conservation Districts, TU</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">NRCS, BLM, USFS, CPW, U.S Army Corps of Engineers, county</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Fish can become entrained in water diversion ditches without the ability to return to the river and will eventually die after the diversions are shut down each year. The prevalence of entrainment for T&E and other native or non-native fish in tributary diversions and the mainstem is unknown (see Study AQ13), but could potentially pose a risk and affect the ability to maintain critical populations into the future. Entrainment of coldwater, sport trout may also be occurring in ditches located upstream of Rifle. Cooperation from the operating ditch companies will be of paramount importance for this action to be undertaken. Recommended upgrades to the structure to mitigate fish entrainment may also present the opportunity for concomitant upgrades to the diversion structure to improve functionality without inhibiting yield or affecting existing water rights.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td colspan="2">TIMEFRAME</td><td>Initiate 1+ years, 10-20 yr timeframe</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Project sponsor(s) develop implementation phasing plans reflecting agreements with private landowners/ditch companies.
• Consult with CPW, TU, and Recovery Program staff on design criteria to address specific species requirements and incorporate lessons learned.
• Acquire funds for design/construction.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$ 5,000 – 75,000 per structure</td><td colspan="3">$ Varies widely, depended upon design details</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Observational evidence of screen effectiveness or capture/release monitoring data documenting effectiveness.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Ag, Muni, Industrial</td><td colspan="2">WATER SOURCE</td><td>various</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>53, 39, 45, 70</td></tr>
</table>

<table>
<tr><td colspan="5">ROAN CREEK BARRIER</td><td>PROJECT AQ3</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Construction of a physical barrier in the upper portion of Roan Creek to protect the headwater populations of native fishes over the long-term. Once the barrier is determined to be effective, further upstream invasions of nonnative fish will be eliminated which will allow for additional native fish conservation efforts in the headwaters of Roan Creek.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">AQ(a), AQ(d), AQ(e)</td></tr>
<tr><td>LOCATION OR AFFECTED AREA</td><td colspan="3">Upper Roan Creek</td><td>WATERSHED REGION</td><td>Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">private landowner, BLM, CPW</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">BLM, NRCS, CPW, U.S Army Corps of Engineers, county</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">The upper portion of Roan Creek contains a unique native fish assemblage comprised of Colorado River Cutthroat Trout, Bluehead Sucker, Mottled Sculpin, and Speckled Dace. A protective barrier was constructed in the 1990's but failed, exposing the native fish assemblage to invasion, competition, and interbreeding with nonnatives. The preferred location for reconstruction is on private land at the location of an existing diversion, affording the opportunity for incorporating improvements to its functionality without inhibiting yield or affecting existing water rights.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High. In Progress</td><td>TIMEFRAME</td><td colspan="2">Completion by 2022</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Retain design engineer in summer 2020.
• Acquire funds for construction.
• Construction in 2021/2022 depending upon timing of funding.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$200,000</td><td colspan="3">TBD</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Successful construction implementation according to the design and performance criteria developed by BLM and CPW.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Ag</td><td colspan="2">WATER SOURCE</td><td>Roan Creek</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>70</td></tr>
</table>

PROCESS BASED RESTORATION IN RIFLE CREEK BASIN				PROJECT AQ4
DESCRIPTION	Design and install restoration oriented elements in Butler Creek and West Rifle Creek to restore the hydrologic connection between the stream and its riparian/wetland floodplain, reduce erosion from existing headcutting and enhance aquatic habitat.			
OBJECTIVES ADDRESSED	AQ(a), AQ(d)			
LOCATION OR AFFECTED AREA	Headwaters tributaries of Rifle Creek Above 39°38'41.4"N 107°46'42.0"W		**WATERSHED REGION**	Middle
SPONSOR OR CHAMPION	CPW on West Rifle Creek at State Wildlife Area USFS on Butler Creek			
POTENTIAL PARTNER(S)	BLM, CPW, USFS, MCWC			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	BLM, CPW, USFS, U.S Army Corps of Engineers, county			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Butler Creek is located on USFS land, tributary to Middle Rifle Creek, and has a native fishery isolated by a natural physical barrier. Historic grazing practices, now modified, resulted in headcutting and excessive erosion. West Rifle Creek through the State Wildlife Area was also subject to historic overgrazing and is now deeply incised. It has the potential to improve habitat for Bluehead Sucker as well as provide habitat for Leopard Frogs. Combine with improvements to Clark Reservoir on SWA to provide timed base flows.			
DEGREE RIPENESS	High	**TIMEFRAME**	Initiate 1+ years, 3-yr completion	
IMPLEMENTATION STEPS	• Contract for design services. • Acquire grant funds for implementation. • Implementation likely a 2-year project. Utilize contractor and volunteer forces to construct. • Evaluate existing ISF(s) in consultation with CPW. Install gaging devices if needed.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$50,000/mile	$10,000-25,000/year for 3 years		
EVALUATION CRITERIA	Documentation of changes in pre- and post-restoration streamflow hydrographs, stabilized channel profile, and creek usage by target species 5-years post project.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Butler and W. Rifle Creeks
	BASIN	Colorado	**WATER DISTRICT**	39

EDUCATIONAL SIGNAGE ABOUT ILLEGAL TRANSPORT OF AQUATIC SPECIES					PROJECT AQ5
DESCRIPTION	Install signage around gravel pits, public ponds, boat ramps, and river access area indicating prohibition against moving nonnative fish, bullfrogs and other aquatic species between waterbodies.				
OBJECTIVES ADDRESSED	AQ(c), AQ(e), AQ(g)				
LOCATION OR AFFECTED AREA	Colorado River mainstem			**WATERSHED REGION**	All
ORGANIZING ENTITY	CPW and MCWC				
POTENTIAL PARTNER(S)	CPW, TU, USFS, MCWC, individual municipalities, counties, BLM				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW				
OPPORTUNITIES CONSTRAINTS CHALLENGES	There are abundant points of public access to the river and other waterbodies along the mainstem of the Colorado River where education signage could be installed. Messaging about nonnative transport could be combined with other educational messaging contemplated by Projects REC8 and WQR5.				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW				
DEGREE RIPENESS	High		**TIMEFRAME**	3-yr completion	
IMPLEMENTATION STEPS	• Inventory locations for sign installation. • Consult with CSU on research results regarding social aspects of working with the public on non-natives control. • Develop and vet sign text and graphics. • Acquire grant funds for implementation. • Contract for sign fabrication. • Hire contractor for installation.				
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**		
	$ 250-500 per location		$ 50/year per location		
EVALUATION CRITERIA	Post-project surveys indicate increased community awareness regarding nonnative transport. Survey participants are able to articulate a minimum of three best practices for eliminating spread of nonnatives.				
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River	
	BASIN	Colorado	**WATER DISTRICT**	45, 39, 53, 70	

<table>
<tr><td colspan="4">COLLABORATIVE POST FIRE WATERSHED MANAGEMENT</td><td>INITIATIVE AQ6</td></tr>
<tr><td>DESCRIPTION</td><td colspan="4">Achieve greater watershed health and fire protection in the watershed through coordinated fuel treatment planning, wildfire response, and post-wildfire rehabilitation efforts. Organize an ad hoc coalition to serve as a post-fire planning and coordination hub that bridges individual entity interests and efforts. Immediate focus will be on post-fire recovery and rehabilitation in the Grizzly Creek and Pine Gulch burn areas to reduce the risk of well-known post-fire hazards, such as flooding and erosion/debris flows. Longer-term efforts can turn towards planning for and implementing future fire risk mitigation throughout the watershed.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">AQa, AQc, AQd, AQe, AQg</td></tr>
<tr><td>FOCUS AREA</td><td colspan="2">Mainstem and tributaries within watershed area</td><td>WATERSHED REGION</td><td>Upper, Middle, Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">BLM, USFS, CDOT, USGS, NRCS, CPW, CDPHE, CWCB, Garfield/Mesa/Eagle counties, municipal governments, ERWC, CRD, local NGOs, HUP and W&S Stakeholder Group participants, Conservation Districts, NWS, DWR, Recovery Program, downstream water interests</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">CWCB, CDPHE, CDOT, CPW, BLM, USFS, DWR, counties</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">Recognizing that no single entity has jurisdiction over the two immediate burned areas of initial focus, a coalition of interests can provide a forum for individual stakeholders, both public and private, to discuss actions, arrive at consensus, and implement solutions to address the most vulnerable areas and natural resource assets. One challenge is that collaborative efforts can often take time to come to fruition and some post fire work is very time sensitive. Collaborative processes can also be complex, but the sum can be greater than the parts. There is an opportunity to plan and respond within larger efforts to manage watershed heath and wildfire in Colorado through efforts of the Colorado Forest and Water Alliance and specifically in the Colorado River basin through efforts of the CBRT.</td></tr>
<tr><td>DEGREE RIPENESS</td><td>High</td><td>TIMEFRAME</td><td colspan="2">Ongoing, 10-20 year process</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">• Designate a lead entity to coordinate the ad hoc coalition. Quickly identify and engage key stakeholders to formulate an operating structure, identify immediate tasks at hands, and deploy resources needed for highest priority activities.
• Coordinate with USGS and other entities to establish a program for gathering long-term baseline info ASAP to evaluate recovery needs and efforts.
• Work with implementing agencies to assess risk and develop/disseminate credible information to the public.
• With time, develop common goals for the collaborative effort while building relationships and trust amongst participating entities.
• Share personnel, equipment, and information to increase efficiency and effectiveness of efforts undertaken by implementing agencies. Broaden the base of funding and resources.
• Engage with local homeowners to foster dialog, understand the local context, build legitimacy, communicate risk, and implement on the-ground projects.
• Enhance monitoring of precipitation in burn areas with real-time reporting for early-warning of post-fire flooding events.
• Engage local producers and assist in rebuilding agricultural infrastructure that may be impacted by fire and post-fire flooding/debris flow events.
• Broaden the base of political support for collaboration and wildfire risk mitigation through social acceptance of established practices. Work towards adoption of new policies such as local building ordinances.
• Execute projects such as post-fire restoration (e.g., reseeding, debris catchments, erosion control structures) and proactive risk mitigation including fuels treatments (e.g., fuel thinning, creation of defensible space, and prescribed burns).
• Conduct outreach and education by organizing or attending community events, hosting tours of sites where treatments have been completed, offering educational seminars on fire-related topics, and publishing timely articles in local news outlets.</td></tr>
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<tr><th rowspan="2">ESTIMATED COSTS</th><th colspan="2">CAPITAL</th><th colspan="2">OPERATION/MAINTENANCE</th></tr>
<tr><td colspan="2">$10M over 5 years</td><td colspan="2">$480K over 5 years</td></tr>
<tr><th>EVALUATION CRITERIA</th><td colspan="4">Successful development and facilitation of an ad hoc group.
Demonstrated ability of the group to collaborate and leverage actions and resources.</td></tr>
<tr><th rowspan="2">CWCB METADATA</th><th>PROJECT TYPE</th><td>Envir/Rec, Ag, Muni, Industrial</td><th>WATER SOURCE</th><td>Various</td></tr>
<tr><th>BASIN</th><td>Colorado</td><th>WATER DISTRICT</th><td>39, 45, 53, 70</td></tr>
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PARTICIPATION IN FLOW MANAGEMENT FORUMS				INITIATIVE AQ7
DESCRIPTION	Assign a local representative to participate in: 1) Historic User Pool (HUP), 2) Coordinated River Operations (CROS), 3) Upper Colorado Wild and Scenic Stakeholder forums, 4) future Demand Management forums, and 5) global water settlements to advocate for annual water management scenarios that benefit the mainstem. This may include timed releases in spring to inhibit smallmouth bass reproduction, timed releases during peak runoff to enhance opportunities for channel maintenance and riparian regeneration, and releases to mitigate effects of post-wildfire runoff. This also includes implementing operational BMPs at Shoshone to minimize impacts from flushing sediment from behind the dam and to protect fish from stranding or flushing with drastic changes to flow. Also see related Initiatives REC13 and WQR8.			
OBJECTIVES ADDRESSED	AQ(a), AQ(c), AQ(e)			
FOCUS AREA	Mainstem Colorado River		**WATERSHED REGION**	All
ORGANIZING ENTITY	MCWC			
POTENTIAL PARTNER(S)	HUP Forum, CWCB for the CROS Forum, W&S SG, Recovery Program			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	BOR, CWCB, CPW, DWR, counties			
OPPORTUNITIES CONSTRAINTS CHALLENGES	HUP, CROS and the W&S SG through its Cooperative Measures Committee meet on a regular basis to discuss coordinated opportunities to optimize reservoir releases to balancing a number of water uses and interests. These forums provide the opportunity for exchanging technical information regarding water needs and timing. Flow needs and thresholds were developed as part of the IWMP process and can be used to inform discussions with these management entities.			
DEGREE RIPENESS	High	**TIMEFRAME**	Ongoing	
IMPLEMENTATION STEPS	• Secure funding for MCWC to provide annual representation at the forums with the ability to furnish technical data to support flow management requests. • Provide periodic reports to Garfield (through Garfield County Water Forum) County Commissioners regarding partnership outcomes.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$ NA	$3,000/yr		
EVALUATION CRITERIA	Participation in forum discourse and decision process for a minimum period of five years.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70

SUPPORT RENEWAL OF UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM					INITIATIVE AQ8
DESCRIPTION	Implement a focused outreach effort that aims to inform local governments and water user entities about the merits of the Recovery Program emphasizing its aspects that benefit flows in the watershed while complying with Endangered Species Act (ESA) requirements. Request and collect letters of support from these entities to present to State of Colorado for use in its efforts for program reauthorization from Congress.				
OBJECTIVES ADDRESSED	AQ(a), AQ(c)				
FOCUS AREA	Mainstem Colorado River			**WATERSHED REGION**	All
ORGANIZING ENTITY	MCWC				
POTENTIAL PARTNER(S)	State of Colorado, Recovery Program, Garfield County Water Forum, CRD				
OPPORTUNITIES CONSTRAINTS CHALLENGES	In 2023 the Recovery Program sunsets and its source of federal funding ceases. A report on Program effectiveness is due to Congress at the end of fiscal year 2021, along with proposed post-2023 activities. Program managers and Program beneficiaries are interested in convincing Congress of the importance of continued recovery efforts and federal support for these activities. The Recovery program partners are actively developing proposed post-2023 program activities, estimated costs, and funding mechanisms. The Recovery Program may disappear if not reauthorized but the ESA and its requirements remain, which may result in water users being directly responsible for ESA compliance rather than having the Recovery Program provide ESA compliance through coordinated recovery actions implemented basin-wide.				
DEGREE RIPENESS	High		**TIMEFRAME**	Before 2023	
IMPLEMENTATION STEPS	• Secure funding for MCWC to conduct focused outreach while soliciting written letters of support.				
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**		
	None		$3,000		
EVALUATION CRITERIA	Collection of a minimum ten letters of support from watershed stakeholder entities.				
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Municipal, Industrial, Ag	**WATER SOURCE**	Colorado River	
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70	

<table>
<tr><th colspan="5">BEST PRACTICES FOR GRAVEL PIT RECLAMATION</th><th>INITIATIVE AQ9</th></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Develop best practices for reclamation of completed gravel operations for use in development reviews by the counties and local governments that may eventually be incorporated into land use codes. Incorporate reclamation techniques that minimize opportunities for nonnative fish reproduction and escapement, minimize water losses due to open water evaporation, and maximize regeneration of riparian communities. Also see associated Project WQR4 and Initiative WQR12.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">AQ(a), AQ(c), AQ(e), AQ(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Mainstem Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">Garfield County Community Development</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">MCWC; Colorado Stone, Gravel and Sand Association</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CWCB, CPW, DWR, Recovery Program, counties</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Gravel pits throughout the watershed have been documented to support nonnative fish, necessitating the need to devote annual state resources for their mechanical removal. Future gravel extraction sites can be intentionally reclaimed to mitigate these issues by incorporating best practices in the reclamation design plan. The state permitting authority, Division of Reclamation, Mining and Safety (DRMS), does not currently recognize the need for mitigation of habitat or resource losses, or the issues posed by creating nonnative fish habitat. Land use codes would need to go above and beyond requirements established by the DRMS. Input from the regulated industry would be needed to explore and establish feasible practices.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Medium</td><td>TIMEFRAME</td><td colspan="2">5-yr completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">Secure funding for County to retain consultant to develop best practices including organizing a community forum for gathering input from CPW, the affected industry and interested stakeholders.
Work through county process of revising and adopting existing code.
Request local governments to adopt best practices in municipal code.
Request Mesa County to adopt best practices in land use code.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">None</td><td colspan="3">$25K</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Garfield County adopts land use code that mitigates adequately for habitat losses, resource losses (evaporative water), and nonnative fish propagation and spread.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Industrial</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
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<tr><th colspan="4">LANDOWNER OUTREACH FOR FISHERY MANAGEMENT BEST PRACTICES</th><th colspan="2">INITIATIVE AQ10</th></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Expand current program implemented by CPW on delivery of targeted outreach to private landowners about best practices for fishery management. Focus effort on landowners adjacent to the river with existing ponds. Outreach would include educational information about obtaining a stocking permit, isolating nonnatives, prohibiting movement of nonnatives from pond to river or off-property, drying ponds out annually to minimize reproduction of invasive species, etc.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">AQ(a), AQ(c), AQ(e), AQ(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Mainstem</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">CPW</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CPW</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Private landowners are generally receptive to information that will help them be good stewards of the resource. Information delivered personally is also more readily received and the easiest way to gain their attention. Outreach effort could be combined with outreach associated with Project WQR3 and Initiatives WQR9 and WQR13.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td colspan="2">2-yr completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Coordinate with CPW staff to develop a list of best practices for private pond management. Translate information into meaningful and understandable text and tools for private landowner use. Consult with CSU on research results regarding social aspects of working with the public on non-natives control.
• Analyze county records in association with aerial photography to derive a list of property/owners for targeted outreach.
• Conduct one on one outreach efforts.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">NA</td><td colspan="3">$6,000/year</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Contacting and having information exchanges with a minimum of 50% of landowners with privately managed ponds.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
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CITIZEN SCIENCE PROGRAM TO TRACK INVASIVE SPECIES					INITIATIVE AQ11
DESCRIPTION	Develop a free application for use by anglers that allows for timely reporting of captured nonnative invasive species, for example Northern Pike, Bullfrogs, invasive aquatic plants, etc. and any new, emerging species. Include functionality for identify and reporting on capture and release of endangered fishes.				
OBJECTIVES ADDRESSED	AQ(a), AQ (c), AQ(e), AQ(f), AQ(g)				
FOCUS AREA	Mainstem Colorado River			**WATERSHED REGION**	All
ORGANIZING ENTITY	MCWC				
POTENTIAL PARTNER(S)	CPW, local outfitters/guides, local tackle shops, Universities				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, Recovery Program				
OPPORTUNITIES CONSTRAINTS CHALLENGES	The app could be structured as an education tool as well as a tool for exchange of important information. The app would provide descriptive data and photos to help anglers, recreational boaters and other river users identify and differentiate native and sport fish from nonnative invasive species, provide information on what to do if one is hooked or captured, and give the user the ability to report its location and findings in real time. Aquatic resource managers can review data to learn more about the geographic extent of and current location of invasive species they can subsequently target for mechanical or chemical removal.				
DEGREE RIPENESS	High		**TIMEFRAME**	2 years for development and piloting	
IMPLEMENTATION STEPS	• Solicit for college-level student assistance with development of the application and jointly acquire grant funding for planning, development and testing. • Collaborate with CPW on application functionality requirements. • Develop, pilot and refine with assistance of local guides/outfitters. • Market the free app through local guides and equipment outlets.				
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**		
	$15K		$2,000 for post-beta upgrades		
EVALUATION CRITERIA	Steady, annual increase in app usage over a five-year period with concurrent demonstration of use of data by CPW aquatic biologists.				
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River	
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70	

EVALUATE FISH MOVEMENT ABOVE CAMEO DIVERSION				STUDY AQ12
DESCRIPTION AND PURPOSE	Evaluate the efficacy of threatened and endangered (T&E) fish handling methodologies at the Cameo diversion fish ladder by testing and monitoring fish movement in upstream habitat.			
OBJECTIVES ADDRESSED	AQ(a), AQ(b), AQ(c), AQ(f)			
FOCUS AREA	Colorado mainstem upstream of Cameo Roller Dam diversion structure 39°11'25.8"N 108°16'57.3"W		**WATERSHED REGION**	Below Lower
ORGANIZING ENTITY	Recovery Program and USFWS staff			
POTENTIAL PARTNER(S)	CPW, Grand Valley Water Users, MCWC			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	USFWS, CPW			
OPPORTUNITIES CONSTRAINTS CHALLENGES	T&E fish routinely utilize the fish ladder at the Cameo diversion to migrate upstream. After passing up the ladder, fish are manually handled and released immediately upstream. Anecdotal evidence suggests that released fish may be turning around and swimming downstream, possibly because the habitat above the roller dam is of poor quality (i.e., large silt pool created by impounded water above the diversion structure). If this is proven to be an impediment to fish migration into the Middle Colorado Watershed, fish handling methodologies could be adjusted to release fish into habitat of higher quality further upstream.			
DEGREE RIPENESS	High		**TIMEFRAME**	2-year completion
IMPLEMENTATION STEPS	• Secure funding for study. • Develop study design. • Implement study over a two-year period to capture seasonality of different species movement patterns.			
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**	
	$		$100,000	
EVALUATION CRITERIA	Study results inform the development of refined methodologies for fish handling after moving through the Cameo fish ladder.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	72

MONITOR FISH ENTRAINMENT IN MAINSTEM DIVERSION STRUCTURES				**STUDY AQ13**
DESCRIPTION AND PURPOSE	Monitor to evaluate entrainment of fish in open diversion structures on the mainstem Colorado River. Design the study to evaluate entrainment risk by species, life stage and season. Evaluate entrainment at structures diverting >10 cfs which includes Lower Cactus Valley, Last Chance, Bluestone Valley, Larkin and WA Skelton Ditches. The purpose of the evaluation is to determine the prevalence and impact of entrainment on maintaining critical populations. Results can inform the possibility of reconfiguring the diversions and installing protective fish screen or similar hardware.			
OBJECTIVES ADDRESSED	AQ(a), AQ(c), AQ(d), AQ(e), AQ(f)			
FOCUS AREA	Colorado River mainstem		**WATERSHED REGION**	All
ORGANIZING ENTITY	Recovery Program/USFWS staff or TU			
POTENTIAL PARTNER(S)	Ditch companies, BLM, Conservation Districts, TU			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	USFWS, CPW			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Fish can become entrained in water diversion ditches without the ability to return to the river and will eventually die after the diversions are shut down each year. The prevalence of entrainment for T&E and other native fish in diversions along the mainstem is unknown, but could potentially pose a risk and affect the ability to maintain critical populations into the future. Entrainment of coldwater, sport trout may also be occurring in ditches located upstream of Rifle. Cooperation from the operating ditch companies will be of paramount importance for this action to be undertaken. Recommended upgrades to the structure to mitigate fish entrainment may also present the opportunity for concomitant upgrades to the diversion structure to improve functionality.			
DEGREE RIPENESS	Medium		**TIMEFRAME**	5-year completion
IMPLEMENTATION STEPS	• Meet with ditch companies to form partnership and secure permission for study access. • Secure funding for study. • Develop study design. Implement study over a four-year period.			
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**	
	$NA		$100,000	
EVALUATION CRITERIA	Study results inform whether fish screens or similar hardware is recommended to improve the long-term viability of native fish populations.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Ag, Municipal, Industrial	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70

<table>
<tr><th colspan="4">DEVELOP AND DISTRIBUTE RECREATIONAL RIVER GUIDE</th><th>PROJECT REC1</th></tr>
<tr><td>DESCRIPTION</td><td colspan="4">The River Recreation Guide will be assembled as an atlas illustrating the river, its features, and its amenities from the Shoshone Dam in Glenwood Canyon to the Cameo Roller Dam in De Beque Canyon, a distance of approximately 80 miles. The goal of the Guide is several-fold: 1) to raise awareness among the public (residents and visitors) around the value of the Middle Colorado River, 2) to provide information on how to recreate in and around the river in a safe and responsible manner, 3) to establish an inventory of available recreational resources, opportunities and constraints, and 4) to foster continued cooperation and planning coordination among recreational interests. A geoPDF version of the Guide will be developed for cell phone, tablet, or use with other digital devices.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">REC(b), REC(c), REC(d), REC(e), REC(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="2">Mainstem Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">Local municipalities, Garfield County, TU, AW, CBRT</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">CPW, BLM, USFS, CDPHE</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">This will be the first guide of its type produced for the middle river. A first publication and printing will produce 500 hard copies. The Guide will require periodic updating and reprinting which could be financed through Guide sales and/or selling advertising spots in the Guide.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td>1-yr completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">• Secure funding to retain consultant to develop and print Guide (complete).
• Work with Recreation Focus Group members and W&S SG to complete and finalize text and graphics.
• Print and distribute to project partners.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="2">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$12,000</td><td colspan="2">$6,000 every two-years to update and reprint</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">The first 500 copies will be distributed free of change with a request for feedback through a survey provided in print and accessible digitally. Success will be measured by how quickly these Guides are distributed and by the nature of feedback received through the survey.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td>WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
</table>

IMPROVEMENTS AT SILT BOAT RAMP AT ISLAND PARK				PROJECT REC2
DESCRIPTION	Complete improvements that: 1) increase capacity for boat launching, and 2) improve traffic movement and flow at Island Park, a boat ramp and day-use recreation facility owned and operated by the Town of Silt. Include other improvements described in Project REC8.			
OBJECTIVES ADDRESSED	REC(b), REC(g)			
FOCUS AREA	Silt Park 39°32'28.9"N 107°38'43.9"W		**WATERSHED REGION**	Middle
ORGANIZING ENTITY	Town of Silt			
POTENTIAL PARTNER(S)	CPW, TU, AW, AVLT			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, U.S. Army Corps of Engineers, county, MCWC			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Island Park currently contains two gravel/dirt boat ramps and day-use picnic facilities. This boat launch has experienced a rapid increase in user traffic over the last few years. The launch area can accommodate one to two vehicles depending upon flow conditions. The vehicular approach to the launch area is limited by a single lane dirt road that connects to a large parking area, resulting in traffic flow issue involving vehicles and vehicles towing boat trailers. Design will need to include a sensitive approach that minimizes impacts to riparian vegetation and maintains streambank and channel integrity.			
DEGREE RIPENESS	High	**TIMEFRAME**	Initiate in 1-3 years	
IMPLEMENTATION STEPS	• Secure funding to retain engineer to develop a design for improved park usability and circulation and to acquire construction permits. • Secure funding for construction of improvements. • Construction implementation.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$250,000	$5,000/year		
EVALUATION CRITERIA	Demonstration of improved user traffic flow without significant hinderance or extended wait times with proven capacity for increased day use.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	45

RIFLE WHITEWATER PARK AND RICD			PROJECT REC3
DESCRIPTION	Support evaluation and feasibility investigations for a new whitewater park at Rifle near the existing boat ramp and a recreational in channel diversion (RICD) water right to ensure the availability of recreation flows through this reach into the future. Also see Project REC8. Develop and implement a long-term operation and maintenance plan.		
OBJECTIVES ADDRESSED	REC(b), REC(f), REC(g)		
FOCUS AREA	Rifle 39°31'40.5"N 107°46'53.6"W	**WATERSHED REGION**	Middle
ORGANIZING ENTITY	City of Rifle		
POTENTIAL PARTNER(S)	GRIT, Rifle Chambers of Commerce, Rifle Economic Development Corporation, CDOT, AW		
REGULATORY/ MANAGING/ CONSULTING AGENCIES	DWR, CWCB, CPW, U.S. Army Corps of Engineers, county, MCWC		
OPPORTUNITIES CONSTRAINTS CHALLENGES	The City of Rifle installed a new concrete boat ramp a couple years ago at Lions Park where access to a whitewater park is contemplated. Lions Park is located at a CDOT rest stop where there is existing parking, restrooms, and picnic facilities, although parking expansion and construction of a permanent restroom will have to be considered, along with related maintenance and staffing. Advance agreements should be secured with CDOT if any of its existing facilities may serve the park. Lions Park is also home to The River Stop, a Colorado River Interpretive Center developed by MCWC. The RICD is a several-year process that should be initiated sooner rather than later. The project may require federal consultation under the Endangered Species Act and should avoid impacts to resident fish, fish movement during critical spawning periods, seasonal fish movement, and important habitat (see CPW Whitewater Park Fact Sheet HERE).		
DEGREE RIPENESS	Medium	**TIMEFRAME**	Initiation in next 3-5 years
IMPLEMENTATION STEPS	• Complete research on land ownership to inform project feasibility. • Initiate the federal consultation process to inform project feasibility. • Raise funds for land acquisition or long-term lease, as needed. • Secure appropriate long-term facilities use and maintenance agreements. • Secure funding and retain design engineer and water rights attorney. • Complete water court process to acquire RICD water right. • Secure funding for construction of improvements. • Construction implementation.		
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**	
	$2-4 million	$150K/year for 3 years	
EVALUATION CRITERIA	Demonstrated use documented through visitor surveys (see Study REC16).		

CWCB METADATA			
PROJECT TYPE	Envir/Rec	**WATER SOURCE**	Colorado River
BASIN	Colorado	**WATER DISTRICT**	45

CONSTRUCT NEW BOAT RAMP AT RULISON				**PROJECT REC4**
DESCRIPTION	Construct a new boat ramp at the Rulison Exit off I-70. Include a reinforced concrete boat ramp, informational signage, trash receptacle, vehicle/trailer parking, and a pit-style restroom. Also see Project REC8. Develop and implement a long-term operation and maintenance plan.			
OBJECTIVES ADDRESSED	REC(b), REC(g)			
FOCUS AREA	Rulison 39°29'40.4"N 107°56'23.2"W		**WATERSHED REGION**	Lower
ORGANIZING ENTITY	Town of Parachute			
POTENTIAL PARTNER(S)	Garfield County, CPW, TU			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, U.S. Army Corps of Engineers, county, MCWC			
OPPORTUNITIES CONSTRAINTS CHALLENGES	There is an existing, little used, informal launch located in the right-of-way (ROW) for County Road 323 that shares a gravel access with an adjacent private residence. ROW boundaries and ownership in the area is unclear and requires additional research. Additional land acquisition will be necessary to include trailer parking and turn-around which is currently restricted to the ROW of CR 323. A boat launch at this location fills a large river access gap between Rifle and Parachute and will allow for reasonable day floats to or from both municipalities.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	Initiation in next 3-5 years	
IMPLEMENTATION STEPS	• Complete research on land ownership to inform project feasibility. • Raise funds for land acquisition, as needed. • Acquire commitments on long-term maintenance responsibilities. • Secure funding to retain and employ design consultant. • Secure funding for construction of improvements. • Construction implementation.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$500K-$1 million depending on land acquisition costs	$10,000 per year		
EVALUATION CRITERIA	Demonstrated use documented through user surveys (see Study REC16).			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	45

<table>
<tr><td colspan="5">UNA BRIDGE BOAT RAMP IMPROVEMENTS</td><td>PROJECT REC5</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Complete improvements at Una Bridge Boat Ramp to include a reinforced concrete boat ramp, informational signage, and a trash receptacle. Coordinate work with improvements to an adjacent parking area for waterfowl hunting foot access. Also see Project REC8. Develop and implement long-term operation and maintenance plan.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">REC(b), REC(c), REC(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Downstream of Parachute
39°23'37.7"N 108°06'09.0"W</td><td>WATERSHED REGION</td><td>Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">CPW and Town of Parachute</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">Garfield County</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CPW, U.S. Army Corps of Engineers, county, MCWC</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Colorado Parks and Wildlife received a donated parcel of property located off Stone Quarry Road (CR 300) at the Una Bridge that it intends to open for public boating access. The existing gravel approach requires upgrades for stabilization and there is some on-site parking available. Monies have been secured for construction of a pit toilet that the Town of Parachute has agreed to maintain. Adjacent to the launch site is public access to a waterfowl hunting lease that needs parking upgrades that could double as overflow parking for other river users. Will not require additional land acquisition. A boat launch at this location fills a large river access gap between Parachute and De Beque and will allow for reasonable day floats to or from both municipalities.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Medium</td><td>TIMEFRAME</td><td colspan="2">Initiation in next 3-5 years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Secure funding to retain and employ design consultant.
• Acquire construction permits.
• Acquire commitments on long-term maintenance responsibilities.
• Secure funding for construction of improvements.
• Construction implementation.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$300,000</td><td colspan="3">$2,000/yr</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Demonstrated use documented through visitor surveys (see Study REC16).</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>45</td></tr>
</table>

CONSTRUCT NEW BOAT RAMP IN DE BEQUE CANYON				PROJECT REC6
DESCRIPTION	Construct a new boat ramp along the old stretch of US-6 adjacent to the I-70 tunnel. Include a reinforced concrete boat ramp, in-channel boulder deflector, informational signage, trash receptacle, vehicle/trailer parking, and a pit-style restroom. Also see Project REC8. Develop and implement long-term operation and maintenance plan.			
OBJECTIVES ADDRESSED	REC(b), REC(g)			
FOCUS AREA	De Beque Canyon 39°11'40.4"N 108°15'49.8"W		**WATERSHED REGION**	Below Lower
ORGANIZING ENTITY	BLM			
POTENTIAL PARTNER(S)	Mesa County, CPW, AW, CDOT			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, U.S. Army Corps of Engineers, CDOT, county, MCWC			
OPPORTUNITIES CONSTRAINTS CHALLENGES	The site is owned by CDOT and currently used for material storage and maintenance activities. There is an existing, informal two-track trailer ramp extending into the river from the gravel area and another informal small-craft launch about ¼ mile downstream. Access to the site is one-way through eastbound I-70. Although this location is downstream of the IWMP planning area, it is an important river access point to complement the existing boat launch at De Beque, allowing for a day float between the two points. This launch opens up access to De Beque Canyon while providing a safe and final river exit point about 1.8 miles upstream of the Cameo roller dam diversion.			
DEGREE RIPENESS	Low	**TIMEFRAME**	Initiation 5 – 10+ years	
IMPLEMENTATION STEPS	• Secure BLM as project champion (or identify alternate). • Coordinate with CDOT on feasibility and use issues or alternatively negotiate with adjacent private landowners with direct river access. • Raise funds for land acquisition, as needed. • Acquire commitments on long-term maintenance responsibilities. • Secure funding to retain and employ design consultant. • Secure funding for construction of improvements. • Construction implementation.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$500,000	$10,000/yr		
EVALUATION CRITERIA	Demonstrated use documented through visitor surveys (see Study REC16).			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	72

<table>
<tr><th colspan="5">RIVERSIDE CAMPING IN TOWN OF PARACHUTE</th><th>PROJECT REC7</th></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Plan and design camping facilities for public use on Parachute Island Park, an island parcel owned by the Town of Parachute. For overnight use by boaters, improvements should include cleared camping areas, metal fire rings, boat tie-off posts, and informational signage. Educational signage should be incorporated as described in Project REC8.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">REC(b), REC(c), REC(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Town of Parachute
39°27'22.2"N 108°02'20.9"W</td><td>WATERSHED REGION</td><td>Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">Town of Parachute</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5"></td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CPW, U.S. Army Corps of Engineers, MCWC, REW</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">The Town recently acquired the river island to further implementation of its long-term parks and recreation plan. The approximate 20-acre size island is located immediately upstream of CR-215 and easily accessible from the Town's new boat launch also located upstream of CR-215. Tamarisk and Russian olive are present and should be removed and replaced with native vegetation. A bridge could be installed in the future to allow for walk-in camping. This project could be the first dedicated overnight boating use facility developed in the middle Colorado River.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Medium</td><td>TIMEFRAME</td><td colspan="2">Initiation in next 2+ years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Secure funding to retain and employ design consultant.
• Secure funding for construction of improvements.
• Construction implementation.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$100,000 – 250,000</td><td colspan="3">$10-15K/year</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Demonstrated use documented through user surveys and Town of Parachute operations records (see Study REC16).</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>45</td></tr>
</table>

<table>
<tr><td colspan="4">RIVER ACCESS FACILITIES IMPROVEMENTS</td><td>PROJECT REC8</td></tr>
<tr><td>DESCRIPTION</td><td colspan="4">Coordinate with private and public landowners to improve existing and future river access points with: 1) trash, picnic and restroom facilities, and 2) educational information on river ecology, and river safety, etiquette, and stewardship.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">REC(d), REC(e), REC(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="2">Mainstem Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">TU, AW, GRIT, Garfield County, Glenwood and Rifle Chambers of Commerce, Rifle Economic Development Corporation, W&S SG, private landowners</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">CPW, BLM, BOR, CDOT</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">River access points provide an excellent opportunity for posting information to educate river visitors. Using common branding and messaging between access location can be most effective but will require close coordination and agreement among parties. Providing for common amenities like picnic tables, trash receptacles, and restroom will work to minimize impacts of river visitors on private property. Utilize American Whitewater Open Source Tool Box as a planning resource.</td></tr>
<tr><td>DEGREE RIPENESS</td><td>High</td><td>TIMEFRAME</td><td colspan="2">3-5 yr completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">Acquire funding to organize, plan and coordinate among participating entities.
Obtain agreements for long-term operation/maintenance of facilities.
Develop common educational branding and messaging plus agreement on common facilities to install.
Acquire finding for capital improvements.
Contract for fabrication and installation of signage plus amenities.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td>CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td>$150,000</td><td colspan="3">$3,000/year</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">River visitors are able to articulate three river-related concepts conveyed through educational signage (as demonstrated through surveys, see Study REC16. Little to no negative reports from private landowners regarding access conflicts with recreational boaters.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td>WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
</table>

<table>
<tr><td colspan="6">PROPERTY OWNERSHIP RIVER SIGNAGE</td><td>PROJECT REC9</td></tr>
<tr><td>DESCRIPTION</td><td colspan="6">Install riverside signage demarcating boundaries between public and privately owned properties. Signage is intended to help recreation boaters identify where public land access is permissible.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="6">REC(b), REC(c), REC(d), REC(e)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="4">Mainstem Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="6">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="6">TU, AW</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="6">CPW, BLM, BOR, local municipalities</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="6">Several IWMP projects and initiatives aim to increase access to the river corridor for recreational uses. The majority of landownership along the middle Colorado River is privately held with some public land interspersed. It is critical that recreational users respect private property rights and can do so in a more informed way with properly located boundary indicators. Integrate with Project REC1 for uniformity.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td colspan="3">3-yr completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="6">• Secure funding for survey work, sign construction, and installation.
• Work with municipalities and federal/state landowners to acquire parcel boundary location information.
• Retain contractor to install signage.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="4">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$50,000</td><td colspan="4">$1,000 annually for upkeep</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="6">Little to no negative reports from private landowners regarding access conflicts with recreational boaters.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td colspan="3">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="3">WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
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INCREASE RIVER CAMPING OPPORTUNITIES					INITIATIVE REC10
DESCRIPTION	Provide information to municipalities, federal/state landowners, and private landowners that support coordination of a strategic plan for developing primitive camping opportunities. Revise Garfield and Mesa County land use codes to allow for primitive camping uses adjacent to the Colorado River and in the floodplain that incorporate best design and operation practices.				
OBJECTIVES ADDRESSED	REC(b), REC(c), REC(d), REC(e), REC(g)				
FOCUS AREA	Mainstem Colorado River			**WATERSHED REGION**	All
ORGANIZING ENTITY	Garfield County Community Development (for code development)				
POTENTIAL PARTNER(S)	GRIT, Glenwood and Rifle Chambers of Commerce, Rifle Economic Development Corporation, Mesa County Planning, private landowners				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, REW, MCWC				
OPPORTUNITIES CONSTRAINTS CHALLENGES	A map of potential camping sites, picnicking areas and other points of river access was developed as part of the IWMP (Appendix B). This work product can be used by a consortium of regional interests to develop a comprehensive strategy for future recreational development. County land use codes currently include provisions for private and commercial recreational camping facilities in the floodplain but outside of the floodway. While a few of these types of camping opportunities already exist, largely as drive-up SOURCEs, there are currently no known primitive camping areas along the mainstem between Glenwood and De Beque, limiting boating experiences to daytime use only. Small riverside or island properties could be "developed" for day or overnight boaters with very minor improvements that are deemed acceptable in a floodplain. Primitive uses may already be allowed in code but explicit definition of this use is suggested along with accompanying best design and operational practices.				
DEGREE RIPENESS	Medium		**TIMEFRAME**	5-10 yr completion	
IMPLEMENTATION STEPS	• Secure funding and retain consultant to organize a community forum for gathering input from interested stakeholders. • Work through Garfield County process of revising and adopting existing code. Request Mesa County to adopt best practices in land use code. • Offer language to municipalities for inclusion in code.				
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**		
	$N/A		$5,000		
EVALUATION CRITERIA	Counties adopt land use code that explicitly defines acceptable uses and practices for developing primitive camping on public and privately-owned parcels on the mainstem Colorado River.				
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River	
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70	

<table>
<tr><td colspan="5">LAND ACQUISITION FOR RIVER ACCESS</td><td>INITIATIVE REC11</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Organize municipalities, counties and local land trusts to coordinate in development of a strategic plan for acquiring open space properties for purposes of river access and protection. Also see Initiatives REC10 and WQR11.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">REC(b), REC(c), REC(e), REC(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Mainstem Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">AVLT, Community Builders</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">GRIT, Glenwood and Rifle Chambers of Commerce, Rifle Economic Development Corporation, Garfield County, Mesa County Planning, private landowners</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CPW, MCWC</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">A map of potential camping sites, picnicking areas and other points of river access was developed as part of the IWMP (see Appendix B). As described in Initiative REC10, this work product can be used to develop a comprehensive strategy for future recreational development, which could be expanded to include identification of properties for public acquisition. Other opportunities to explore include incorporating river access into existing or new conservation easements and hunting leases on private lands managed by CPW.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Medium</td><td>TIMEFRAME</td><td colspan="2">Initiate in 5+ years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Determine community support for an open lands acquisition process and evaluate feasible methods for long-term funding.
• Based on outcomes (from analysis above), develop subsequent implementation steps.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$N/A</td><td colspan="3">$50,000</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Creation and adoption of new, local mechanisms that support open land acquisitions over the long-term.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
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RIVER TRAIL PLANNING				INITIATIVE REC12
DESCRIPTION	Coordinate local trail planning efforts to connect each of the municipalities along the river corridor from Glenwood to De Beque.			
OBJECTIVES ADDRESSED	REC(c), REC(e), REC(g)			
FOCUS AREA	Mainstem Colorado River		**WATERSHED REGION**	All
ORGANIZING ENTITY	LoVa			
POTENTIAL PARTNER(S)	GRIT, Glenwood and Rifle Chambers of Commerce, Rifle Economic Development Corporation, Garfield County, Mesa County Planning, private landowners, BLM, Town of New Castle, City of Glenwood Springs, Town of Silt, RFTA, LiveWell and CMC-Rifle campus, Garfield RE-2 school district			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, U.S. Army Corps of Engineers, county, local municipalities			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Each of the municipalities along the mainstem river maintain a local network of community trails. The Lower Valley Trails Group is in the process of planning and promoting development and use of non-motorized transportation and recreational trails and other designated routes connecting communities and SOURCEs along the Colorado River corridor with Garfield County, which can generate increased recreational use by residents and visitors while boosting local economies. LoVa has created a master plan describes a 47-mile long recreational path roughly paralleling the river, from west Glenwood Springs to the Garfield County line near De Beque. There is considerable private land as well as ecologically sensitive habitat to consider while planning.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	Initiate in 5 - 10+ years	
IMPLEMENTATION STEPS	• Secure funding for planning and organization efforts. • Retain consultant to organize a community forum for gathering input from interested stakeholders. • Produce a recreation transportation master plan. • Seek plan adoption by local governments • Develop a construction phasing plan and schedule. • Acquire funds for construction. • Construction implementation.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$17 million estimated for the 11-mile segment from Glenwood to New Castle	$25,000/year		
EVALUATION CRITERIA	Creation of a recreation transportation plan with wide stakeholder buy-in and defined phases of implementation.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70

PARTICIPATION IN FLOW MANAGEMENT FORUMS				INITIATIVE REC13
DESCRIPTION	Assign a local representative to participate in: 1) Historic User Pool (HUP), 2) Coordinated River Operations (CROS), 3) Upper Colorado Wild and Scenic Stakeholder forums, 4) future Demand Management forums, and 5) global water settlements to advocate for annual water management scenarios that benefit the mainstem. This includes periodic timed releases during the recreation boating season to enhance flows for whitewater as well as later season paddling and floating experiences. Also see related Initiatives WQR8 and AQ7.			
OBJECTIVES ADDRESSED	REC(b), REC(f), REC(g)			
FOCUS AREA	Mainstem Colorado River		**WATERSHED REGION**	All
ORGANIZING ENTITY	MCWC			
POTENTIAL PARTNER(S)	HUP Forum, CROS Forum, W&S SG, Recovery Program			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	BOR, CWCB, CPW, DWR, counties			
OPPORTUNITIES CONSTRAINTS CHALLENGES	HUP, CROS and the W&S SG through its Cooperative Measures Committee meet on a regular basis to discuss coordinated opportunities to optimize reservoir releases to balancing a number of water uses and interests. These forums provide the opportunity for exchanging technical information regarding water needs and timing. Recreational flow preferences and thresholds were developed as part of the IWMP process and can be used to inform discussions with these management entities.			
DEGREE RIPENESS	High		**TIMEFRAME**	Ongoing
IMPLEMENTATION STEPS	• Secure funding for MCWC to provide annual representation at the forums with the ability to furnish technical data to support flow management requests. • Provide periodic reports to Garfield County Commissioners (through Garfield County Water Forum) regarding partnership outcomes.			
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**	
	None.		$3,000/yr	
EVALUATION CRITERIA	Participation in forum discourse and decision process for a minimum period of five years. Recognition of middle Colorado River management objectives by forum participants.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70

GLENWOOD RECREATIONAL IN-CHANNEL DIVERSION STRUCTURE				INITIATIVE REC14
DESCRIPTION	Support ongoing evaluation and feasibility investigations for the City of Glenwood Recreational In-Channel Diversion Structure (RICD) water right on the mainstem Colorado River.			
OBJECTIVES ADDRESSED	REC(b), REC(f), REC(g)			
FOCUS AREA	Mainstem Colorado River		**WATERSHED REGION**	Upper
ORGANIZING ENTITY	City of Glenwood Springs			
POTENTIAL PARTNER(S)	AW			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	DWR, CWCB, CPW, U.S. Army Corps of Engineers, county, MCWC			
OPPORTUNITIES CONSTRAINTS CHALLENGES	The City of Glenwood Springs is in the process of developing an instream water right for recreation uses during the spring/summer boating season. Flows supported through exercise of this water right, now and into the future, will be visible to and benefit the full section of the middle Colorado River as it relates to recreation use (and other environmental uses). Support the development of the RICD in the least environmentally damaging location using a design that avoids impacts to important habitat, resident fish, fish movement during critical spawning periods, seasonal fish movement, and connections to the critical spawning tributaries of Grizzly and No Name Creeks (see CPW Whitewater Park Fact Sheet HERE).			
DEGREE RIPENESS	High	**TIMEFRAME**	Ongoing	
IMPLEMENTATION STEPS	• Secure decree for RICD through water court. • Select location for RICD structure and negotiate agreement with landowner. • Raise funds for project construction. • Construction implementation.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$500K to $1 million	$ 250,000/year for 3 years		
EVALUATION CRITERIA	Successful installation of a recreational in-channel diversion structure.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	53

FLOW PREFERENCE SURVEY				STUDY REC15
DESCRIPTION AND PURPOSE	Develop and administer a flow preference survey, complete both a boatable and fishable days analysis, and quantitatively assess/link flow conditions with recreation use opportunities and visitor enjoyment.			
OBJECTIVES ADDRESSED	REC(a), REC(f)			
FOCUS AREA	Colorado mainstem		**WATERSHED REGION**	All
ORGANIZING ENTITY	AW, TU			
POTENTIAL PARTNER(S)	CPW, local municipalities, MCWC			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, W&S Stakeholder Group			
OPPORTUNITIES CONSTRAINTS CHALLENGES	The IWMP process identified stakeholder perceptions about the primary constraints on recreational use opportunities on the Colorado River mainstem. These identified constraints were largely related to access which is limited by a lack of facilities on public lands and will continue to be limited into the future by private property. These issues are addressed in Initiatives REC10 and REC11. There is not yet enough visitor use of the river, notably between Rifle and De Beque, to understand visitor needs and preferences related to flow. Flow limitations may arise in stakeholder's perceptions as use increases through other projects and initiatives undertaken.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	Initiate in 5+ years	
IMPLEMENTATION STEPS	• Secure funding for study. • Develop study design. Consult with W&S SG on opportunities for coordination. • Implement study over a two-year period.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$	$10,000		
EVALUATION CRITERIA	Study results inform the development of refined flow preferences that can be referenced and used in water management discussions (see Initiative REC13).			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	53, 39, 45, 70

<table>
<tr><td colspan="4">TRACK RIVER USE, NEEDS, CONTRIBUTIONS</td><td>STUDY
REC16</td></tr>
<tr><td>DESCRIPTION AND PURPOSE</td><td colspan="4">Quantitatively and qualitatively track and routinely assess recreational river use as IWMP projects are implemented using the following methods: 1) collect and/or conduct web surveys and intercept surveys at public access points along the river, 2) survey local community leaders about the perceived value of river access and amenities, and 3) track other quantitative measures, e.g., tax receipts, number of commercial permits, total visitor days, etc. that measure river usage directly or indirectly.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">REC(a), REC(f), REC(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="2">Colorado mainstem</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">To be determined</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">GRIT, Glenwood and Rifle Chambers of Commerce, Rifle Economic Development Corporation, TU, AW, University faculty/graduate students, local outfitters and river guides</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">CPW, MCWC</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">Developing future river access and amenities should occur within the context of comprehensive planning conducted to balance visitor needs, preferences, and desired experiences while minimizing impacts to sensitive habitats and private property. Data on river usage and its impact on local communities, facilities, and economies can also be a valuable decision-making tool to prioritize future projects, initiatives and investments. Data collection could be initiated now, but will become more important as the IWMP recreation-based actions are implemented, access and use increases, and visitor preferences develop. Universities may be available for partnering because of the research-oriented component of this work.</td></tr>
<tr><td>DEGREE RIPENESS</td><td>Medium</td><td>TIMEFRAME</td><td colspan="2">Initiate in 5+ years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">• Secure funding for 5-year period of data collection.
• Develop study design. Consult with W&S SG on opportunities for coordination.
• Implement study over a five-year period.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td>CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td>$85,000</td><td colspan="3">Monies will be needed to extend beyond initial 5-year period.</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">Study results inform the selection, prioritization and phasing of future river recreation related actions.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td>WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>53, 39, 45, 70</td></tr>
</table>

IMPLEMENT WATER QUALITY MONITORING STRATEGY				PROJECT WQR1
DESCRIPTION	Fund and implement a stakeholder-developed water quality monitoring strategy as presented in the "Middle Colorado Watershed Surface Water Quality Monitoring Plan" (Dec 2018). Include a monitoring component to model longitudinal salinity loading between Glenwood and De Beque. Install and operate a new (or rehabilitated) discharge and real-time water quality monitoring station on the mainstem between Parachute and De Beque. See Tables for more detail. Coordinate with USGS on post-fire monitoring needs and new NGWOS program (see Initiative AQ6).			
OBJECTIVES ADDRESSED	WQR(a), WQR(h)			
LOCATION OR AFFECTED AREA	Middle Colorado Watershed		**WATERSHED REGION**	Upper, Middle, Lower
ORGANIZING ENTITY	MCWC			
POTENTIAL PARTNER(S)	Local governments, oil/gas interests, USGS, RiverWatch Colorado, BLM, USFS, local schools			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CDPHE			
OPPORTUNITIES CONSTRAINTS CHALLENGES	A "Surface Water Quality Data Analysis for the Middle Colorado River Watershed", compiled in 2015, evaluated the health of the watershed using water quality as its indicator. The study concluded there are large data gaps, both spatial and temporal, in the knowledge base. At-risk areas where data gaps have been identified include: 1) tributaries where industrial development (i.e., resource extraction) is occurring in the western 2/3rds of the watershed, 2) in the Colorado River downstream of heavy industrial activities (below Rifle), and 3) in the tributaries that originate in wilderness areas where multiple-use pressures are increasing. There is an immediate need to develop a baseline for existing conditions and a program for continued data collection that can be used to identify current impairments, signal when trends are moving toward future impairments, and to inform the setting of protection and restoration goals.			
DEGREE RIPENESS	High	**TIMEFRAME**	Immediate/Ongoing	
IMPLEMENTATION STEPS	• Acquire funding for minimum 5-year period. • Re-establish capacity at MCWC for implementation (program initiated in 2017 but reduced in size due to lack of funding).			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$20,000	$450,000		
EVALUATION CRITERIA	Measure the number of water quality samples collected annually combined with an incremental reduction over time in stream miles included on the state's 303(d) impairment and monitoring/evaluation list.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Muni, Ag, Industrial	**WATER SOURCE**	Colorado River and tribs
	BASIN	Colorado	**WATER DISTRICT**	53, 45, 39, 70

DEVELOP SITE-SPECIFIC TEMPERATURE STANDARDS				**PROJECT WQR2**
DESCRIPTION	Collect and analyze temperature data in the mainstem Colorado River from Glenwood Canyon to Rifle. Based on results, develop site-specific temperatures standards for this reach to reflect reasonable and achievable seasonal instream temperatures. See Table for more detail.			
OBJECTIVES ADDRESSED	WQR(a)			
LOCATION OR AFFECTED AREA	Mainstem Colorado River between Glenwood and Rifle		**WATERSHED REGION**	Upper
ORGANIZING ENTITY	City of Glenwood			
POTENTIAL PARTNER(S)	MCWC, RFC			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CDPHE			
OPPORTUNITIES CONSTRAINTS CHALLENGES	The state's 2019 303(d) list of impaired water bodies lists this reach of the Colorado River as impaired for temperature. The causes of impairment are unknown but may be influenced by naturally-occurring geothermal inputs and highly managed flow patterns. The City of Glenwood's wastewater facility discharge permit may be, in the future, subject to temperature limitations in order to meet existing standards if site-specific standards are not developed.			
DEGREE RIPENESS	Medium		**TIMEFRAME**	Initiate 2021 for use at 2024 Reg 33 hearing
IMPLEMENTATION STEPS	• Hire consultant to develop monitoring design and standards proposal. • Coordinate with MCWC, RFC to collect data (or collect in-house). • Analyze/synthesize data and develop alternate standards proposal. • Work with CDPHE staff to advance proposal in 2023. • Present to Water Quality Control Commission for adoption June 2024.			
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**	
	$		$75,000	
EVALUATION CRITERIA	Adoption of appropriate and achievable instream temperature standards. Possible relief to Glenwood in needing to install temperature control treatments at the wastewater facility.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Industrial, Muni	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	45, 39

<table>
<tr><th colspan="4">RIPARIAN RESTORATION AND INVASIVES CONTROL</th><th>PROJECT WQR3</th></tr>
<tr><td>DESCRIPTION</td><td colspan="4">Conduct tamarisk and Russian olive removal in the near-term on: 1) public lands located along the mainstem, and 2) on private properties located on tributaries upstream of Silt. Apply the "Riparian Restoration Stewardship Framework" watershed-wide, utilizing existing inventory and mapping tools developed through the IWMP process, to create a long-term prioritized plan. to facilitate future on-the-ground restoration implementation.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">WQR(d), WQR(e), WQR(f), WQR(g)</td></tr>
<tr><td>LOCATION OR AFFECTED AREA</td><td colspan="2">Mainstem Colorado River; and Elk, Alkali, Garfield, Divide and Dry Hollow Creeks</td><td>WATERSHED REGION</td><td>Upper, Mid, Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">MCWC and Garfield County Vegetation Management</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">Conservation Districts, local municipalities, private landowners, REW, WCCC, USFWS Partners in Wildlife Program, CPW, BLM</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">CDPHE, CPW, NRCS</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">GarCo Vegetation Management has been actively assisting private landowners with voluntary invasive species control on private properties; there is still considerable work to do, including control on municipal owned properties. Prioritizing assistance to private landowners on upstream tributaries addresses control of upstream seed sources. Removal and control should also be paired with native species restoration, secondary weed control, monitoring to determine effectiveness of controls and management, and support for advances in biological control measures. Riparian areas were inventoried as part of the IWMP process and the resulting mapping will provide useful baseline information for application of the prioritization framework. Partners are coalescing around restoration work for riparian and wetlands habitat at the Silt River Preserve, presenting a near-term project opportunity.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td>10-20 year completion</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">Acquire funding to coordinate initial planning and outreach efforts.
Use County Assessor records to determine ownership and execute targeted outreach to determine landowner interest and willingness.
Develop coordinated implementation plan among sponsoring entities, partners, and Riparian Restoration Advisory Committee.
Seek funding on a revolving 3 to 5-year basis to execute the plan.
Share monitoring results and use for adaptive planning and management.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="2">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$1000/ac or $50,000/stream mile</td><td colspan="2">$250/ac or $12,500/stream mile for 3-5 yrs</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">Number of control projects conducted annually. Acreage of habitat restored. Increase in number of contiguous acres treated over time.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Ag</td><td>WATER SOURCE</td><td>Colorado River and tribs</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>45, 39, 70</td></tr>
</table>

PILOT GRAVEL OPERATION RECLAMATION PROJECT					PROJECT WQR4
DESCRIPTION	Select a pilot location for testing best practices for reclaiming a completed or nearly complete aggregate mining operations to mitigate local impact issues including: 1) undesirable, nonnative fish reproduction and escape, 2) water losses due to open water evaporation, and 3) loss of local, native riparian communities. See associated Initiative AQ9.				
OBJECTIVES ADDRESSED	WQR(f), WQR(g)				
LOCATION OR AFFECTED AREA	Mainstem Colorado River			**WATERSHED REGION**	All
ORGANIZING ENTITY	Gravel pit operator				
POTENTIAL PARTNER(S)	MCWC				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CWCB, CPW				
OPPORTUNITIES CONSTRAINTS CHALLENGES	Reclaimed gravel pits throughout the watershed have been documented to support nonnative fish, shifting the habitat from native riparian vegetation to open water, and unnecessarily evaporating away exposed groundwater. As these issues are of local concern, it is desirable to partner with a gravel mining company interested in piloting a set of best practices for reclamation. Results of the pilot would be used to inform updates to the county land use code related to gravel mine reclamation requirements. Per state permit records, there are currently 7 active gravel pits, 1 permit application in review, and 1 operation temporarily in cessation in the watershed area.				
DEGREE RIPENESS	Medium		**TIMEFRAME**	Initiation 3-5 years	
IMPLEMENTATION STEPS	• Identification of owner/operator interested in creating a partnership. • Agreement on conceptual plans for reclamation. • Acquire grant funds for pilot implementation to cover higher costs associated with reclamation. • Implementation likely a multi-year project and will need to be phased with mine completion plan.				
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**		
	$200,000 - $500,000		$3,000/year		
EVALUATION CRITERIA	Documentation of positive pilot outcomes. Translation of lessons learned into county code revisions, if appropriate.				
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Industrial	**WATER SOURCE**	Colorado River	
	BASIN	Colorado	**WATER DISTRICT**	45, 39, 70	

INTERPRETIVE EDUCATION AT RIVER STOP ↗				PROJECT WQR5
DESCRIPTION	Educate the public on important watershed issues including water quality, and riparian area and floodplain function. Utilize the River Stop Interpretive Center in Rifle as the outlet for education. Add new interpretive information on IWMP projects as they are implemented.			
OBJECTIVES ADDRESSED	WQR(d), WQR(h)			
LOCATION OR AFFECTED AREA	Mainstem Colorado River 39°31'30.3"N 107°47'10.4"W		WATERSHED REGION	All
ORGANIZING ENTITY	MCWC			
POTENTIAL PARTNER(S)	Various			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	Various			
OPPORTUNITIES CONSTRAINTS CHALLENGES	The River Stop Interpretive Center is scheduled to open in 2020 at its location at the I-70 and Rifle interchange adjacent to the Colorado River. While the center will have relatively permanent programming, there is opportunity to include revolving programming to feature new projects and initiatives underway in the watershed.			
DEGREE RIPENESS	High		TIMEFRAME	Initiation 1+ years
IMPLEMENTATION STEPS	• Develop conceptual interpretive information as part of project or initiative implementation. • Assemble funding from local donors associated with the featured projects or include funding for the educational element as part of the implementation grant funding package. • Use River Stop contractor to design, create and install interpretive features.			
ESTIMATED COSTS	CAPITAL		OPERATION/MAINTENANCE	
	$100,000 over 5 year period		$	
EVALUATION CRITERIA	Positive feedback from center visitors on the content and value of the educational information offered. Visitors willing to complete post-visit surveys are able, on average, to articulate at least three river-related ecological, social, or economic concepts.			
CWCB METADATA	PROJECT TYPE	Envir/Rec	WATER SOURCE	Colorado River
	BASIN	Colorado	WATER DISTRICT	45, 39, 72, 53

<table>
<tr><td colspan="5">SECURING SHOSHONE WATER RIGHTS</td><td>INITIATIVE WQR6</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">The Shoshone Hydro Generating Station in Glenwood Canyon has a senior 1902 non-consumptive water right that provides baseline flows of 1,250 cfs (less if the hydrology is dry) in the middle Colorado River, which is important especially in late summer and winter. The water right pulls flows from the headwaters that might otherwise be diverted across the Continental Divide and these flows serve irrigation, recreational, environmental and municipal interests after passing through the plant. The Colorado River District and many other stakeholders on the West Slope have a goal of protecting these flows against the eventuality of the plant ever shutting down permanently and the water rights made moot, damaging Western Slope interests who depend on these flows. The plant was put in place in the early 1900s and while it has been upgraded over time, the facility is old and maintenance shutdowns are not infrequent. Securing Shoshone flows is a top planning priority of the CBRT and is identified as a cooperative project in the 2013 Colorado River Cooperative Agreement between Western Colorado water and governmental entities and Denver Water.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">WQR(c), WQR(d), WQR(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Mainstem Colorado River
39°34'12.1"N 107°13'37.5"W</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">CRD</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">A consortium of many Western Colorado irrigation, governmental and water-provider entities from the headwaters to Mesa County.</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">DWR, CWCB, CPW, U.S. Army Corps of Engineers</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Shoshone is owned by Xcel Energy, a major energy provider in Colorado. Xcel has said the plant is not for sale. Nevertheless, the CRD and its partners have pursued talks with Xcel. The challenge is to develop a willing partner in Xcel and to agree on the right mechanisms to make the flows perpetual. Costs are unknown but are expected to be expensive.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Low</td><td>TIMEFRAME</td><td colspan="2">Ongoing</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Ongoing talks with Shoshone
• If a deal can be made, developing financial resources to close it</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">TBD</td><td colspan="3">TBD</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Permanent acquisition of the Shoshone water rights with addition of an instream flow use.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Muni, Industrial, Ag</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
</table>

CONTRACT WATER FOR ENVIRONMENTAL SUPPORT				INITIATIVE WQR7
DESCRIPTION	Identify and secure existing or new sources of upstream reservoir contract water for maintaining or improving habitat and water quality conditions in the middle Colorado River.			
OBJECTIVES ADDRESSED	WQR(a), WQR(c), WQR(d), WQR(g)			
FOCUS AREA	Mainstem Colorado River		**WATERSHED REGION**	All
ORGANIZING ENTITY	Garfield County Board of Commissioners			
POTENTIAL PARTNER(S)	Could be various			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	DWR, CWCB, CPW, USFWS			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Ruedi and Wolford Reservoirs both currently have contract water available for lease or possible purchase (Wolford) for environmental uses. Water leased from Wolford could be applied directly for instream uses whereas water from Ruedi would need a defined, pre-approved end use (e.g., CWCB's 15-Mile Reach instream flow right located downstream) or an alternative mechanism for application in the middle Colorado River. Garfield County currently owns contract water out of Ruedi Reservoir that has been managed historically to benefit the Fryingpan and Colorado Rivers under timed release schedules. This existing source of water, in combination with other contract water available through lease, trade or purchase, could be considered for maintaining or improving conditions in the mainstem if timed for optimum release on a periodic basis. Coordinating timed releases is ongoing and described in Initiatives AQ7, WQR8, and REC13. Coordinate with W&S SG for any future Wolford Reservoir contract water (lease or purchase) for potential partnership opportunities.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	Ongoing	
IMPLEMENTATION STEPS	• Utilize IWMP generated technical analyses to identify specific circumstances and thresholds under which contract water would be sought on a one-time or periodic basis. • Develop "banked" fund for lease or purchase on as needed basis. • Execute lease on as-needed basis and in close coordination with Colorado River flows management cooperating entities.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$	$500K		
EVALUATION CRITERIA	Monitor ecological or recreational outcomes to evaluate effectiveness and document benefits.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70

<table>
<tr><th colspan="4">PARTICIPATION IN FLOW MANAGEMENT FORUMS</th><th>INITIATIVE WQR8</th></tr>
<tr><td>DESCRIPTION</td><td colspan="4">Assign a local representative to participate in: 1) Historic User Pool (HUP), 2) Coordinated River Operations (CROS), 3) Upper Colorado Wild and Scenic Stakeholder forums, 4) future Demand Management forums, and 5) global water settlements to advocate for annual water management scenarios that benefit the mainstem. This includes periodic timed releases in spring to enhance opportunities for riparian regeneration, fall to mitigate critical low flow conditions, or to offset post-wildfire runoff that impacts fish or water quality. Also see related Initiatives REC13, AQ6 and AQ7.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">WQR(a), WQR(c), WQR(d), WQR(g)</td></tr>
<tr><td>/FOCUS AREA</td><td colspan="2">Mainstem Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">MCWC</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">HUP Forum, CWCB for the CROS Forum, W&S SG, Recovery Program</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">BOR, CWCB, CPW, DWR, counties</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">HUP, CROS and the W&S SG through its Cooperative Measures Committee meet on a regular basis to discuss coordinated opportunities to optimize reservoir releases to balancing a number of water uses and interests. These forums provide the opportunity for exchanging technical information regarding water needs and timing. Flow needs and thresholds were developed as part of the IWMP process and can be used to inform discussions with these management entities.</td></tr>
<tr><td>DEGREE RIPENESS</td><td>High</td><td>TIMEFRAME</td><td colspan="2">Ongoing</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">Secure funding for MCWC to provide annual representation at the forums with the ability to furnish technical data to support flow management requests
Provide periodic reports to Garfield (through Garfield County Water Forum) County Commissioners regarding partnership outcomes</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="2">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$</td><td colspan="2">$3,000/yr</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">Participation in forum discourse and decision process for a minimum period of five years.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec</td><td>WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>39, 45, 53, 70</td></tr>
</table>

TARGETED OUTREACH FOR SALINITY CONTROL				INITIATIVE WQR9
DESCRIPTION	Deliver targeted outreach to private landowners and ditch companies about best management practices and associated funding for salinity control. Focus is on Silt Salinity Management Area as defined by NRCS.			
OBJECTIVES ADDRESSED	WQR(b), WQR(h)			
FOCUS AREA	Silt Salinity Program Project Area (Area between Grand Hogback and Colorado River from east end of Silt Mesa to Rifle Creek)		**WATERSHED REGION**	Middle
ORGANIZING ENTITY	NRCS			
POTENTIAL PARTNER(S)	Bookcliff Conservation District			
REGULATORY/ MANAGING/ CONSULTING AGENCIES				
OPPORTUNITIES CONSTRAINTS CHALLENGES	Projects in this area are eligible for cost share funds through the EQUIP-Salinity and EQIP – Salinity Wildlife programs in order to reduce salinity loads to the Colorado River. Qualified projects are completed in the targeted project area by increasing irrigation system and/or conveyance efficiency and applying water according to NRCS Irrigation Water Management recommendations. Many lands in this area have been previously targeted, but some opportunity exists for further improvement.			
DEGREE RIPENESS	High	**TIMEFRAME**	Initiate in next 1-2 yrs	
IMPLEMENTATION STEPS	• Identification of potential projects within the specified area. • Targeted outreach to make water users aware of these funding sources exist to aid in cost of efficiency upgrades.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$5,000	$N/A		
EVALUATION CRITERIA	• Annual increase in number of new participants in salinity control program and affected acreage. • Reduction in salinity loading to the Colorado River.			
CWCB METADATA	**PROJECT TYPE**	Ag, Envir/Rec	**WATER SOURCE**	Rifle Creek basin
	BASIN	Colorado	**WATER DISTRICT**	39

BEST MANAGEMENT PRACTICES FOR FLOODPLAIN USES				INITIATIVE WQR10
DESCRIPTION	Utilize IWMP Fluvial Hazard Zone (FHZ) mapping to improve management decisions related to floodplain development and uses. This includes: 1) development of best management practices associated with allowable FHZ uses, and 2) future creation of zoning overlays and code modifications that refine the definition of allowable and nonallowable uses in the FHZ, including the use of setbacks.			
OBJECTIVES ADDRESSED	WQR(d), WQR(f), WQR(g), WQR(h)			
FOCUS AREA	Mainstem Colorado River from Glenwood to De Beque		**WATERSHED REGION**	All
ORGANIZING ENTITY	Garfield County Community Development			
POTENTIAL PARTNER(S)	Local municipalities			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CWCB, U.S. Army Corps of Engineers			
OPPORTUNITIES CONSTRAINTS CHALLENGES	A Fluvial Hazard Map has been developed for the middle Colorado River as an IWMP deliverable. Fluvial hazard mapping is a component of the Colorado Hazard Mapping Program effort underway by the CWCB in partnership with the Colorado Geological Survey, the Colorado Department of Local Affairs, and local governments. An understanding of the components of an FHZ can elucidate the need for carefully crafted use regulations to reduce risk to life, property, and river function.			
DEGREE RIPENESS	High		**TIMEFRAME**	5-yr completion
IMPLEMENTATION STEPS	• Secure funding for County to retain consultant to advise the county on appropriate application of FHZ tools to advise in development of best management practices and to modify and update zoning maps and land use code. • Work through county process of revising and adopting existing code. • Request local governments to adopt similar zoning and best practices in municipal code. • Request Mesa County to adopt similar zoning and best practices in municipal code.			
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**	
	$		$40,000	
EVALUATION CRITERIA	Garfield County adopts land use code modifications based on FHZ tools that actively seeks to reduce risk to life and property while preserving the river's ability to perform in a high functioning capacity.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Muni, Ag, Industrial	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70

DEVELOP AND ADMINISTER INCENTIVE PROGRAMS FOR RIVER HABITAT PROTECTION				INITIATIVE WQR11
DESCRIPTION	Use existing tools and funding sources, and develop new tools/funding sources, for acquiring conservation easements on priority lands. Develop and administer market-based incentives for protection of high-quality riparian areas, functional portions of the river floodplain, and other designated high-quality habitat areas. Apply results from the IWMP Fluvial Hazard Zone mapping and application of the "Riparian Restoration Stewardship Framework" analysis to inform prioritization of conserved properties (see Initiative WQR10 and Project WQR3).			
OBJECTIVES ADDRESSED	WQR(d), WQR(e), WQR(f), WQR(g), WQR(h)			
FOCUS AREA	Mainstem	**WATERSHED REGION**	All	
ORGANIZING ENTITY	AVLT, Community Builders			
POTENTIAL PARTNER(S)	Local governments, private landowners, conservation-oriented foundations			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW			
OPPORTUNITIES CONSTRAINTS CHALLENGES	AVLT currently uses state and federal tax incentive programs and targeted grants to finance the acquisition of conservation easements to protect lands with significant conservation values in the watershed, and in some cases purchases land outright to be managed as parks or river preserves in partnership with local governments or other entities. These mechanisms could be modified or crafted in different ways to incentivize wider participation by private landowners along the Colorado River mainstem to further protect the functional river channel, its floodplain and riparian areas. AVLT may be revisiting voter supported open space funding in Garfield County with key partners, which could promote specific goals like riverine protection and carefully planned public river access. The HB19-1264 Working Group is currently developing an "Alternative Valuation" system for appraising conservation easements in Colorado that emphasizes payment for ecosystem services over strict valuation of real estate, the results of which could be piloted in the watershed and other areas where real estate values are not always high enough to make use of existing conservation easement incentives.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	Ongoing	
IMPLEMENTATION STEPS	• Monitor progress and outcomes of HB19-1264 Working Group • Administer public poll to inform strategy/feasibility for Garfield County open space tax referendum • Conduct marketing campaign for GarCo open space tax program • Set up administrative mechanisms for open space tax application			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$50,000 to $75,000	Upfront exploratory costs would have to be paid for with grants or donations. Administrative costs for running an open space program could be paid for by tax proceeds.		
EVALUATION CRITERIA	Vote approved open space tax in Garfield County			

BEST PRACTICES FOR GRAVEL PIT RECLAMATION				INITIATIVE WQR12
DESCRIPTION	Develop best practices for reclamation of completed gravel operations for use in development reviews by the counties and local governments that could eventually be incorporated into land use codes. Incorporate reclamation techniques that: 1) minimize water losses due to open water evaporation, 2) maximize regeneration of riparian communities, and 3) avoid undesirable, nonnative fish reproduction and escape. See associated Projects WQR4 and Initiative AQ9.			
OBJECTIVES ADDRESSED	WQR(d), WQR(f), WQR(g)			
FOCUS AREA	Mainstem Colorado River		**WATERSHED REGION**	All
ORGANIZING ENTITY	Garfield County Community Development			
POTENTIAL PARTNER(S)	MCWC; Colorado Stone, Gravel and Sand Association			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CWCB, CPW, DRMS			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Reclaimed gravel pits throughout the watershed have been documented to support nonnative fish, shifting the habitat from native riparian vegetation to open water, and unnecessarily evaporating away exposed groundwater. Future gravel extraction sites can be intentionally reclaimed to mitigate these issues by incorporating best practices in the reclamation design plan. The state permitting authority, Division of Reclamation, Mining and Safety (DRMS), does not currently recognize the need for mitigation of habitat or resource losses, or the issues posed by creating nonnative fish habitat. Land use codes would need to go above and beyond requirements established by the DRMS. Input from the regulated industry would be needed to explore and establish feasible practices.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	5-yr completion	
IMPLEMENTATION STEPS	• Secure funding for County to retain consultant to develop best practices including organizing a community forum for gathering input from CPW, the affected industry and interested stakeholders. • Work through county process of revising and adopting existing code. • Request local governments to adopt best practices in municipal code. • Request Mesa County to adopt best practices in land use code.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$	$20,000		
EVALUATION CRITERIA	Garfield County adopts land use code that mitigates adequately for habitat losses, resource losses (evaporation) and nonnative fish propagation and spread.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Industrial	**WATER SOURCE**	Colorado River
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 53, 70

<table>
<tr><td colspan="4">EDUCATIONAL PROGRAMMING TO PROTECT LOCAL WATER RESOURCES</td><td colspan="2">INITIATIVE WQR13</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Develop and deliver education programming to protect local water resources in the following topical areas: 1) protection and proper management of private drinking water wells, 2) source water protection for municipal water systems, 3) municipal and private water conservation strategies, 4) proper use and need for private water softener systems, and 5) proper use and maintenance of onsite wastewater treatment systems (OWTS).</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">WQR(a), WQR(e)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Glenwood to Parachute</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">Garfield County Environmental Health, City of Rifle</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">Colorado Rural Water Association, municipal utilities, MCWC, RFC</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CDPHE</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Focus areas 1, 2, 3, and 5 described above have been identified as priorities by Garfield County Environmental Health where additional staff resources should be directed. Rifle Utilities has identified overuse of in-home water softener systems as a potential source of excessive salt loading to the wastewater facility. These governmental entities can leverage outreach efforts in place with local watershed groups to help deliver messaging on these subjects.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td colspan="2">Ongoing</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">Acquire supplemental funding for Garfield County to engage watershed group assistance
Utilizing existing programs, like the “Keep it Clean” partnership, expand the suite of topics for educational messaging and develop new programming
Deliver expanded programming through expanded outlets (e.g., utility bill mailings, Conservation District functions, etc.) and existing outlets used by nonprofits</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$N/A</td><td colspan="3">$10,000/yr</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Audiences willing to complete post-interaction surveys are able, on average, to articulate at least two personal behavior changes that could either: 1) affect the quality of drinking water they consume, or 2) improve the way they manage an OWTS.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Envir/Rec, Muni</td><td colspan="2">WATER SOURCE</td><td>Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45, 70</td></tr>
</table>

COORDINATE AGRICULTURE INFRASTRUCTURE UPGRADE DESIGNS WITH AQUATIC HABITAT AND FISH PASSAGE					PROJECT CONS1
DESCRIPTION	Coordinate water infrastructure upgrades or efficiency projects recommended in Conservation Districts' assessment with recommendations for habitat restoration/fish passage projects to provide multiple benefits.				
OBJECTIVES ADDRESSED	CONS(d)				
FOCUS AREA	Mainstem Colorado River and tributaries			**WATERSHED REGION**	Upper, Middle, Lower
ORGANIZING ENTITY	Conservation Districts				
POTENTIAL PARTNER(S)	TU, MCWC, NRCS				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	CPW, DWR, USFS, BLM, BOR, NRCS				
OPPORTUNITIES CONSTRAINTS CHALLENGES	Work is ongoing to inventory diversion structures throughout the watershed, providing opportunity to identify structures in need of upgrade or modernization that would benefit fish passage or population isolation. A preliminary list of critical fish passage structures has already been developed for targeted ditch assessment. Challenges include securing funding for necessary upgrades.				
DEGREE RIPENESS	High		**TIMEFRAME**	Ongoing, 20-30-year completion	
IMPLEMENTATION STEPS	• Finalize prioritization of structures for inventory assessment that are most critical for fish passage. • Identify partners to aid landowner in fish passage structural improvements. • Secure funding for design and construction of structure upgrades and improvements.				
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**		
	$100k – $500k per structure		$1k-5k per structure		
EVALUATION CRITERIA	Identification of benefit to critical species to have access to tributary streams for spawning and refuge. Observational evidence of fish movement through the structure on an annual basis or capture/release data documenting movement. Documented improvement in efficacy of structure related to water diversion.				
CWCB METADATA	**PROJECT TYPE**	Ag, Env/Rec	**WATER SOURCE**	Colorado River and tribs	
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70	

<table>
<tr><td colspan="4">INCREASED STREAMFLOW MONITORING</td><td colspan="2">PROJECT CONS2</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Install and maintain streamflow measurement gages on tributaries to the Colorado River. Support continued operation of all USGS gages currently in operation in the Middle Colorado watershed.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">CONS(g)</td></tr>
<tr><td>LOCATION OR AFFECTED AREA</td><td colspan="3">Tributaries to Colorado River</td><td>WATERSHED REGION</td><td>Upper, Middle, Lower</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">DWR</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">USGS</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CRD, USGS</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">The Division of Water Resources is already near capacity for operating and maintaining stream gaging locations. The DWR generally does not install stream gages unless they are required for water right administration. There may be a potential for collaboration where these gages are desirable but not required for administration.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Medium</td><td>TIMEFRAME</td><td colspan="2">Initiate 1 – 5 years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Identify suitable location for a gaging station.
• Installation of continuous monitoring equipment.
• Installation of equipment for transmitting data (satellite).
• Periodic streamflow measurements to develop rating curve with ongoing measurements to ensure rating curve has not shifted.
• Maintenance of equipment and QA/QC of data.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$35,000/station</td><td colspan="3">$15,000/station/year</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Determination if a station is needed for Administration, those would be given the highest priority. Availability of additional streamflow data.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Admin, Env/Rec, Ag</td><td colspan="2">WATER SOURCE</td><td>Colorado River and tribs</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45</td></tr>
</table>

<table>
<tr><td colspan="6">FEASIBILITY EVALUATION AND CONSTRUCTION OF KENDIG RESERVOIR</td><td>PROJECT CONS3</td></tr>
<tr><td>DESCRIPTION</td><td colspan="6">Construction of Kendig Reservoir to provide additional storage on the south side of the Colorado River where existing and future shortages occur.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="6">CONS(b), CONS(c), CONS(d), CONS(e)</td></tr>
<tr><td>LOCATION OR AFFECTED AREA</td><td colspan="4">West Divide Creek drainage</td><td>WATERSHED REGION</td><td>Upper</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="6">West Divide Water Conservancy District</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="6">CRD</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="6">CPW, USFS, U.S. Army Corps of Engineers, TU</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="6">Feasibility studies for the construction of Kendig Reservoir on West Divide Creek have been conducted in the past and are ongoing. These studies provide insight into the firm water supply and fatal flaw analysis associated with construction of a 16k+ acre-foot reservoir. This reservoir has the potential to partially fill the water supply gap experienced by water users in the Divide Creek drainage.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="3">Medium</td><td>TIMEFRAME</td><td colspan="2">Immediate/Ongoing</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="6">• Continue to support feasibility studies unless a fatal flaw that prohibits construction is identified.
• Create models to identify optimal reservoir operations to fill water supply gaps.
• Work with water right owners who may wish to store available flow during runoff for use later in the irrigation season (i.e., create storage accounts).
• Aid in identification of grant/loan opportunities for construction.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="3">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="3">$106 M</td><td colspan="3">$10K/yr</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="6">Positive feasibility studies to move construction of Kendig Reservoir forward.</td></tr>
<tr><td rowspan="3">CWCB METADATA</td><td>PROJECT TYPE</td><td>Ag, Env/Rec, Industrial</td><td colspan="3">WATER SOURCE</td><td>West Divide, Garfield, Baldy, East Divide Creeks</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="3">WATER DISTRICT</td><td>45</td></tr>
<tr><td></td><td></td><td colspan="3">ESTIMATED WATER YIELD/UNITS</td><td>0 – 16,500 ac-ft</td></tr>
</table>

SUPPORT FOR COLORADO RIVER DISTRICT				INITIATIVE CONS4
DESCRIPTION	Support CRD in continued, long-term protection of west slope water, including funding initiatives, ballot measures, and other mechanisms that support operations.			
OBJECTIVES ADDRESSED	CONS(a), CONS(e), CONS(f), CONS(g)			
FOCUS AREA	Colorado River Basin		**WATERSHED REGION**	All
ORGANIZING ENTITY	CRD			
POTENTIAL PARTNER(S)	MCWC, Conservation Districts, TU, American Rivers, Colorado River Outfitters Association			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	WDWCD, SWCD			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Local river entities can encourage their constituents to support the CRD and its mission of protecting western slope water. Various challenges to our water supplies require a central entity to monitor evolving water supply conditions such as development pressure from Eastern Slope as well as lower basin states and uncertainty of supplies in future climate scenarios.			
DEGREE RIPENESS	High	**TIMEFRAME**	Immediate	
IMPLEMENTATION STEPS	Identify the needs of the CRD and coordinate with other local entities to educate their stakeholders and encourage their participation in initiatives undertaken by the CRD.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	In-Kind	$N/A		
EVALUATION CRITERIA	Protection of western slope water resources. Documentation of effective public outreach and education related to ongoing Colorado River water issues.			
CWCB METADATA	**PROJECT TYPE**	Envir/Rec, Ag, Muni	**WATER SOURCE**	Colorado River tribs
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70, 53

<table>
<tr><td colspan="4">ENCOURAGE WATER RIGHTS OWNERS TO KEEP WATER RIGHTS TIED TO LAND</td><td colspan="2">INITIATIVE CONS5</td></tr>
<tr><td>DESCRIPTION</td><td colspan="5">Promote conservation-based or market-based incentive programs for producers to keep water on the land and maintain water right ownership. Use existing tools/funding sources, and develop new tools/funding sources, for acquiring conservation easements on lands with associated high priority water rights. (also see Initiative WQR11).</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">CONS(c), CONS(d)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Mainstem and tributaries</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">Bookcliff, Mt. Sopris and Southside Conservation Districts</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">AVLT, CCLT, CWT</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">NRCS, DWR</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Agricultural producers on tributaries to the Colorado River experience shortages each year which is compounded by recent dry years. Incentives to keep water on the land can provide alternatives to “buy and dry” and/or other water investments that create uncertainty for future water use in the basin. Land trusts currently use state and federal tax incentive programs and targeted grants to finance the acquisition of conservation easements to protect lands with significant conservation value. These mechanisms could be modified or crafted in different ways to incentivize wider participation by private landowners to further protect water rights. Incentives can be beneficial for agricultural producers by encouraging ongoing and new conservation practices related to water and natural resources.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td colspan="2">Initiate in 1-5 yr timeframe</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Monitor progress and outcomes of HB19-1264 Working Group
• Select market or conservation- based incentives most feasible/desirable to local producers
• Identify highest priority lands to keep water rights tied to lands (i.e., high development areas)
• Perform targeted outreach to secure program participants</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$70,000-150,000</td><td colspan="3">$N/A</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Prioritization of pre-compact/senior water rights which have reliable yields from year to year in areas of high development pressure.
Benefit to the local economy in keeping these water rights tied to lands.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Agricultural</td><td colspan="2">WATER SOURCE</td><td>Colorado River and tribs</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45</td></tr>
</table>

LOCAL WATER MARKET LEASING				INITIATIVE CONS6
DESCRIPTION	Develop a local market for water leasing between water users.			
OBJECTIVES ADDRESSED	CONS(c), CONS(d), CONS(e)			
FOCUS AREA	Watershed wide		**WATERSHED REGION**	Upper Middle, Lower
ORGANIZING ENTITY	To be determined			
POTENTIAL PARTNER(S)	CWT, CAWA, local municipalities, willing water users			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	DWR, CWCB			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Opportunity for municipalities to lease unchanged excess water supplies that have been acquired for backup or future growth planning. Leasing agreements can be developed to support environmental, recreational, or consumptives uses. Opportunity between water users to lease water to each other, for instance when one producer is not irrigating because they are haying, their water can be leased to another user. Water right constraints exist because water rights are decreed to specific lands to prevent expansion of use.			
DEGREE RIPENESS	Low	**TIMEFRAME**	Initiate program development in 5+ yrs	
IMPLEMENTATION STEPS	• Identify local municipalities that have future planning supplies available that could be leased for other uses. • Identify water users that may want to lease their water rights for other uses. • Identify water right restrictions which may prevent these types of leases. • Create a local market where these supplies can be leased and establish administrative framework.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$100,000	$5,000/yr		
EVALUATION CRITERIA	Determination of available water for lease to determine if a local market can be created. Determination of demand for leased water.			
CWCB METADATA	**PROJECT TYPE**	Ag, Muni, Env/Rec	**WATER SOURCE**	Colorado River and tribs
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70

PILOT A LOCAL MARKET FOR LOCALLY PRODUCED AGRICULTURAL PRODUCTS				INITIATIVE CONS7
DESCRIPTION	Partner with Garfield Healthy Communities Coalition to craft and pilot a local market for locally-produced agricultural goods.			
OBJECTIVES ADDRESSED	CONS(c)			
FOCUS AREA	Watershed wide		**WATERSHED REGION**	All
ORGANIZING ENTITY	Garfield Healthy Communities Coalition			
POTENTIAL PARTNER(S)	Conservation Districts, CSU Extension, Colorado Cattlemen's Association			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	NRCS, Colorado Department of Agriculture			
OPPORTUNITIES CONSTRAINTS CHALLENGES	Opportunity for local agricultural producers to sell goods locally through Community Supported Agriculture (CSA). There is community interest in obtaining locally sourced food to secure food supplies. Challenges arise due to how some products (meat/dairy) are processed, either a local USDA inspection facility is needed or greater coordination with meat packaging plants for processing animals within regulations.			
DEGREE RIPENESS	Medium	**TIMEFRAME**	Medium	
IMPLEMENTATION STEPS	• Identify producers willing to participate in a CSA. • Identify demand for various agricultural products from the local community. • Aid producers in setting up CSA for their farms.			
ESTIMATED COSTS	**CAPITAL**	**OPERATION/MAINTENANCE**		
	$10,000/farm for upstart and marketing	$		
EVALUATION CRITERIA	Level of producer participation and demand for various products.			
CWCB METADATA	**PROJECT TYPE**	Ag	**WATER SOURCE**	Colorado River and tribs
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70

<table>
<tr><th colspan="4">LIMIT OUT OF BASIN WATER EXPORTS</th><th>INITIATIVE CONS8</th></tr>
<tr><td>DESCRIPTION</td><td colspan="4">Increase communication between Garfield County and local water focused groups (CRD, WDWCD, BWCD, MCWC) to monitor the potential sale and/or transfer of water rights and limit exports from the basin. Ensure the County Attorney monitors the Division 5 water court resume and be proactive in identifying potential basin exports or changes to water rights that may be detrimental to the Middle Colorado River existing water users. Use County 1041 authority to limit out of basin water exports that may cause economic and water right injury within the County's jurisdiction.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">CONS(b), CONS(e)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="2">Garfield County</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">Garfield County</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">Conservation Districts, CRD, WDWCD, BWCD</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">DWR, CWCB</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">Opportunity to utilize local government and local water focused groups to prevent further reduction to water supplies in our basin.</td></tr>
<tr><td>DEGREE RIPENESS</td><td>High</td><td>TIMEFRAME</td><td colspan="2">Initiate in 1 year</td></tr>
<tr><td>IMPLEMENTATIO N STEPS</td><td colspan="4">• Monitor changes and/or transfers of water rights in the Middle Colorado Watershed
• Work within the constructs of the Colorado River Cooperative Agreement.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="2">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$50,000</td><td colspan="2">$N/A</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">Extent to which water exports are limited from the watershed.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Ag/Muni/Env/Rec</td><td>WATER SOURCE</td><td>Colorado River and tribs</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>39, 45, 70</td></tr>
</table>

<table>
<tr><th colspan="4">CONNECT AG PRODUCERS WITH FUNDING SOURCES</th><th>INITIATIVE CONS9</th></tr>
<tr><td>DESCRIPTION</td><td colspan="4">Host a bi-annual event for agricultural producers that matches interested parties with potential partners and funders for specific project types.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="4">CONS(g)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="2">Watershed wide</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="4">Conservation Districts</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="4">NRCS</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="4">CAWA, BOR, NRCS</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="4">This type of event can likely be included in the annual Ag Expo and community picnic hosted by the Conservation Districts.</td></tr>
<tr><td>DEGREE RIPENESS</td><td>High</td><td>TIMEFRAME</td><td colspan="2">Initiate in 1+ years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="4">• Gather required information/participants regarding funding opportunities and make available to local producers at events bi-annually.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td>CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td>$10,000</td><td colspan="3">$N/A</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="4">Level of participation in the outreach events.
Amount of funding awarded for various agricultural products from funding partners.</td></tr>
<tr><td rowspan="2">CWCB METADATA</td><td>PROJECT TYPE</td><td>Ag</td><td>WATER SOURCE</td><td>Colorado River and tribs</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td>WATER DISTRICT</td><td>39, 45, 70</td></tr>
</table>

EDUCATIONAL OPPORTUNITIES FOR WATER RIGHTS OWNERS ON ALTERNATIVE TRANSFER MECHANISMS				INITIATIVE CONS10
DESCRIPTION	Host a series of information seminars for ag water rights owners on the options for and benefits of leasing water for other uses.			
OBJECTIVES ADDRESSED	CONS(c), CONS(g)			
FOCUS AREA	Watershed wide		**WATERSHED REGION**	All
ORGANIZING ENTITY	CRWCD			
POTENTIAL PARTNER(S)	Conservation Districts, CWT, CACD			
REGULATORY/ MANAGING/ CONSULTING AGENCIES	NRCS, CWCB, DWR			
OPPORTUNITIES CONSTRAINTS CHALLENGES	A series of outreach events can be held outlining the options available within the Prior Appropriation System to lease water to other beneficial uses. These events can detail recent statues passed by the legislature allowing ATMs that do not impact the quantification of a water right.			
DEGREE RIPENESS	High	**TIMEFRAME**	Immediate	
IMPLEMENTATION STEPS	• Reach out to CWT and CWCB to determine the best entities for provide this information. • Advertise these events to local water right holders to understand the demand for these types of programs. • Host a series of events describing how these transfers are conducted and how they can benefit local water right holders.			
ESTIMATED COSTS	**CAPITAL**		**OPERATION/MAINTENANCE**	
	$50,000		$	
EVALUATION CRITERIA	Participation level at various seminars.			
CWCB METADATA	**PROJECT TYPE**	Ag, Env/Rec	**WATER SOURCE**	Colorado River and tribs
	BASIN	Colorado	**WATER DISTRICT**	39, 45, 70

<table>
<tr><th colspan="5">MULTI-BENEFIT WATER STORAGE PROJECTS</th><th>STUDY
CONS11</th></tr>
<tr><td>DESCRIPTION AND PURPOSE</td><td colspan="5">Support ongoing evaluation and feasibility studies for multi-benefit water storage in tributary drainages of the Colorado River. See opportunities list HERE.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">CONS(b), CONS(e)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Tributaries to the Colorado River</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">WDWCD</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">Conservation Districts, TU, MCWC, Colorado Cattlemen's Association</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">DWR, CPW, U.S. Army Corps of Engineers, CWCB</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">Small scale, multi-benefit storage projects create opportunities for multiple water uses, including habitat enhancement. These small projects can be used as a supplemental irrigation supply, to boost late season baseflows or utilized as an augmentation supply. Along with the opportunities from the storage, multi-use projects are also attractive to funding partners. Constraints and challenges include the cost of construction, operation and maintenance as well as the ability to store water in-priority with a very junior water right.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">Medium</td><td>TIMEFRAME</td><td colspan="2">Initiate in 1-5 yrs</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Identify ongoing or planned feasibility investigations.
• Identify areas where these projects are critically important and urge feasibility studies to be conducted.
• Provide letters of support/aid in funding for such studies.</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$50,000-200,000</td><td colspan="3">$N/A</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Prioritization of tributaries that can most benefit from small scale storage projects.
Documentation of constructed multi-benefit storage structures.</td></tr>
<tr><td rowspan="3">CWCB METADATA</td><td>PROJECT TYPE</td><td>Ag, Env/Rec</td><td colspan="2">WATER SOURCE</td><td>Tributaries of Colorado River</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>45, 35, 70</td></tr>
<tr><td></td><td></td><td colspan="2">ESTIMATED WATER YIELD/UNITS</td><td>10-5,000 AF</td></tr>
</table>

<table>
<tr><th colspan="5">DEMAND MANAGEMENT INVESTIGATIONS</th><th>STUDY CONS12</th></tr>
<tr><td>DESCRIPTION AND PURPOSE</td><td colspan="5">Develop and distribute local survey to solicit feedback on expectations and/or requirements for local landowner/municipality participation in potential Demand Management programs. Provide feedback to CBRT Demand Management Subcommittee and CRD west slope workgroup.</td></tr>
<tr><td>OBJECTIVES ADDRESSED</td><td colspan="5">CONS(b), CONS(c), CONS(e)</td></tr>
<tr><td>FOCUS AREA</td><td colspan="3">Watershed wide</td><td>WATERSHED REGION</td><td>All</td></tr>
<tr><td>ORGANIZING ENTITY</td><td colspan="5">Conservation Districts</td></tr>
<tr><td>POTENTIAL PARTNER(S)</td><td colspan="5">CAWA, CCA</td></tr>
<tr><td>REGULATORY/ MANAGING/ CONSULTING AGENCIES</td><td colspan="5">CWCB, NRCS, CRD, DWR</td></tr>
<tr><td>OPPORTUNITIES CONSTRAINTS CHALLENGES</td><td colspan="5">This study would provide insight into the opportunities and challenges of Middle Colorado agricultural producers and municipalities participation in a demand management program. A survey would solicit feedback as to what requirements are needed for participation in such a program. The survey would reveal the various opportunities and constraints of such a program in the Middle Colorado watershed.</td></tr>
<tr><td>DEGREE RIPENESS</td><td colspan="2">High</td><td>TIMEFRAME</td><td colspan="2">Complete in next 5 years</td></tr>
<tr><td>IMPLEMENTATION STEPS</td><td colspan="5">• Identify partners with survey experience.
• Develop survey questionnaire with CWCB input.
• Analyze results
• Provide feedback to CBRT Demand Management subcommittee</td></tr>
<tr><td rowspan="2">ESTIMATED COSTS</td><td colspan="2">CAPITAL</td><td colspan="3">OPERATION/MAINTENANCE</td></tr>
<tr><td colspan="2">$50,000 – 100,000</td><td colspan="3">$N/A</td></tr>
<tr><td>EVALUATION CRITERIA</td><td colspan="5">Determine if there is an opportunity for a successful demand management program in the Middle Colorado watershed.</td></tr>
<tr><td rowspan="3">CWCB METADATA</td><td>PROJECT TYPE</td><td>Ag, Env/Rec</td><td colspan="2">WATER SOURCE</td><td>Colorado River and tribs</td></tr>
<tr><td>BASIN</td><td>Colorado</td><td colspan="2">WATER DISTRICT</td><td>39, 45, 70</td></tr>
<tr><td></td><td></td><td colspan="2">ESTIMATED WATER YIELD/UNITS</td><td>5-5,000 AF</td></tr>
</table>

STUDY IRRIGATION SCHEDULING EFFECTIVENESS					STUDY CONS13
DESCRIPTION AND PURPOSE	Study the effectiveness of using local CoAgMet weather data for irrigation scheduling for better water management. Target Colorado River supplies where water supply and management have more flexibility.				
OBJECTIVES ADDRESSED	CONS(b), CONS(c), CONS(e)				
FOCUS AREA	Colorado River			WATERSHED REGION	Upper, Middle
ORGANIZING ENTITY	Conservation Districts				
POTENTIAL PARTNER(S)	CSU Extension, SWCD				
REGULATORY/ MANAGING/ CONSULTING AGENCIES	NRCS, DWR				
OPPORTUNITIES CONSTRAINTS CHALLENGES	This type of study would evaluate the effectiveness of using local weather data to more effectively schedule irrigation events. Constraints include the ability of ditch users to schedule water according to crop demands.				
DEGREE RIPENESS	High		TIMEFRAME	Complete in 5 yr timeframe	
IMPLEMENTATION STEPS	• Identify willing participants • Estimate water savings by only irrigating when crops require it.				
ESTIMATED COSTS	CAPITAL		OPERATION/MAINTENANCE		
	$50,000 – 100,000		$N/A		
EVALUATION CRITERIA	• Determination of amount of water savings using irrigation scheduling • Determine changes to yield using irrigation scheduling techniques.				
CWCB METADATA	PROJECT TYPE	Ag	WATER SOURCE	Colorado River	
	BASIN	Colorado	WATER DISTRICT	39, 45	
			ESTIMATED WATER YIELD/UNITS	TBD	

APPENDIX A: ANNOTATED BIBLIOGRAPHY

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APPENDIX C: HYDROLOGICAL TRENDS AND SCENARIO MODELING

APPENDIX D: CHANNEL GEOMORPHOLGY AND SEDIMENT TRANSPORT

APPENDIX E: RIVER CORRIDOR CHARACTERISTICS

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APPENDIX G: WATER QUALITY REPORT CARD

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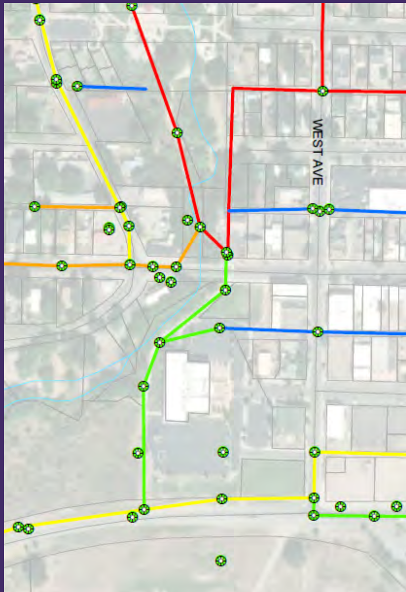
APPENDIX L: COLORADO PARKS AND WILDLIFE CONSULTATION ROLES AND STEWARDSHIP RESPONSIBILITIES

DRAFT - FOR REVIEW

Rifle, Colorado
Utility Maintenance, Capital, and Rate Study

April 2021

Prepared for:



UTILITY MAINTENANCE, CAPITAL, AND RATE STUDY

FOR THE

CITY OF RIFLE

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JVA Project No. 1114e

APRIL 2021

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AC	asbestos cement
ADF	average daily flow
AF	acre-feet
BOD_5	five-day biological oxygen demand
CCTV	closed-circuit television
CDPHE	Colorado Department of Public Health and Environment
CIP	Capital Improvement Plan
DIP	ductile iron pipe
DMR	Discharge Monitoring Report
DOLA	Department of Local Affairs
DWRF	Drinking Water Revolving Fund
EFM	enhanced flux maintenance
EIAF	Energy and Mineral Impact Assistance Fund
EQR	equivalent residential unit
FM	flux maintenance
GAC	granular activated carbon
GIS	Geographic Information System
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
HDPE	high density polyethylene
HP	horsepower
I/I	inflow and infiltration

lb/hr	pounds per hour
MCL	maximum concentration limit
MG	million gallons
MGD	million gallons per day
mg/L	milligrams per liter
MMADF	maximum month average daily flow
NOM	natural organic matter
NPDES	National Pollutant Discharge Elimination System
OPC	opinion of probable cost
PEL	Preliminary Effluent Limits
PER	Preliminary Engineering Report
PHF	peak hour flow
ppd	pounds per day
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinyl chloride
RAS	return activated sludge
RAW	Record of Approved Waterworks
RO	reverse osmosis
SRF	State Revolving Fund
TDS	total dissolved solids
TIN	total inorganic nitrogen
TMP	transmembrane pressure
TP	total phosphorus
TSS	total suspended solids

UV	ultraviolet
VCP	vitrified clay pipe
WAS	waste activated sludge
WEP	2019 Water Efficiency Plan
WQCD	Water Quality Control Division
WQCC	Water Quality Control Commission
WPCRF	Water Pollution Control Revolving Fund
WPF	Water Purification Facility
WWRF	Wastewater Reclamation Facility

EXECUTIVE SUMMARY

INTRODUCTION

The purpose of the City of Rifle (City) Utility Maintenance, Capital, and Rate Study (Utility Study) is to develop a comprehensive planning document providing guidance for the City's water and wastewater system to reliably serve the existing and future service area. The Utility Study should be viewed as a dynamic working document, reviewed annually, and updated as conditions in the City's service area change. This report is an update to the 2006 water and wastewater master plans with a focus on annual maintenance and proactive rehabilitation and replacement.

The capital improvement plan (CIP) will assist the City in prioritizing projects and developing annual budgets. Recommendations identified in this Utility Study should be considered as conceptual only. Additional details and potential alternatives should be further investigated and analyzed in the preliminary design engineering phase of each project. This report includes planning and water demands, raw water source and delivery, raw water quality, drinking water treatment, potable water distribution and storage, pumping and pressure reducing valve stations, as well as evaluations and projections of wastewater flows and loading, population projections, and an evaluation of the collection system and wastewater treatment facility. It also includes a capital improvements plan, options for project financing, and a rate study.

There are limited system capacity expansions expected over the next 20 years since sufficient treatment capacity is available. Therefore, the City will be able to apply resources to repair and replace aging infrastructure and maintain high quality water and wastewater service.

PLANNING CONDITIONS

The City provides drinking water, as well as centralized sewage collection and treatment, to residential and commercial customers located within the City's service area. The service area consists of developed and undeveloped properties within Garfield County, Colorado. The water system currently serves an estimated population of 9,483 people. The City's service area now stands at 5.6 square miles. Population, water demand projections, and sewage flow projections are based on information from the City, Department of Local Affairs, and American Community Survey data. Based on billing data provided by the City, the City currently serves 4,028 residential equivalent residential units (EQRs) and 712 non-residential EQRs. Based on information provided in the Comprehensive Plan, a 3.0 percent annual average increase in the number of EQRs was used to determine future water demands and wastewater loading.

The planning period for this Utility Study is 20 years. The population growth rate and development rate for the City have not been historically steady, but growth is expected to continue in the future.

A discussion of what constitutes full buildout is presented in more detail in Section 2. The improvement recommendations in this Utility Study are based on projected water treatment demand increases necessary to serve the developments committed by the City, projected wastewater flows and loading, future regulations, and aging wastewater infrastructure.

The boom-and-bust cycles typical for the City makes the rate of development in the area more difficult to predict. Therefore, the infrastructure recommendations and 10-year CIP are based on commitments to provide water and wastewater services to existing development within the City, and an estimate for water and wastewater system improvements needed to serve Tier 1 developments in accordance with the Comp Plan.

Residential water consumption accounts for approximately 68 percent of the overall water usage in Rifle. Commercial customers use 24 percent and nearly 8 percent of water is used for irrigation. Based on the 2018 through 2020 WPF production data, the annual average production rate is 328 gallons per day (gpd) per EQR. Peak day water production, which occurred in June 2020, was 3.8 MGD, which equates to 806 gpd/EQR. Peak day water production rates can be used to determine water storage needs, while maximum month average day water production rates are used to determine WPF treatment capacity needs.

The Colorado Department of Public Health and Environment (CDPHE) requires planning and design for a plant capacity expansion begin when the maximum month average daily flow (MMADF) reaches 80 percent of the plant's rated capacity. The planning limit of 80 percent of the rated hydraulic capacity is 1.6 MGD, and is projected to be reached by 2034, assuming a 3.0 percent annual growth rate and no change in the wastewater generation per EQR. The planning limit for BOD_5 loading is 4,337 pounds per day (ppd), while the average daily loading was only 1,773 ppd BOD_5. At the current per capita loading rates, the WWRF is projected to reach the planning threshold for loading in 2034.

WATER SYSTEMS

The City's primary water source is the Colorado River. Raw water from the Colorado River is diverted into a storage/settling pond that was converted from a gravel pit. From the settling pond, vertical turbine pumps at the raw water pump station pump the water to transport through a 24-inch pipe for treatment at the Water Purification Facility (WPF).

The Colorado River is the only approved water source for the WPF at this time. The new WPF meets all the requirements of the Primary Drinking Water Regulations. The City's main concern is the secondary water quality (taste and odor). The Colorado River has high concentrations of total dissolved solids (TDS) and natural organic matter (NOM) that affect the taste and smell of the water. A formal evaluation will be needed to confirm that the Colorado River within the City has the assimilative capacity to receive the RO concentrate from the proposed RO and GAC facility. This evaluation would then need to be presented to CDPHE for approval as part of the application process for a discharge permit. The evaluation would require two primary components: additional finished water sampling of the WPF and an investigation into the feasibility that the RO concentrate could meet the instream standards of the Colorado River.

Water is collected from the Colorado River via a concrete intake structure on the riverbank. There are currently two intake options to collect raw water from the Colorado River to feed the raw water pump station. There is no backup power source for the raw water pump station and there are no redundant pump stations to convey raw water to the treatment plant, so if the pump station were to lose power, water production would be halted until power is restored.

The WPF was completed in the spring of 2017 and replaced the Graham Mesa Water Treatment Plant. The primary treatment processes at the WPF are sedimentation, microfiltration, and disinfection. The overall approved capacity of the new plant is 6.0 MGD but the majority of the processes are rated at 8.0 MGD. As the WPF is approximately four years old at the time of this report, most of the equipment is in good condition. The microfiltration membranes have a nominal life span of 10 years, and so far, none have had to be replaced.

There are several operational features or challenges that were communicated by the operators. There has been some inconsistency between the flow rates as indicated on the peristaltic sodium hypochlorite pumps and what was determined from chlorine residual calculations. The operators are also dissatisfied with the frequency with which the pH sensors need to be replaced. There are occasional, enigmatic turbidity spikes in the effluent. Other potential projects are to replace the control valves on the discharge lines and replace the sand floor with concrete in the drying basins.

The City's water distribution system is comprised of raw water collection, treatment, distribution, booster pump stations, and potable water storage tanks. The water distribution system is comprised of approximately 417,400 lineal feet of active potable water mains with diameters ranging from 4 inches to 24 inches. The City has a total of six potable water storage tanks, eleven pressure reducing valves (PRVs), and three booster pump stations within the water system, which is separated into six pressure zones.

The City has identified redundancy and increased capacity needed from the WPF and the 5MG Storage Tank Complex. At the south end of the City Pressure Zone, redundancy is needed for the pipeline to the Beaver Creek Tank.

WASTEWATER SYSTEMS

The City's sanitary sewer collection system is comprised of north and south gravity collection and a south lift station and force main. There is a total of approximately 292,800 lineal feet of active sewer pipe within the collection system with pipe sizes ranging from 4 inches to 30 inches. The collection system on the north side of the Colorado River generally drains north to south before draining west to the WWRF. The collection system on the south side of the Colorado River generally drains west to the only lift station in the system. Flows are pumped to an interceptor main near the WWRF. The WWRF discharges into the Colorado River.

The WWRF was constructed to replace the old North Wastewater Treatment Plant and South Wastewater Treatment Plant. The new WWRF was brought online in 2009. The WWRF was designed for a peak flow of 5.0 MGD. It has a hydraulic capacity of 2 MGD MMADF with the potential for expansion up to 4 MGD.

The WWRF is designed for an average flow capacity of 2.0 MGD and a peak hourly flow capacity of 5.0 MGD. Currently, the monthly average influent flow to the WWRF is below 1.0 MGD. Influent data shows that while there are some small peaks in influent flow to the WWRF during the summer months, wastewater flow throughout the year is fairly steady.

The WWRF is 12 years old and is largely operating well. Solids handling is the staff's main concern, and it is anticipated that this issue will be resolved with the addition of the new screw press, which is currently under design. Ongoing maintenance needs include re-lining concrete tanks and channels. The control board in the headworks building is starting to fail and technical support is no longer covered by manufacturer. The interchange tanks are currently operated as digesters, which is not what those tanks were designed to do. During the winter, the WWRF experiences bulking and foaming issues in the interchange tanks, digesters, and, to a lesser extent, the oxidation ditches. The programmable logic controller (PLC) system for the UV disinfection units is not currently working. Staff also has trouble finding replacement ballasts for the UV system.

The WWRF enrolled in the Voluntary Inventive Program in 2018. The WWRF has not historically met the Regulation 85 TP limit of 1 mg/L. However, it has consistently met the TIN limit of 15 mg/L. Under Policy 17-1, the Rifle WWRF could extend its Regulation 31 compliance schedule up to 1 year for every year it achieves an annual median TIN concentration less than 7 mg/L, as it did in 2019. For years in which the TIN annual median is above 7 mg/L but below 15 mg/L, the WWRF will earn relatively less additional compliance time based on a sliding scale to a maximum of one year.

The renewed NPDES discharge permit issued by CDPHE that took effect in April 2015 identified that the WWRF effluent TDS had exceeded the Colorado River Salinity Standards. The City submitted a report to the CDPHE Water Quality Control Division (WQCD) on August 31, 2015. CDPHE has not granted the City a TDS waiver but did administratively extend the permit in 2019, which requires only quarterly reporting of effluent TDS concentrations.

GIS Mapping and Asset Management

The ESRI GIS mapping system offers the ability to visually depict and communicate data as it is spatially located. The City has an extensive GIS database that includes the water distribution and sewer collection systems. The database includes water pipes and structures and sanitary pipes and structures with attribute data consisting of installation date, size, material type, and status. Other data such as waterline break locations, identified defects based on closed-circuit television (CCTV) analysis, inflow and infiltration reports, bottleneck locations, high groundwater locations, and background data from Garfield County and the State were used in the creation of the asset management priority grading. The use of GIS allows for organizing, mapping, and selecting features within the shapefiles to populate the condition and criticality grades and create a prioritization of the pipe segments.

Prioritization of the City's distribution and collection system pipes was used to create a proactive evaluation program that uses a calculated priority grade to determine timing on when inspection and ultimately rehabilitation or replacement should occur. The final priority grades distinguish the pipe segments on a scale from 1 to 5 with 5 being the highest priority. The priority grades are determined based on a matrix using condition and criticality grading factors. Overall, the priority grades will allow the City to have a better understanding of where within their system they should focus inspections and more in-depth evaluations. The prioritization grading will provide improved estimates of service life. The program should reduce the frequency of emergency repairs, extended service disruptions, restoration costs due to environmental and property damage, and premature pipe replacement or rehabilitation.

The next step for the City is to start a CCTV inspection program for the sanitary sewer system based on the priority grades. Since there are future street improvement projects that have been outlined for the next 5 years, it is imperative to inspect and determine which pipes the collection and distribution system are required to be rehabilitated or replaced within the areas of the street improvement projects.

Inspection of the water distribution system is more difficult. External infrared or sonic sensors and internal traveling sensors may provide condition information, but it can be expensive. It is recommended that the pipes with a grade of 5 based on the material should be placed on the schedule to be replaced rather than investigated.

Maintenance and Capital Improvements Plan

The City of Rifle has completed significant capacity expansions for both the water and wastewater treatment facilities recently enough that no future treatment expansions are anticipated until 2039 or later. With no capacity related projects required, the City's focus is on utility maintenance projects and improvements for operations. This is reflected in Section 5, which discusses the recommended capital improvement plan and additional annual Operation & Maintenance budget items.

Before preparation of the Utility Study, the City had two significant capital projects identified for 2020 through 2023; the water utility Reverse Osmosis/Granular Activated Carbon Facility (RO/GAC) project and the wastewater utility Salinity Removal/Mitigation Solution project for an estimated cost of $80M combined. These two projects are no longer included in the CIP as near-term projects due to the uncertainty of the timing of regulatory requirements, limited water quality information available, and to avoid unintended negative impacts of changing the drinking water characteristics. Removing these two projects from the CIP significantly reduced the capital improvement projects total for 2021-2030. While these projects are no longer anticipated within the next ten years, salinity removal will likely be required and should be planned for within the next twenty years.

Funding Options

The capital improvement projects associated with City growth and development will have a larger impact on City funding over the next 10 years. A preliminary summary of financial options for State and Federal grants and loans has been provided in Section 6. The City has other capital funding mechanisms including plant investment fees (connection fees) and user charges.

(Final Draft to incorporate the Raftelis Utility Rate Study Info)

SECTION 1 – INTRODUCTION

BACKGROUND

The City of Rifle (City) is located in western Colorado in Garfield County along the Colorado River and Interstate Highway 70, 62 miles northeast of Grand Junction. The City currently provides water and wastewater services for a population of approximately 9,483 full-time residents and serves residential, commercial, and institutional (e.g., schools) customers, as well as irrigation water for open spaces and public parks.

In 2006 the City completed a Water Master Plan and a Wastewater Master Plan to evaluate the City's ability to provide water and sewer service in the short- and long-term. Each master plan recommended significant capital improvements and treatment facility expansions to meet a growing service area and population. Several of the large capital projects have now been completed and in 2019 the Planning and Development Department completed an update to the Comprehensive Plan. With a history of boom-and-bust growth cycles, the City's vision, as described in the *2019 Comprehensive Plan* (Comp Plan), is to focus on infill development projects in order to limit large utility projects necessary to serve areas further away from existing infrastructure.

This Utility Maintenance, Capital, and Rate Study (Utility Study) is an update to the 2006 water and wastewater master plans with a focus on annual maintenance and proactive rehabilitation and replacement. There are limited system capacity expansions expected over the next 20 years since sufficient treatment capacity is available. Therefore, the City will be able to apply resources to repair and replace aging infrastructure and maintain high quality water and wastewater service.

PROJECT PURPOSE AND GOALS

The primary components of a utility master plan include conducting a capacity analysis based on current growth projections and establishing a Capital Improvement Plan (CIP) for short- and long-term projects. The growth projections and CIP are critical for setting utility rates as the growth projections determine expected revenue from utility billing and the CIP will, in part, establish the revenue requirement. The primary goals of this Utility Study are to:

- provide capital improvement and maintenance planning for wastewater and water services; and
- recommend a rate structure that supports a maintenance strategy that improves City infrastructure while remaining sustainable and fair for consumers.

The utility rates and rate design may be revised to improve equitability and sustainability. The rates may also be adjusted to improve the ease of understanding and ability to administer. With recent large treatment expansion projects, another objective for updating utility rates is to evaluate current debt and reserve funding.

A significant component of this Utility Study is the incorporation of assets into the existing Geographic Information System (GIS). This process allows the City to establish a prioritization system for distribution and collection system projects.

Existing Reports

Existing reports and documentation were reviewed for this Utility Study. Information in these documents was used to develop planning conditions for assessments of current capacity and future growth.

These include the following documents:

- 2020 Utility Capital Improvements Plans
- 2019 Comprehensive Plan
- 2006 Water Master Plan
- 2006 Wastewater Master Plan
- Water Efficiency Plan
- Water Treatment RO and GAC Study
- Record drawings
- GIS database and mapping
- Permitting documentation
- Operations data
- Operator questionnaires

Utility Rate Study

(To be completed by Raftelis)

SECTION 2 – PLANNING CONDITIONS

SERVICE AND PLANNING AREA

Rifle was established in 1882 and later incorporated as a town in 1905. Rifle's service area currently consists of 5.6 square miles of incorporated zones. The majority of the City's service area is generally bordered by Interstate 70 and the Colorado River to the south and State Highway 13 to the northwest.

The City currently provides water and wastewater services for a population of approximately 9,483 full-time residents and serves residential, commercial, industrial, and institutional customers and bulk water haulers. It also provides irrigation water for open spaces and public parks.

PLANNING PERIOD

The planning period for this Utility Study is 20 years. The population growth rate and development rate for the City have not been historically steady, but growth is expected to continue in the future.

A discussion of what constitutes full buildout is presented in more detail in the following section regarding future development. The improvement recommendations in this Utility Study are based on projected water treatment demand increases necessary to serve the developments committed by the City, projected wastewater flows and loading, future regulations, and aging wastewater infrastructure.

EXISTING AND FUTURE DEVELOPMENT

The existing population and growth rates used in this Utility Study correspond to the City's Planning and Development Department's Comp Plan. The Comp Plan used equivalent residential units (EQRs) and a Tiered Growth System to forecast the City's development over the next 20 years. The Comp Plan identified three tiers for development: Tier 1, Tier 2, and Tier 3. Tier 1 areas are defined as the priority growth areas that are expected to be built out without the next 20 years and are preferred for near-term development. The neighborhoods currently included in Tier 1, along with the expected number of EQRs, is shown in Table 1. Tier 2 areas are defined as the secondary growth areas that represent properties that will require major infrastructure improvements to be developed and are not expected to be developed within the next 20 years unless the infrastructure issues are resolved by the developer. Tier 3 areas are defined as the rural preservation reserve areas that represent a tertiary ring of land around the City and is not currently annexed. Any development in Tier 3 areas will be low density clustered growth and outside of the planning horizon. The Comp Plan projections are used to estimate future water demands and wastewater loading.

Table 1 – Tier 1 Buildout Summary

Tier 1 Neighborhood	Buildout EQRs
Shetland Acres	37
Queens Crown	30
Kings Crown	70
Animal Shelter	144
Creekside	13
Park Avenue	6
Trapper Hollow	81
Scalzo Ranch	28
Rifle Heights	88
Two Creeks	177
Promontory	49
Vetter	3
The Farm	376
Rifle Creekside	58
Tier 1 Total	**1,160**
Total Existing EQRs	**4,751**

HISTORICAL TRENDS

The following sections discuss historical trends for population growth, historical potable water production and demand for the Water Purification Facility (WPF), and influent wastewater flow and organic loading to the Wastewater Reclamation Facility (WWRF). The historical data is used as the basis for future projections.

POPULATION

Historical and current population trends were obtained from the Colorado Department of Local Affairs (DOLA) and the American Community Survey, which has collected data annually since 2010. Population projections were developed using information from the Comp Plan. The Comp Plan projected an average annual population growth rate of 3.0 percent. The City’s current population is 9,483 people with 4,751 EQRs for water customers and 4,396 EQRs for wastewater customers. Water customer EQRs consist of residential, commercial, trucking, institutional, industrial, irrigation, and standby users. Wastewater customers largely consist of residential, commercial, and standby customers. There are fewer wastewater customers than water customers due to the non-overlapping user categories such as irrigation, trucking, and standby.

Using a 3.0 percent annual growth rate, the projected population in 2040 is 17,641 with 8,838 water EQRs and 8,178 wastewater EQRs. Based on the Comp Plan, buildout for the City will occur beyond this Utility Study’s planning horizon of 2040.

HISTORICAL WATER CONSUMPTION AND PRODUCTION

The City provided annual billing data for the 2019 billing year. Based on this billing data, the City currently serves 4,028 residential EQRs and 712 non-residential EQRs. Residential water consumption accounts for approximately 68 percent of the overall water usage in Rifle. Commercial customers use 24 percent and nearly 8 percent of water is used for irrigation. Table 2 summarizes the residential and non-residential water consumption based on available billing data from 2019.

Table 2 – Summary of 2019 Water Billing Data

Water User	EQRs	2019 Water Consumption (MG)	Percent of Total Use
Residential	4,028	310	67.4%
Commercial	542	111	24.2%
Trucking	1	1.53	0.3%
Irrigation	98	36.4	7.9%
Standby	71	0.39	0.1%
Total	**4,740**	**461**	**100%**

In addition to the 2019 billing data, the City provided water production data from the WPF from 2017 through 2020. A summary of the historical water production is provided in Table 3. Using the EQR information from the 2019 billing data, the historical water production data was used to determine the water production rate per EQR.

Table 3 – Historic Water Production Summary

Year	Water Production (*gallons/EQR/day*)											
	Summer					Winter						
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2017	445	659	581	515	464	231	183	182	-	-	-	-
2018	452	612	640	557	493	229	173	155	180	185	183	240
2019	280	439	513	539	445	249	203	177	159	161	165	193
2020	463	547	571	593	416	272	-	-	151	172	159	197
Monthly Average	**398**	**533**	**575**	**563**	**451**	**245**	**186**	**171**	**163**	**173**	**169**	**210**
Seasonal Average	**510**					**191**						
Yearly Average	**328**[1]											
Maximum Month Average Day	**593**[1]											
Peak Day	**806.1**[1]											

[1] Data based on information from 2018 through 2020, excludes 2017

Based on the water production data from May 2017 to October 2020, peak day water production was higher in 2017 than other years. This is likely because the WPF was going through an equipment startup process and testing the peak hydraulic capacity of the new WPF processes. For this reason, the 2017 data has been excluded from reported average and peak day values that are presented in Table 3. Based on the 2018 through 2020 WPF production data, the annual average production rate is 328 gallons per day (gpd) per EQR. The maximum month average day production, which represents the average daily water production during the month with the highest total water production rate, occurred in August 2020 with an average plant production of 2.9 million gallons per day (MGD), or 593 gpd/EQR. Peak day water production, which occurred in June 2020, was 3.8 MGD, which equates to 806 gpd/EQR. Peak day water production rates can be used to determine water storage needs, while maximum month average day water production rates are used to determine WPF treatment capacity needs. Historical water production is shown in Figure 1.

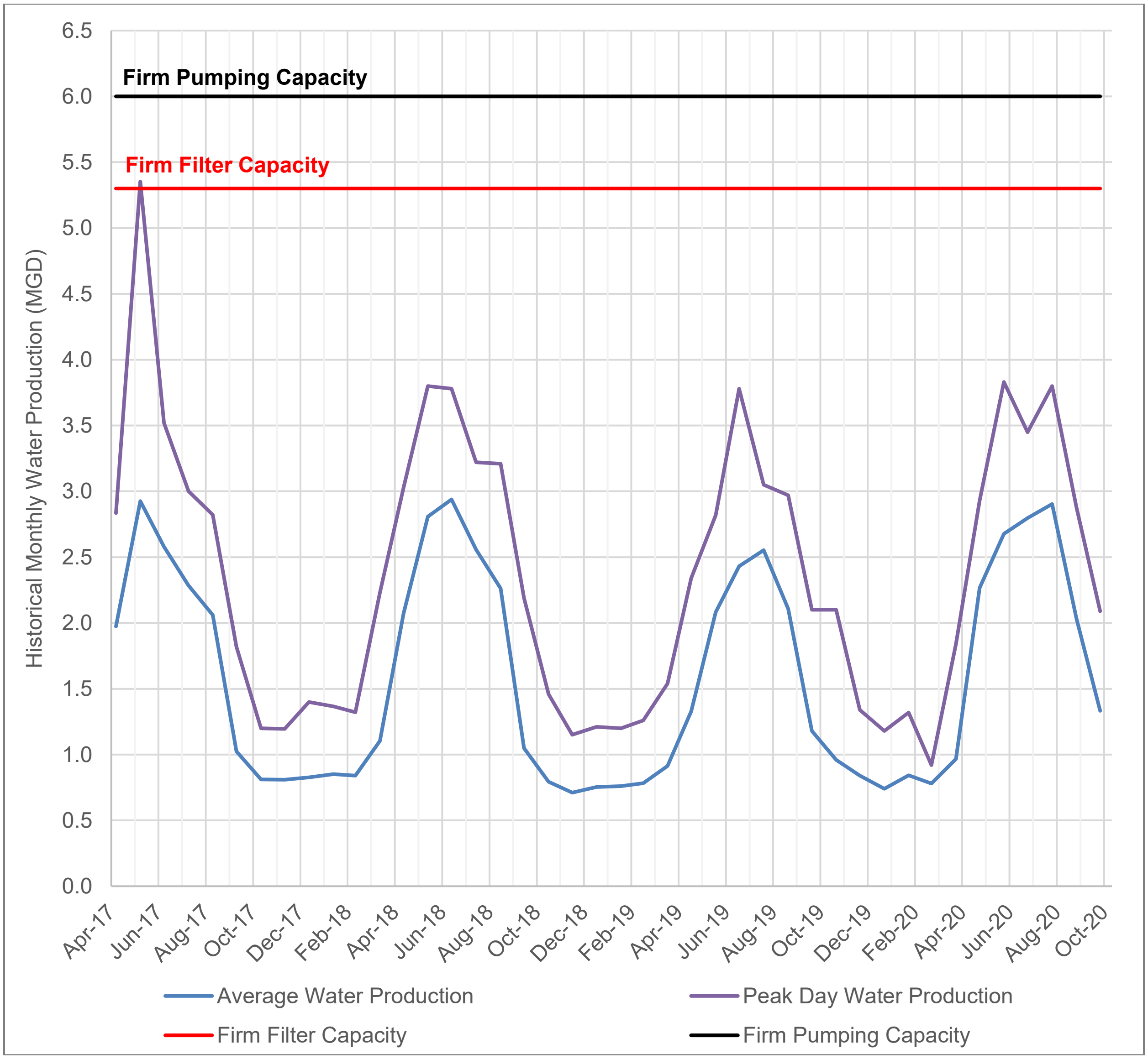


Figure 1. Historical Water Production Rates

The 2019 WPF production data was compared to the City's water billing data to calculate unaccounted for water within the distribution system. The production exceeds the billing data for 2019 by 9.5 percent. A summary of the unaccounted for water is provided in Table 4. The unaccounted for water may be a result of meter reading inaccuracies, meter calibration error, unaccounted for water, and/or losses within the distribution system. Losses less than 10 percent (historically accepted standard losses per American Water Works Association standards) are considered acceptable for a distribution system and standard deviation in meter accuracies. The calculated percent difference of 9.5 percent is considered to generally be within industry standards; however, additional annual billing data is required to perform a more thorough analysis of water loss in the system.

Table 4 – Water Production and Consumption Comparison

Parameter	2019 Water Production and Consumption (*gal/yr*)
Total Consumption (Customer Meters)	460,720,436
Total Production (WPF Meter)	509,100,000
Percent Difference	9.5%

HISTORICAL WASTEWATER FLOW AND LOADING

Historical wastewater flow and loading were analyzed to project future wastewater flows and loading and determine current and future WWRF capacity. Wastewater flow and loading projections are used to help determine CIP projects for processes limited by the capacity of the system.

HISTORICAL WASTEWATER FLOW

To determine historical wastewater flow and loading to the WWRF, the City provided influent flow data from October 2017 through September 2020. Influent flow rates are monitored continuously and reported as daily values seven days a week. The monthly average influent flows for this period are shown in Figure 2. The data shows that while there are some small peaks during summer months, wastewater flow to the WWRF is fairly steady.

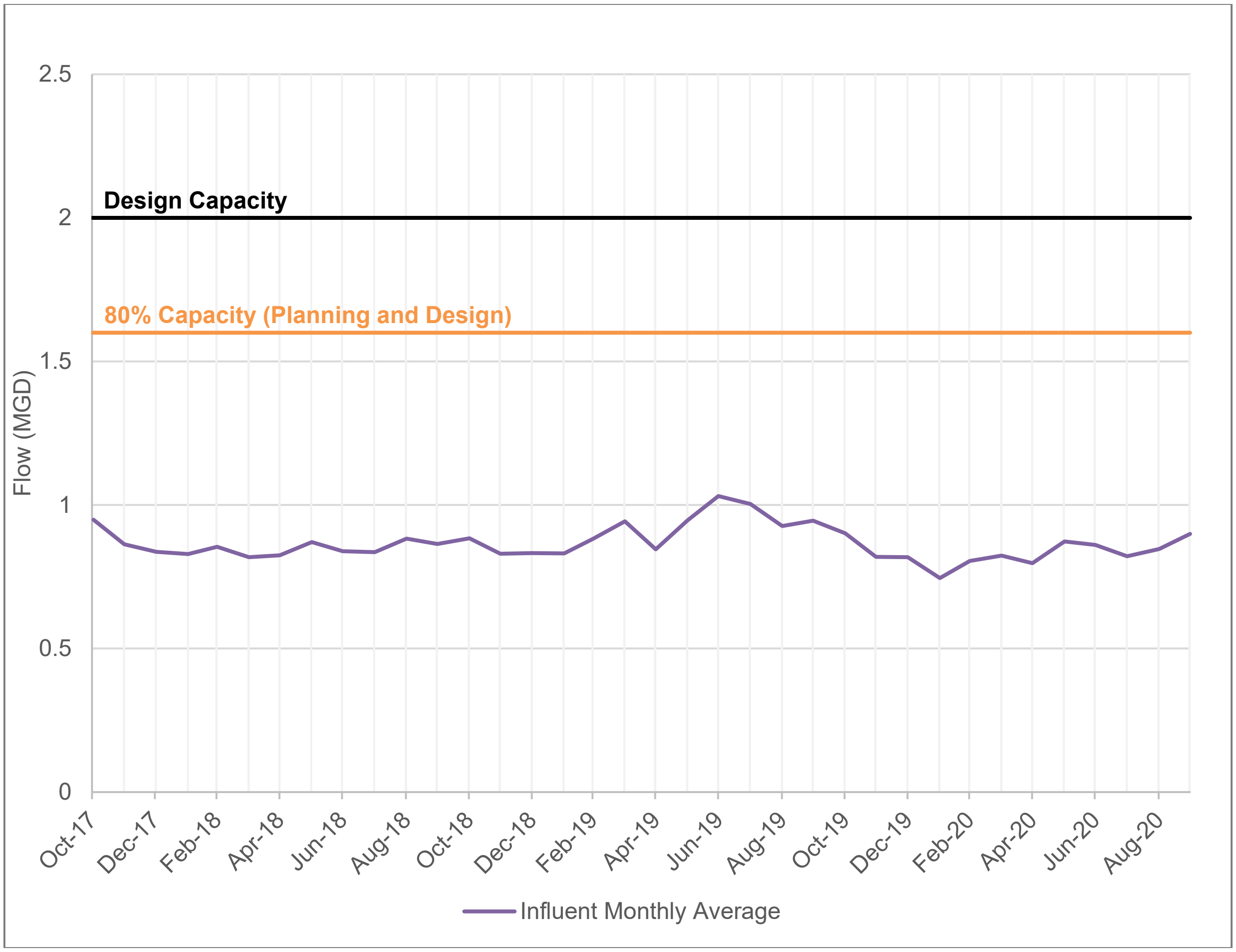


Figure 2. Historical Influent Wastewater Flow

Along with the historical flow data, the current design capacity of the WWRF and the planning limits are also shown on Figure 2. The Colorado Department of Public Health and Environment (CDPHE) requires planning and design for a plant capacity expansion begin when the maximum month average daily flow (MMADF) reaches 80 percent of the plant's rated capacity, and construction of the upgrades must begin by the time the MMADF has reached 95 percent of the plant's capacity. The MMADF data is used for projections in the following sections. The MMADF is a more conservative planning value than the average daily flow and CDPHE Regulation 22 recommends using the MMADF for establishing design capacity.

The WWRF is designed for an average flow capacity of 2.0 MGD and a peak hourly flow capacity of 5.0 MGD. The planning limit of 80 percent of the average design capacity is 1.6 MGD. Currently, the monthly average influent flow to the WWRF is below 1.0 MGD.

The daily influent flow data provides an understanding of the current peak flows to the WWRF; however, MMADF values are used to determine design capacity, as discussed above. The average daily influent flow (ADF), MMADF, and peak day flow (PDF) are summarized in Table 5.

Table 5 – Historical Influent Wastewater Flow Annual Averages

Year	ADF (*MGD*)	MMADF (*MGD*)	Peak Day (*MGD*)
2017 (Oct-Dec)	0.88	0.95	1.30
2018	0.85	0.88	1.38
2019	0.91	1.03	1.58
2020 (Jan-Sep)	0.83	0.90	1.05
Average	**0.87**	**1.03**	**1.58**

Sewer billing data was used to compare against the measured influent flow to the WWRF. The City provided billing data from July 2019 through June 2020, as summarized in Table 6 below. Sewer billing is based off of water consumption and is not directly measured. According to these billing records, the City only billed a total of 2.06 million gallons (MG) during this period. This equates to a daily flow rate of 0.56 MGD, which is only 65 percent of the actual ADF observed at the WWRF (0.87 MGD). Inflow and infiltration could account for some additional, un-billed flow to the WWRF, but likely not enough to make up the 35 percent gap. Rifle should consider revising its billing scheme to better match the actual influent flow being treated at the WWRF.

Table 6 – Sewer Billing Data (July 2019-June 2020)

Billing Category	Number of Customers	Number of EQRs	Flow Billed (*MGD*)	Average Billed Flow per Account (*gpd/EQR*)	Percentage of Influent ADF
Sewer - Residential - Single	2,756	2,759	0.2968	108	34.27%
Sewer - Residential - MF	470	980	0.1249	127	14.42%
Sewer - Senior 80% Base	19	19	0.0011	56	0.12%
Sewer - Senior MF 80% Base	5	64	0.0036	57	0.42%
Sewer - Single Family OC	12	12	0.0014	113	0.16%
Sewer - Commercial	325	470	0.1314	279	15.17%
Sewer - Commercial OC	16	16	0.0008	49	0.09%
Sewer Reduced rate @ 50%	2	3	0.0023	769	0.27%
Sewer - Mt. Clear 76% 2019	1	1	0.0009	945	0.11%
Sewer - Standby 50%	8	72	0.0007	9	0.08%
Total	**3,614**	**4,396**	**0.5638**	**N/A**	**65.09%**

The billing data indicated there are currently 4,396 sewer EQRs in the Rifle WWRF service area. The ADF and MMADF per EQR are 197 gpd/EQR and 235 gpd/EQR, respectively. The average per capita flow was also calculated in order to compare wastewater generation to industry standards; the result was 91 gallons per capita per day (gpcd). This per capita flow rate is consistent with standard literature values for residential wastewater production, which range from 46 to 97 gpd per person depending on household size (see Table 3-1 of *Wastewater Engineering Treatment and Reuse*, fourth edition, Metcalf & Eddy). Wastewater flow projections for the future were based on the current "per EQR" flow rate.

Historical Wastewater Loading

The City currently tracks monthly loading data as required by their Discharge Monitoring Report (DMR). The influent five-day biological oxygen demand (BOD_5) concentration to the WWRF is measured approximately twice per week. The influent BOD_5 concentration ranged from 110 milligrams per liter (mg/L) to 575 mg/L. The average concentration during this period was 249 mg/L and the maximum month average day concentration was 373 mg/L. Loading is calculated using both the BOD_5 concentration and influent flow. The BOD_5 loading between October 2017 and September 2020 is shown in Figure 3.

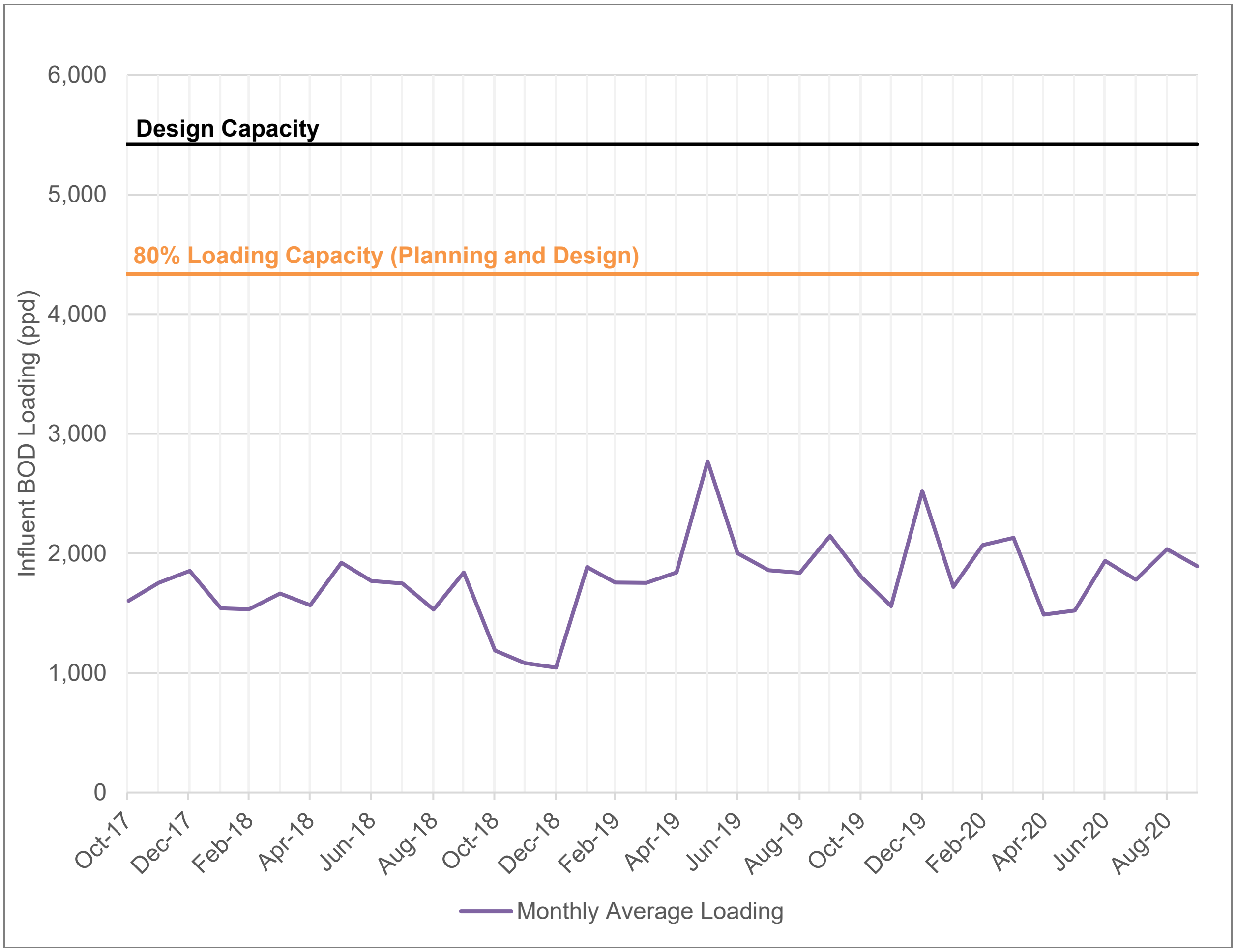


Figure 3. Historical Wastewater Organic Loading

The 80 percent trigger point for commencement of planning and engineering and the 95 percent trigger point for construction of a new facility are noted above in Figure 3. The design capacity for BOD_5 loading is 5,421 pounds per day (ppd) and the planning/engineering limit is 4,337 ppd.

The BOD_5 loading between October 2017 and September 2020 is also summarized in Table 7. The average daily loading was 1,773 ppd BOD_5. This yields an average per capita loading rate of 0.187 ppd per person, which is consistent with the range of loading rates of 0.11 to 0.26 ppd per person found in industry standard literature (see Table 3-1 of *Wastewater Engineering Treatment* *and Reuse*, fourth edition, Metcalf & Eddy). This value was used in future projections to estimate the loading stemming from population growth.

Table 7 – Historical Influent Wastewater Loading

Year	Average Day (ppd)	Maximum Month (ppd)	Peak Day (ppd)
Oct-Dec 2017	1,753	1,853	2,329
2018	1,606	1,923	2,284
2019	1,980	2,769	4,565
Jan-Sep 2020	1,833	2,130	2,592
Oct 2017-Sep 2020	**1,773**	**2,769**	**4,565**

The maximum month average day BOD_5 loading was 2,769 ppd in May 2019. As shown in Figure 3, this was a particularly high monthly average. According to the City, the WWRF accepted more septic hauler waste than normal in the summer of 2019, which could explain the high loading in May 2019. The next highest monthly average BOD_5 loading was 2,521 ppd in December 2019.

FUTURE PROJECTIONS

Based on information provided in the Comp Plan, a 3.0 percent annual average increase in the number of EQRs was used to determine future water demands and wastewater loading.

PROJECTED WATER DEMAND

The projected water demand over the planning horizon was calculated by applying the current water production rates for average day, peak day, and summer average water production rates to the anticipated future EQRs. Table 8 summarizes the projected summer, maximum month, and peak day water demands in five-year increments.

Table 8 – Projected Water Demand

Year	EQR	Population	Average Day Demand (*MGD*)	Summer Average Day Demand (*MGD*)	Peak Day Demand (*MGD*)
Current	4,751	9,483	1.39	2.36	3.83
2030	6,774	13,127	2.15	3.28	5.30
2040	9,103	17,641	2.89	4.40	7.12

The WPF has a total finished water pumping capacity of 9.0 MGD and a total filter and pretreatment capacity of 8.0 MGD. Per the *Record of Approved Waterworks* (RAW), CDPHE defines the firm capacity as the water production rate with the largest unit out of service, which is 6.0 MGD. The firm capacity is set by assuming the high service pump, which is rated for 2,100-gallons per minute (gpm), is out of service.

Each of the three filters is rated for 2.67 MGD, so the firm capacity of the filtration system with one filter out of service is 5.3 MGD. Summer average day production rates are not expected to surpass the filter firm capacity within the planning horizon, but peak day water production rates are expected to surpass the filter firm capacity in 2030 or when the City reaches 6,576 EQRs. Peak day demands, however, can be met through the volume of water stored in the distribution system and filter capacity is not required to meet peak day demand.

For pretreatment processes, each flocculation basin is rated for 4 MGD, so with one flocculation basin out of service, the pretreatment firm capacity is only 4 MGD. Summer average day production rates are expected to surpass the pretreatment firm capacity in 2036 when the City reaches 7,853 EQRs. Summer average water production rates are not expected to reach the filter or pumping design capacity within the planning horizon.

The water production projections are shown graphically in Figure 4 and compared to the WPF's pumping and treatment design capacities.

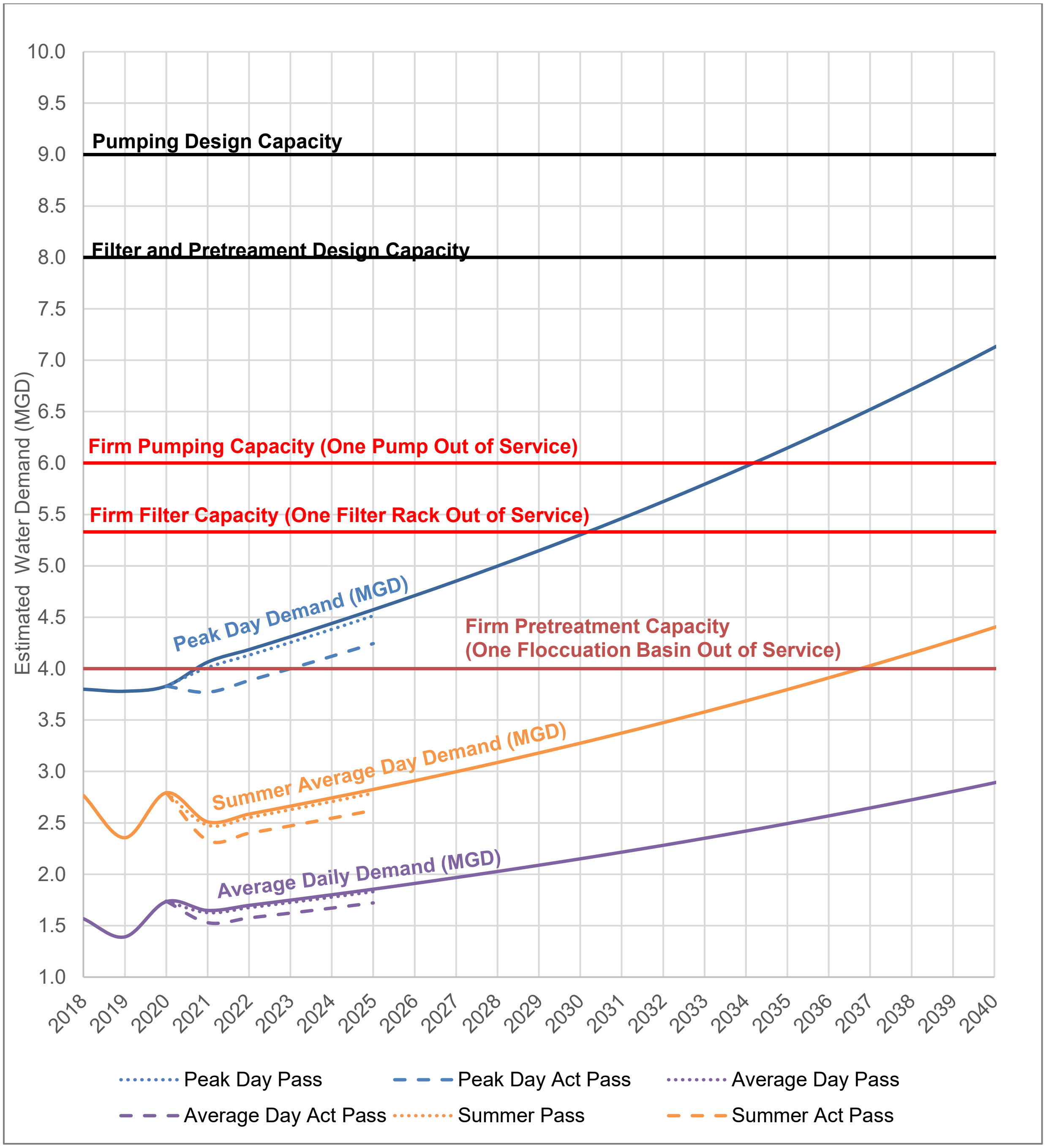


Figure 4. Water Production Projections

It is likely that water demand per EQR will decrease in the future as water efficiency measures are implemented in Rifle. The City commissioned a water efficiency study to analyze the effect of increased water efficiency measures on water demand and wastewater generation through 2025; the findings are documented in the Draft 2019 Water Efficiency Plan (WEP). The WEP separated water efficiency measures into passive and active savings categories. Passive savings occur when water customers replace old and inefficient fixtures with more efficient fixtures without incentive from the water utility. The WEP estimated that passive savings alone would reduce indoor water use 1.3 percent per year through 2025. This is represented by the dotted lines in Figure 4.

Active savings occur when the water utility actively promotes more efficient water use through activities such as improving distribution infrastructure, landscaping restrictions, water audits, etc. It was estimated that active savings would reduce water demand by 5.9 percent per year through 2025. Implementing active savings as detailed in the WEP, in addition to the anticipated passive savings, would reduce water demand over the next five years. This is represented by the dashed lines in Figure 4.

Buildout water production projections were assessed for all Tier 1 developments within the City. Figure 5 shows the buildout capacity of each neighborhood and the associated average and peak day flows. Summer average and peak day water demand for all of the Tier 1 developments are 0.59 and 0.93 MGD, respectively. The Farm neighborhood will have the highest water demand and will make up more than 32 percent of the total Tier 1 water demand with an expected 376 anticipated EQRs.

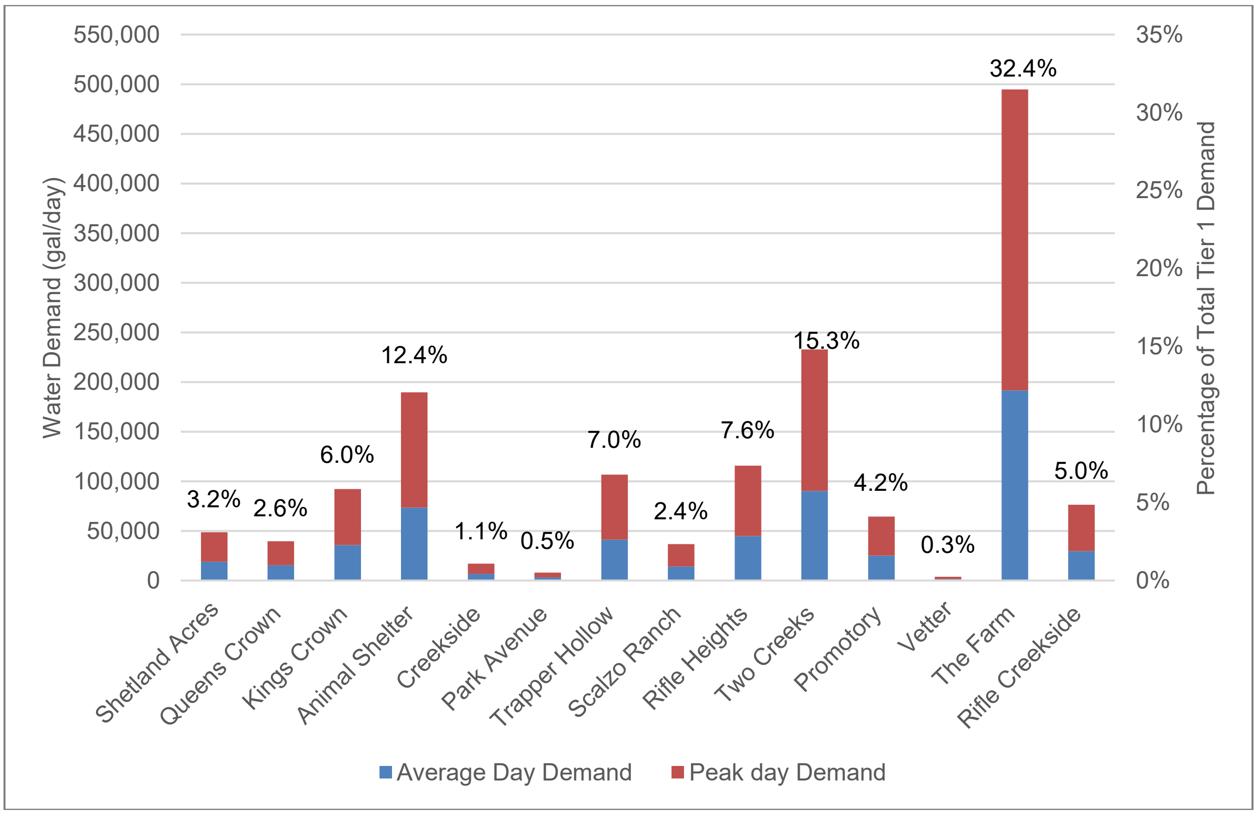


Figure 5. Neighborhood Water Demands

The total future Tier 1 water demands are compared to the projected summer water production demands in Figure 6. Based on the demand projections the total Tier 1 water demand will increase the current demand by 21 percent of the total water demand in 2040. The Tier 1 water demands are not expected to exceed or surpass the capacity within the planning period.

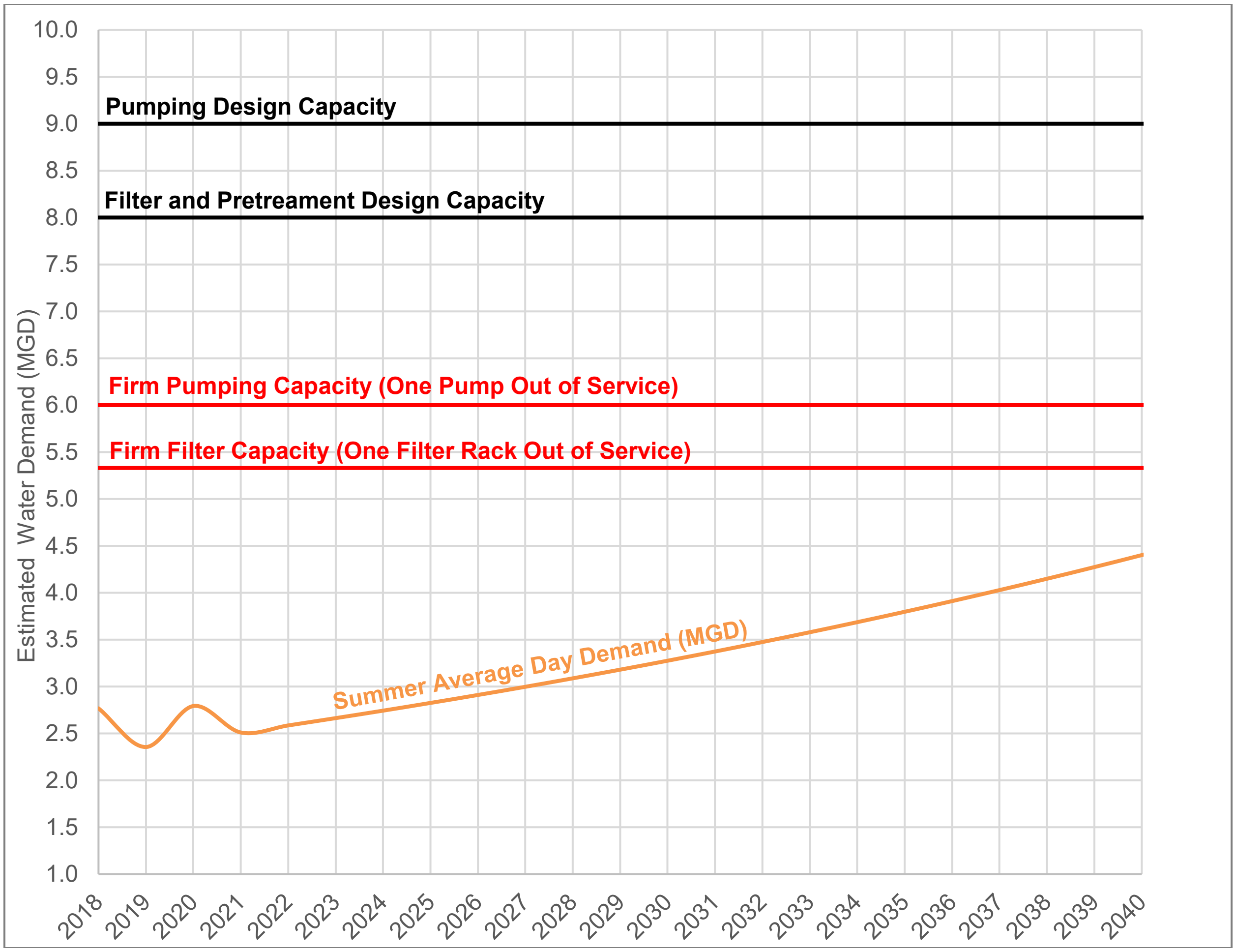


Figure 6. Future Tier 1 EQR Capacity Comparison

In addition, the total future Tier 1 water demands are compared to the firm filter and pumping capacities in Figure 7. Based on the demand projections described, the total Tier 1 water demand at buildout will increase water demand by 1.0 MGD, resulting in a projected summer day water demand of approximately 3.5 MGD. The combined existing and Tier 1 water demands are not expected to exceed or surpass the firm capacities of the WPF's filter and pumping systems by 2040.

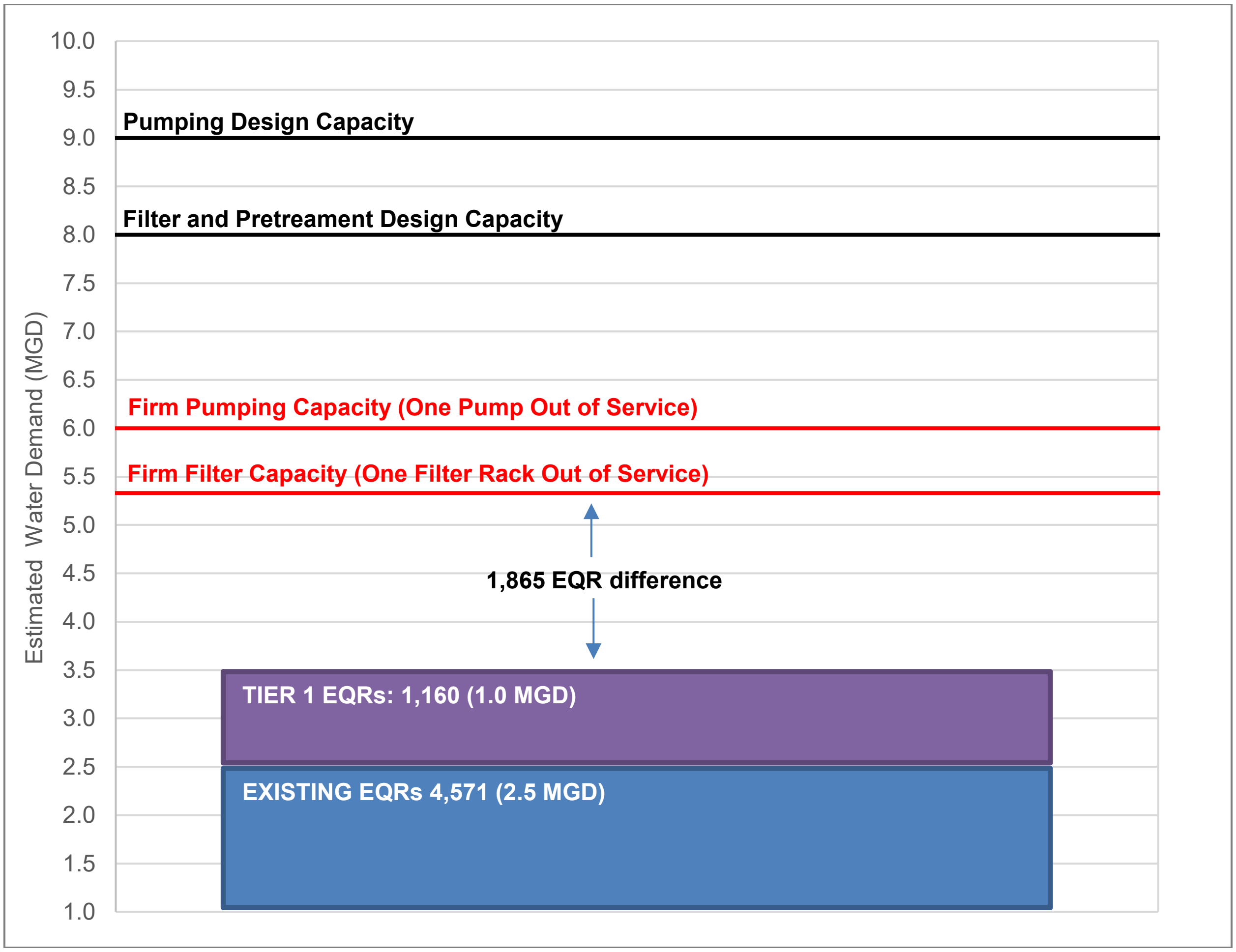


Figure 7. Future Tier 1 Buildout and WPF Firm Capacity Comparison

Based on the projected water demands and the anticipated Tier 1 developments, the WPF has sufficient capacity to meet all future Tier 1 future water demands without requiring a capacity expansion. In addition, the City can develop 1,865 additional EQRs before reaching the WPF's filter firm capacity.

Projected Wastewater Flow and Loading

As discussed previously, the WWRF currently serves 4,396 EQRs and the MMADF per EQR in 2019 was 235 gpd/EQR. The current MMADF to the WWRF is 1.03 MGD, well below the plant's design capacity of 2.0 MGD. Assuming a 3.0 percent annual growth rate and no change in the wastewater generation per EQR, the WWRF's MMADF would increase to 1.92 MGD by 2040. Figure 8 shows the projected wastewater generation over time.

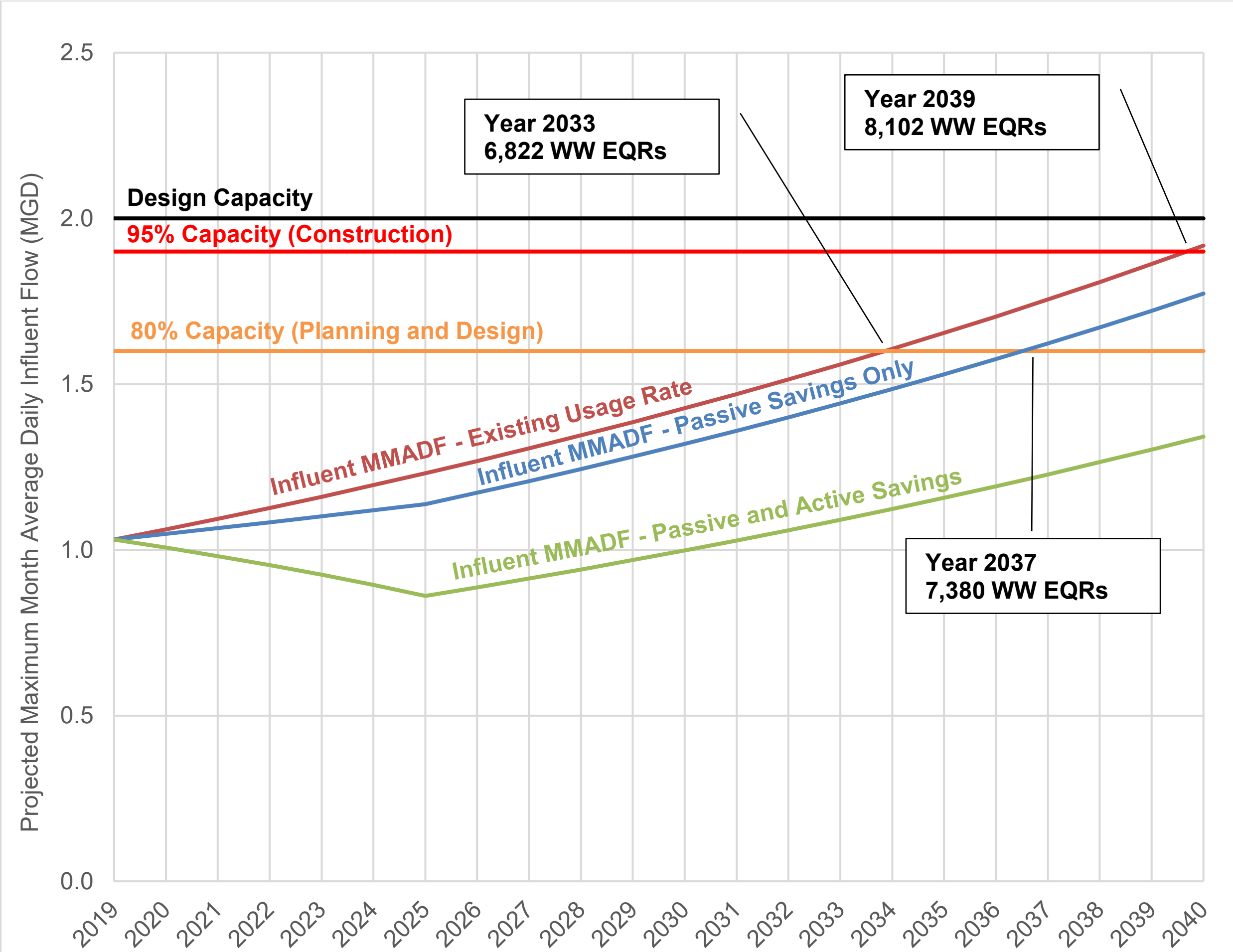


Figure 8. Projected Influent Wastewater Flow

It is likely that influent wastewater flow per EQR will decrease in the future as water efficiency measures are implemented in Rifle. As discussed previously, the WEP estimated that passive savings alone would reduce indoor water use, and therefore wastewater generation, 1.3 percent per year through 2025. As shown in Figure 8, the resulting 2040 influent MMADF would be reduced to 1.78 MGD.

Most of the water efficiency activities detailed in the WEP are focused on landscaping and irrigation, which do not affect wastewater generation. It was estimated that the activities that would affect indoor water use, such as tap fees with water efficiency incentives, would reduce water demand by 24.8 acre-feet (AF) per year. A baseline indoor water demand of 640 AF/year equates to a reduction of 9.1 gpd/EQR per year. As shown on the green line in Figure 8, implementing active savings as detailed in the WEP, in addition to the anticipated passive savings, would substantially reduce wastewater generation rates over the next five years and yield a 2040 MMADF of only 1.36 MGD. This would be a substantial reduction in wastewater generation per EQR and only represents an estimate of the savings possible if Rifle actively implemented water efficiency measures over the next four years.

The water use savings discussed in the WEP are not guaranteed, therefore the wastewater flow projections and proposed CIP projects are based on the existing usage rate of 235 gpd/EQR. As shown in Figure 8, the WWRF is projected to reach the 80 percent planning and design threshold in late 2033 and the 95 percent construction threshold in late 2039. As discussed above, the City expects an additional 1,160 EQRs as part of its Tier 1 buildout. Assuming a consistent 3 percent growth rate, the Tier 1 developments would be completed in late 2026 and would add 0.27 MGD to the current MMADF of 1.03 MGD. Figure 9 shows that the WWRF should have sufficient capacity to handle the additional flows from the Tier 1 buildout without triggering a capacity expansion.

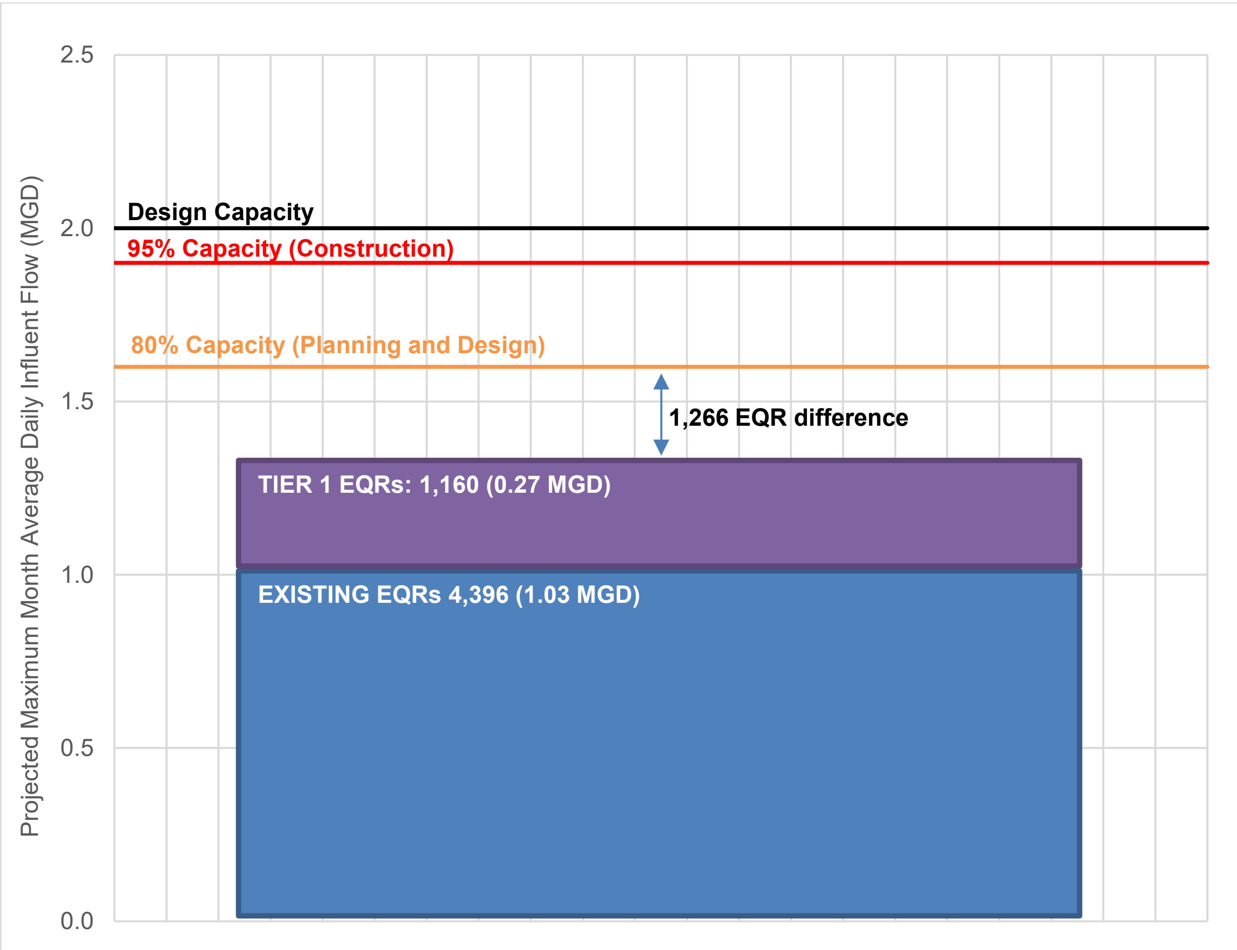


Figure 9. Future Tier 1 Buildout and WWRF Capacity Comparison

BOD_5 loading projections were calculated starting with the current average loading rate of 0.403 ppd/EQR. The loading rate was multiplied by the number of EQRs using the same 3.0 percent growth rate discussed above. This yields an average BOD_5 loading rate of 3,299 ppd in 2040 and a maximum month loading rate of 5,152 ppd, slightly under the current design capacity of 5,421 ppd. These projections are shown in Figure 10. The BOD_5 loading rate per EQR should stay relatively consistent independent of whether any of the water efficiency measures discussed in the WEP are implemented. Loading is based on concentration and flow; as flow goes down, concentration typically goes up, resulting in similar loading values.

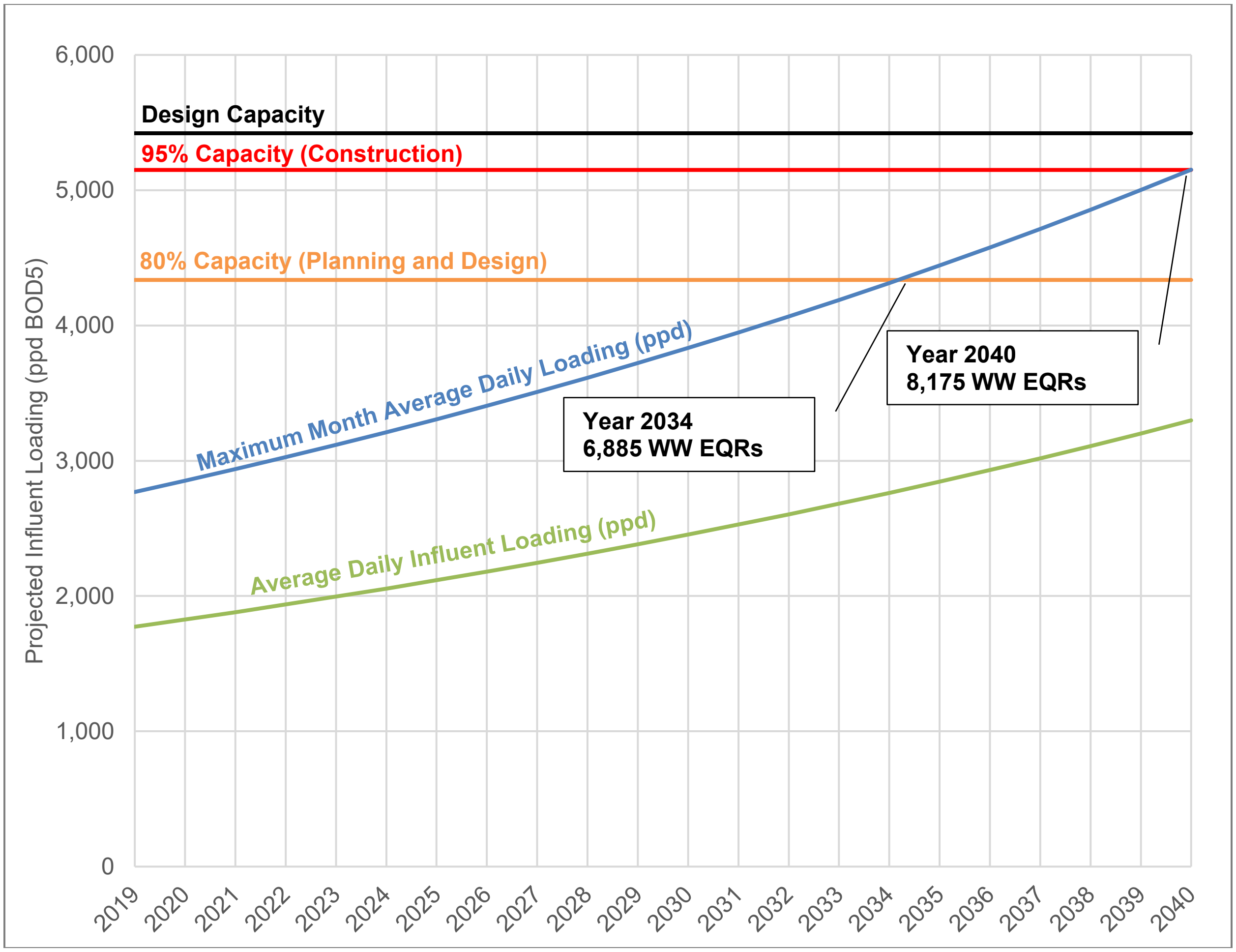


Figure 10. Projected Influent Organic Loading

At the current per capita loading rates, the WWRF is projected to reach the 80 percent capacity planning threshold for loading in 2034 and the 95 percent capacity construction threshold in 2040. These are close to the trigger dates for hydraulic capacity discussed above.

SECTION 3 – EXISTING FACILITIES EVALUATION

RAW WATER

The City's primary water source is the Colorado River. Raw water from the Colorado River is diverted into a storage/settling pond that was converted from a gravel pit. From the settling pond, vertical turbine pumps at the raw water pump station pump the water to transport through a 24-inch pipe for treatment at the WPF.

WATER SOURCE AND QUALITY

The Colorado River is the only approved water source for the WPF at this time. The new WPF meets all the requirements of the Primary Drinking Water Regulations. The City's main concern is the secondary water quality (taste and odor). The Colorado River has high concentrations of total dissolved solids (TDS) and natural organic matter (NOM) that affect the taste and smell of the water. In early 2016, as part of the planning and construction of the WPF, Black & Veatch prepared a report, titled *RO and GAC Facility Siting and Cost Study*, that describes the results of a study they conducted to determine cost estimates and possible locations for a reverse osmosis (RO) and granular activated carbon (GAC) facility intended to improve the secondary characteristics of the finished water. As part of the study, Black & Veatch used raw water quality sampling from City staff as well as historical United States Geological Survey data to assess the viability of a RO-GAC facility.

Raw Water Settling Pond with Raw Water Pump Station in the Background

From a taste and odor perspective, the most concerning parameter is TDS with an average winter concentration of 1,006 mg/L and an average summer concentration of 501 mg/L. The CDPHE Regulation 11 Secondary maximum concentration limit (MCL) for TDS is 500 mg/L. The RO filtration system in the proposed facility would reduce the finished water TDS to acceptable levels. However, RO filtration produces a substantial quantity of waste brine that can be expensive to dispose of. The Black & Veatch report explores the possibility of discharging the RO concentrate back to the Colorado River under a National Pollutant Discharge Elimination System (NPDES) permit. They found that Preliminary Effluent Limits (PELs) obtained by the

City from CDPHE demonstrated viability of this approach. A formal evaluation will be needed to confirm that the Colorado River within the City has the assimilative capacity to receive the RO concentrate from the proposed RO and GAC facility. This evaluation would then need to be presented to CDPHE for approval as part of the application process for a discharge permit. The evaluation would require two primary components: additional finished water sampling of the WPF and an investigation into the feasibility that the RO concentrate could meet the instream standards of the Colorado River. The additional sampling will be required to develop an accurate projection of the RO concentrate water quality profile that could be compared to the instream standards. The feasibility study will need to review current instream standards to determine if the projected RO concentrate would be within range and whether additional treatment or dispersed discharge into the river would be required.

Another contributor to taste and odor concerns are compounds such as methyl-isoborneol and geosmin that result from the death and decay of organisms in the water. The biggest contributor to these compounds in the City's water supply is the seasonal algae blooms in the raw water settling pond. However, there are likely to be significant amounts of these compounds in a large surface water source like the Colorado River as well. These taste and odor compounds are effectively reduced through adsorption to activated carbon. The GAC filtration process in Black & Veatch's study was evaluated for treatment of these compounds. A potential remediation of the algae blooms that contribute these compounds would be to install an aeration system in the ponds. Adding additional dissolved oxygen to the ponds would help reduce anaerobic bacteria that produce an algae food source as well as facilitating the growth of aerobic microbes that compete with the algae for the nutrients in the water.

Raw Water Settling Pond Intake Pipe

Raw Water Intake

Water is collected from the Colorado River via a concrete intake structure on the riverbank. A slide gate at the intake opening regulates flowrate and a bar screen in front of the opening excludes large debris. Flooding in 2012 shifted the river course away from the intake structure and periodic excavations of the riverbed have been required to keep water flowing past the intake structure.

There are currently two intake options to collect raw water from the Colorado River to feed the raw water pump station. One option a pipe through a dike into the settling pond, where the total suspended solids (TSS) from the river water can settle out before it is pumped to the WPF. The settling is useful during high flow events in the river that result in high raw water TSS. The pond is approximately 20 feet deep. Periodic dredging is required to remove the settled solids from the bottom of the pond.

The second option is a 24-inch pipe that runs directly from the river intake structure to the raw water pump station, bypassing the pond. In the warm season, nutrients in the raw water support algae blooms in the pond water. Algae growth results in reduced treatment efficiency, taste and odor issues, and potentially other concerns downstream in the treatment process, including increased chlorine demand, disinfection byproduct formation, and increased residual solids production. During algae blooms, the pond bypass line allows water to be taken directly from the river. The water is directed into either the pond or the pond bypass pipe by slide gates in the raw water intake structure.

The raw water pump station was completed in 2005 and has a permitted capacity of 4 MGD, which matched the capacity of the previous water treatment facility. The pump station, however, has an actual pumping capacity of 7.5 MGD with three vertical turbine pumps, two rated at 1,300 gpm and one at 2,600 gpm. A fourth pump rated at 2,600 gpm is slated to go in next year to increase the capacity to 11.2 MGD.

There is no backup power source for the raw water pump station and there are no redundant pump stations to convey raw water to the treatment plant, so if the pump station were to lose power, water production would be halted until power is restored. As the power supply to the pump station has historically been stable and reliable, a solution may be a portable generator that could power other pump stations or equipment when it is not needed at the raw water pump station.

WATER TREATMENT

The WPF was completed in the spring of 2017 and replaced the Graham Mesa Water Treatment Plant. The primary treatment processes at the WPF are sedimentation, microfiltration, and disinfection. The overall approved capacity of the new plant is 6.0 MGD but the majority of the processes are rated at 8.0 MGD. Below is an overview of the treatment processes followed by discussions of the condition of the facility and the limiting factors to treatment and production.

TREATMENT PROCESS OVERVIEW

PRETREATMENT

Upon entering the treatment train, the raw water undergoes several pretreatment processes that include chlorine dioxide oxidation, aluminum sulfate coagulation, hydraulic jet mixing, and flocculation.

The chlorine dioxide is added to oxidize soluble forms of iron and manganese to less soluble forms. The iron and manganese will then precipitate and form small granules that can be coagulated and settled out in the sedimentation tanks. A side benefit of the chlorine dioxide is that it oxidizes organic taste, odor, and color compounds existing in the Colorado River water or as a result of algae blooms in the raw water settling pond. The chlorine dioxide is generated on site.

Aluminum sulfate is introduced to the raw water stream, serving as a coagulant that destabilizes the static electrical charges on small, suspended particles in the raw water. Neutralizing the charges allows the particles to contact and adhere to each other during flocculation until they contain enough mass to settle out in the settling basins.

Pretreatment Chemical Injection and Jet Mixing Piping

Chlorine dioxide, in addition to the aluminum sulfate, is incorporated into the raw water stream by hydraulic jet mixing. Water is pulled from the process just upstream of the chemical injection points and energized by one of two flash mix pumps before being reintroduced back into the process stream at the chemical injection point. The turbulence caused by the reintroduced stream dissolves the aluminum sulfate and then disperses it with the chlorine dioxide solution throughout the water column to ensure sufficient contact.

After the chemicals have been introduced and mixed, the water flows into a splitter box where it splits to two separate flocculation and sedimentation trains. Each flocculation train consists of a series of three flocculators. Each basin is mixed with paddle-wheel mixers and the motor sizes and mixer assemblies are such that the mixing gets progressively less intense in each of the three flocculators.

PRIMARY TREATMENT PROCESSES

The three components comprising primary treatment are sedimentation, membrane filtration, and chemical disinfection. From the last flocculation basin, the water flows directly into the sedimentation basins. The velocity of the water is slowed so that the flocs that formed through the coagulation and flocculation processes can settle to the bottom. Two rows of stainless-steel plate settlers increase the settling efficiency. The sedimentation basins are periodically cleaned by cable-driven suction mechanisms. The water flows upward through the plates and over effluent launders, before draining to the membrane filtration feed pumps.

Filtration consists of three Pall Microza skid-mounted microfiltration trains. The membranes provide 3-log removal credit for both cryptosporidium and giardia, which meets the minimum removal requirements. Each train has its own feed pump that is immediately followed by a strainer to remove any stray particles. Each of the three membrane skids has a flow capacity of 2.663 MGD with 90 filtration modules per train and 538 square feet of surface area per module, resulting in a total approved capacity of 8.0 MGD. There is space on each train for a total of 108 filter modules. An additional 18 modules could be added to each train which would increase the capacity of each train to 3.2 MGD for a total microfiltration capacity of 9.6 MGD. There is also room in the building for a fourth membrane skid that could increase the filtration capacity to 12 MGD.

The membranes are designed to run at a maximum inlet pressure of 50 pounds per square inch (psi) and with a maximum transmembrane pressure (TMP) of 35 psi. There are two regular maintenance cleans that take place to keep the TMP in the appropriate range. The first, the flux maintenance (FM) protocol, is a mechanical process to remove solid particles that have built up on the surface of the membranes via application of course bubble air agitation to the feed side of the membranes. The air agitation is followed by a flush cycle wherein feed water is used to flush the dislodged particles to drain. The filtration system is designed to run the FM protocol after 450 gallons of permeate have passed through each filtration module. At the design flow rate of 8 MGD, this results in the FM protocol running once every 22 minutes.

The second regular maintenance cleaning is the enhanced flux maintenance (EFM), which consists of a chlorine wash of the membrane surfaces to remove any biological fouling that is present. Each EFM cycle is automatically followed by an FM protocol. The EFM is designed to run after 185,550 gallons per module, which equates to about every seven days at design flow.

Plate Settlers in the West Sedimentation Basin

A third, less frequent cleaning procedure is the clean-in-place procedure, which is performed either every 30 days or when the specific flux of the membranes degrades to 1.5 gallons per square foot of membrane surface per day per psi of pressure, whichever comes first. This procedure involves a primary wash with chlorine and sodium hydroxide followed by a secondary wash with citric acid. Each step is followed by a freshwater rinse. The clean-in-place solutions are made up with water that is softened by an onsite softening system.

To ensure effective filtration, a direct integrity test is performed daily on each filtration rack. Passing criteria is a pressure loss of less than 0.3 psi within five minutes at a minimum test pressure of 25 psi.

The regular cleaning procedures and daily integrity tests reduce the system run time each day. After taking the frequent FM Protocols, the daily integrity tests, and the weekly EFM protocols into account, the daily filter capacity is approximately 7.0 MGD if the system is run according to the manufacturer's specifications.

The membrane effluent is dosed with sodium hypochlorite and pumped to the chlorine contact basin for disinfection. The basin has a volume of 149,600 gallons and is in a two-pass serpentine configuration. The channel is 20 feet deep, 5 feet wide, and 100 feet long on each of the two passes for a total length of 200 feet. There are diffuser walls at the inlet and outlet and the constant volume is maintained via a fixed weir. The length-to-width ratio of 40:1 combined with the influent and effluent baffling provides a baffling factor of 0.7. The contact basin provides the required 4-log inactivation of viruses at the design point of 8 MGD at 3 degrees Celsius and a minimum chlorine residual of 0.4 mg/L. This minimum chlorine residual is based on a peak hour flow rate (PHF) of 6 MGD, which is the firm pumping rate of the finished water pump station.

From the chlorine contact chamber, the finished water flows into a wet well to be pumped to the distribution system by four vertical turbine distribution pumps. The distribution pumps have a total capacity of 9.1 MGD, with two pumps rated at 2,100 gpm and one each at 1,400 gpm and 700 gpm. With the largest 2,100 gpm pump out of service, the firm finished water pumping capacity is 6 MGD.

Pall Microza Membrane Filtration System

Residuals Management

The settled solids from the sedimentation tanks are drained to the backwash waste pump station where they are combined with the backwash from the membrane filters and strainers. Two submersible pumps alternate pumping the contents of the backwash waste pump station to the drying beds. The drying beds consist of three cells lined with a 40-mil polyvinyl chloride (PVC) geomembrane liner under two feet of soil cover and two feet of drying bed sand. Each cell contains an underdrain system consisting of perforated 8-inch high density polyethylene (HDPE) pipe installed in drainage rock and lined with geotextile liner fabric. Water from the drying beds drains through the underdrain system to the recycle basin pump station. Currently, the drying beds are cleaned once annually, at which point roughly 65 cubic yards of waste solids are removed and hauled offsite for disposal.

The 7,180-gallon recycle basin pump station returns recaptured water from the drying beds to the head of the plant, upstream of all treatment, where it mixes with the influent raw water to run through the system again. The recycle water is pumped from the recycle basin pump station to the facility influent by three submersible recycle pumps.

Conditions Assessment

As the WPF is approximately four years old at the time of this report, most of the equipment is in good condition. The microfiltration membranes have a nominal life span of 10 years, and so far, none have had to be replaced.

There has been some inconsistency between the flow rates as indicated on the peristaltic sodium hypochlorite pumps and what was determined from chlorine residual calculations. Operators believe that the pumps may be oversized for the application and alternative pumps are currently being tested. Another potential contributor to the inconsistency is the injection point. There was speculation that excessive agitation was causing an artificially low chlorine reading just downstream.

There are several operational features or challenges that were communicated by the operators. The first is that the operators are dissatisfied with the frequency with which the pH sensors need to be replaced. They expressed interest in pursuing different pH measuring equipment that would require less maintenance. The second challenge is that there are occasional, enigmatic turbidity spikes in the effluent. The operators' best guess is that they are caused by concrete in the lined pipes disintegrating. A study could be conducted to try to narrow down the cause. A third potential project would be to replace the control valves on the discharge lines. Finally, the operators would prefer concrete-floored drying basins rather than the existing sand floors. With the existing basins, it is difficult to separate the solids from the sand, which leads to concerns about damaging the subsurface infrastructure. This also necessitates more frequent sand addition, resulting in higher operations and maintenance costs.

LIMITING FACTORS

The flocculation trains have a total design capacity of 8.0 MGD, with each train being rated to 4.0 MGD. If either of the flocculation/sedimentation trains were to go down, the rated capacity of those processes would be reduced to 4 MGD until the problem could be resolved. The operators indicated that they are able to run flows higher than 4 MGD through each train if necessary. As such, the rate limiting process is the microfiltration, with a nominal firm production capacity of 5.33 MGD.

The microfiltration system has a total design capacity of 8.0 MGD and a firm capacity of 5.33 MGD. Maximizing the capacity of each filtration rack by adding an additional 18 modules, the firm capacity could be increased to 5.6 MGD. Additionally, there is room for a fourth filter rack. A fourth rack equipped with 108 membrane modules would increase the firm filtration capacity to 8.4 MGD. However, as discussed above, the actual firm production rate after taking the FM, EFM, and direct integrity test operations into account will be lower.

The currently approved minimum entry point free chlorine residual of 0.4 mg/L is based on a PHF of 6 MGD, which is the firm capacity of the distribution pumps. To increase the flowrate above that, a higher minimum free chlorine residual would need to be maintained and approved by CDPHE because the facility is required to continuously provide a minimum 4-log virus inactivation by disinfection. The current target entry-point chlorine residual is between 1.5 and 2.2 mg/L so, from an operational standpoint, making this adjustment would not be a problem.

WATER DISTRIBUTION AND POTABLE WATER STORAGE

The City's water distribution system is comprised of raw water collection, treatment, distribution, booster pump stations, and potable water storage tanks. The Overall Utility Map is provided as Figure A1 in Appendix A. The City has a total of six potable water storage tanks, eleven pressure reducing valves (PRVs), and three booster pump stations within the water system. The distribution system is split into six pressure zones, as shown in the hydraulic profile and pressure zone map, Figure A2 in Appendix A. All raw water is delivered from the raw water pump station located at the Colorado River intake and all treatment occurs at the WPF.

DISTRIBUTION SYSTEM

The water distribution system is comprised of approximately 417,400 lineal feet of active potable water mains with diameters ranging from 4 inches to 24 inches. The pipe materials include asbestos cement (AC, also called transite), cast iron, ductile iron, steel, HDPE, PVC, and copper. Based on information from the staff there is no apparent bottlenecks in the existing distribution system, or areas with insufficient fire flow. Valves within the system are exercised by operations staff annually.

The service area south of the Colorado River is served by two distribution lines and the Airport Storage Tank located near the airport. If both distribution lines that cross the Colorado River went out of service, the 6-inch line from the Airport Tank would not be sufficient to feed the demands in the south service area. However, since there are dual pipes across the Colorado River there is a low risk of only the Airport Tank feeding the southern portion of the City.

STORAGE TANKS

Water storage within the water distribution system creates pressure zones and provides for operational, fire, and emergency storage. The City Pressure Zone service area is currently served with six storage tanks throughout the service area with a total storage capacity of 8.2 MG. The storage tanks include the Airport Tank (1.0 MG), Beaver Creek Tank (0.6 MG), 5 MG Tank Complex (containing 2 MG and 3 MG), the West Rifle Tank (0.6 MG), and the Northeast Tank (1.0 MG). The current available storage capacity within the system is adequate for the existing storage volume requirements for the operational, fire, and emergency flows as shown in Table 9. The Rifle and Beaver Creek Tanks are fed by gravity from the City Pressure Zone, while the Northeast Tank and Airport Tanks are filled from booster pump stations.

Table 9 – Storage Volume Requirements for Existing Demand

Storage Volume Type	Volume (MG)	Description
Operational	0.64	4 hours of peak day flow
Fire Flow	0.54	3 hours of 3,000 gpm
Emergency	2.39	24 hours of summer average day
Total Storage Required (MG)	**3.57**	
Available Storage (MG)	**8.20**	
Excess Storage (MG)	**4.63**	

The current available storage capacity within the system is also adequate for future storage volume requirements for the operational, fire flow, and emergency flows as shown in Table 10.

Table 10 – Storage Volume Requirements for Future Demand

Storage Volume Type	Volume (MG)	Description
Operational	1.19	4 hours of peak day flow
Fire Flow	0.54	3 hours of 3,000 gpm
Emergency	4.40	24 hours of summer average day
Total Storage Required (MG)	**6.13**	
Available Storage (MG)	**8.70**	
Excess Storage (MG)	**2.07**	

There is a redundant 0.5 MG tank currently under design at the Airport Tank site to provide additional fire flow for the airport facility. Construction should commence in 2021. This will increase the available storage to 8.7 MG.

Booster Pump Stations and PRVs

The booster pump stations are situated throughout the City to pump potable water from lower pressure zones to higher pressure zones. The PRVs throughout the system are designed to reduce pressure to acceptable pressure while utilizing the storage and distribution system in the higher pressure zones. There are three booster pump stations within the distribution system. There are four finished water pumps from the WPF transporting flow to the 5 MG Tank Complex and City Pressure Zone. The Northeast Booster Station is located at the 5 MG Tank Complex where potable water is pumped from the City Pressure Zone to the Northeast Tank and Northeast Pressure Zone. From the City Zone there are nine PRVs to regulate pressure between the six pressure zones:

- Four PRVs between the City Pressure Zone and the Intermediate Pressure Zone;
- One PRV between the City Pressure Zone and the Northeast Pressure Zone;
- Two PRVs between the City Pressure Zone and the West Rifle Pressure Zone;
- One PRV between the City Pressure Zone and the Village Drive Pressure Zone; and
- One PRV between the City Pressure Zone and the Airport Pressure Zone.

There are also two valves, one that regulates flow into the Airport Pressure Zone (normally closed) and one manually operated valve to regulate flow into the Beaver Creek Tank. The third booster pump station consists of three pumps that boost flow to the Airport zone and tank. The final two PRVs within the system are between the Northeast Pressure Zone and the Intermediate Pressure Zone. A figure of the pressure zones is attached as Figure A3 in Appendix A.

Limiting Factors

The City has identified redundancy and increased capacity needed from the WPF and the 5MG Storage Tank Complex.

At the south end of the City Pressure Zone, redundancy is needed for the pipeline to the Beaver Creek Tank.

COLLECTION SYSTEM

The City's sanitary sewer collection system is comprised of north and south gravity collection and a south lift station and force main. The collection system on the north side of the Colorado River generally drains north to south before draining west to the WWRF. The collection system on the south side of the Colorado River generally drains west to the only lift station in the system. Flows are pumped to an interceptor main near the WWRF. The WWRF discharges into the Colorado River. The collection system layout can be seen in the Overall Utility Map (Figure A1 in Appendix A). The largest collector sewers are shown on the Interceptor Map, attached as Figure A4 in Appendix A.

COLLECTION SYSTEM

There is a total of approximately 292,800 lineal feet of active sewer pipe within the collection system with pipe sizes ranging from 4 inches to 30 inches. The majority of the pipes are 8-inch mains that connect into the larger interceptor system. The pipe materials include PVC, vitrified clay (VCP), AC, transite, and concrete. The older pipe in the system is mostly VCP that has a higher probability of cracking and allowing inflow and infiltration into the system.

INTERCEPTORS

The collection system has major interceptors that collect flows from the mains. The South Rifle Interceptor is located on the south side of the Colorado river and consists of mainly 10-inch pipe. The North Rifle Interceptor runs from northern edge of the town south along Rifle Creek before being directed to the east to the WWRF. The Rifle Creek Interceptor is mostly 18-inch pipe but does have some 30-inch pipe near the WWRF. However, there is a section of pipe near Rifle Creek where the pipe is reduced from 18-inch pipe to an 8-inch pipe before returning to an 18-inch pipe and there are capacity concerns when pipe sizes are reduced downstream. The Park Avenue, Palomino Park, Deerfield Park, and Morrow Drive Interceptors all connect to the North Rifle Interceptor at varying locations. The 2008 Inflow and Infiltration Study by Schmueser Gorder Meyer, Inc. states that the Deerfield Park and Palomino Park Interceptors have identified inflow and infiltration while City staff have stated there is major infiltration in the South Rifle Interceptor and collection system during storm events. The interceptor alignments are shown in Figure A4 in Appendix A.

LIFT STATIONS

The collection system has one lift station, the South Lift Station, required to pump sewer flows from the south side of the Colorado River to the north side to be treated at the WWRF. The lift station is located at the abandoned South Wastewater Treatment Plant and previously functioned as the old plant's influent pump station. The topography of the south side of the River allows for gravity flow from the Airport to the lift station. The lift station pumps have a design flow of 350 gpm with a total dynamic head of 32 feet. The lift station has dual pumps for redundancy and has a 6-inch force main with future plans to provide a 4-inch parallel force main for redundancy.

Condition Assessment

The condition of the lift station building is poor including recent roof failures. There is currently no redundancy or bypass piping for the trash pump, the backup engine driven pump is only sufficient for redundancy of one pump, and the Duperon Rake screen system has no washer compactor which requires operators to manually haul buckets of screenings.

Wastewater Treatment Facility

The WWRF was constructed to replace the old North Wastewater Treatment Plant and South Wastewater Treatment Plant. The new WWRF was brought online in 2009. The WWRF was designed for a peak flow of 5.0 MGD. It has a hydraulic capacity of 2 MGD MMADF with the potential for expansion up to 4 MGD.

Treatment Process Overview

Headworks

Wastewater flows to the WWRF via a 30-inch influent pipe which discharges to a concrete channel at the inlet of the headworks building. A step screen with an integrated washer compactor removes screenings and discharges them through an overhead discharge chute into a dumpster in the northeast corner of the building. There is also a bypass channel with a manual bar screen available as a back-up to the mechanical screen. After screening, grit is removed in an in-floor vortex grit chamber, and the separated grit is pumped to a grit cyclone and classifier in the same area as the screenings dumpster.

Wastewater exits the vortex grit chamber and flows through a 12-inch Parshall flume to the influent pump station wet well on the east side of the building. The wet well is equipped with ultrasonic level sensors which maintain a water depth between 4.9 and 7.9 feet above the bottom of the tank. The pump station currently has three Gorman Rupp pumps which pump the raw wastewater from the wet well via a 16-inch ductile iron pipe (DIP) discharge line. The raw wastewater is then combined with return activated sludge (RAS) and digester decant in a 30-inch DIP line and conveyed to the oxidation ditch splitter box. The influent pump station area has space for two additional pumps if future expansion is needed.

SECONDARY TREATMENT

The WWRF consists of three oxidation ditches in series for secondary treatment. The volume of each oxidation ditch is 666,666 gallons for a total treatment volume of 2,000,000 gallons. The ditches are designed for a combined influent, RAS, and digester decant flow of 4.0 MGD with a peak flow of 8.0 MGD.

At the splitter box, the influent flow is split into two, 24-inch DIP lines which feed into Oxidation Ditches #1 and #2, the easternmost and middle ditches, respectively. All three ditches are hydraulically connected by 48-inch sluice gates in the shared walls between the ditches and also by a 24-inch transfer line connecting Ditches #1 and #3. The ditch channels are 30 inches wide. Weir gates in Ditches #2 and #3 maintain a water depth throughout the system of approximately 14 feet.

Oxidation Ditch

Each of the three oxidation ditches are equipped with four, 30-horsepower (HP) Siemens disc aerators. The WWRF generally runs just one aerator at a time in Oxidation Ditches #1 and #2. The aerators are ramped up or down to maintain oxidation reduction potentials of +50 millivolts in Ditch #1 and -50 millivolts in Ditch #2. The aerators in Oxidation Ditch #3 are operated to maintain a dissolved oxygen level around 1.5 mg/L. Operators use two hoists per aerator to pull motors for maintenance.

Wastewater exits the secondary treatment process over the weirs in Oxidation Ditches #2 and #3. The oxidation ditch effluent is collected in the weir boxes and combined in a 30-inch effluent line which flows to the clarifier splitter box.

SECONDARY CLARIFIERS

Mixed liquor from the oxidation ditches flows from the clarifier splitter box to the secondary clarifiers. There are three, 60-foot circular secondary clarifiers that are operated in parallel. The WWRF currently operates all three clarifiers simultaneously, except for occasional draining for cleaning. Fiberglass weirs maintain a water depth of 14 feet; the total volume of each clarifier is 296,088 gallons. Clarified water flows over the weirs at the top of the tank and collected in an 18-inch effluent line.

Activated sludge settles to the bottom of the clarifiers and is removed at the bottom of the tank using a rotating suction mechanism that is connected to RAS pumps equipped with variable frequency drives. The RAS is conveyed via an 8-inch line to either the oxidation ditch or to solids handling. Foam and scum are skimmed from the water surface using a rotating scum blade and removed via a 6-inch line and conveyed to the interchange tanks.

RAS from the secondary clarifiers is pumped to the UV/RAS building. The RAS pumps discharge into a common 12-inch pipe which splits into RAS and waste activated sludge (WAS) lines. The RAS line is equipped with a magnetic flow meter which regulates how much RAS is conveyed back to the oxidation ditch splitter box. The remainder of the sludge is pumped to the interchange tanks as WAS.

UV Disinfection and Effluent Discharge

Effluent from the three clarifiers is combined in a 30-inch line and conveyed to the UV/RAS building. The WWRF has three, non-contact ultraviolet (UV) disinfection units located on the lower level of the building; there is also space for two addition units if needed for capacity in the future. The UV system is no longer supported by the manufacturer and the WWRF has had difficulty finding replacement ballasts for the units.

UV Disinfection Units

The disinfected effluent exits the three UV units and is discharged to the effluent pump station wet well in the southwest corner of the UV/RAS building. Normally the treated wastewater flows via gravity through a 30-inch effluent pipe which discharges to the Colorado River. If the level of the Colorado River gets too high to allow for gravity flow, an ultrasonic level transducer triggers the electrically-actuated sluice gate on the effluent pipe and turns on the effluent discharge pumps. There are three Gorman Rupp, 25-HP effluent discharge pumps (and space for a fourth) located on the upper level of the UV/RAS building. These pumps discharge to a 10-inch header which is connected to the 30-inch effluent pipe on the other side of the sluice gate.

Aerobic Digestion

WAS and scum from the clarifiers are pumped from the UV/RAS building to the two, 60-foot-diameter interchange tanks on the south side of the site. The term “interchange tank” is a relic of the Cannibal system that was the planned treatment process for the WWRF, but these two tanks are, in practice, aerobic digesters. The two tanks are 296,089 gallons each and have maximum water depths of 14 feet. WAS is aerated using two 15-HP, propeller-type mixers in each tank as well as 6-inch, PVC aeration headers at the bottom of the tanks.

WAS is conveyed from the interchange tanks to two, 55- by 35-foot rectangular digesters operated in parallel for additional aerobic digestion. The digesters are 201,600 gallons each and have a working depth of 14 feet. There are two propeller-type floating aerators per basin. The supernatant is removed by floating decanters and pumped via two decant pumps in the UV/RAS building to the oxidation ditches. Settled sludge is also pumped to the UV/RAS building and discharged to biosolids handling in the headworks building.

BIOSOLIDS HANDLING

Sludge from the aerobic digestion process is pumped to the headworks building via a 6-inch pipe and dewatered with a Tritan belt press and a Velodyne polymer system. The WWRF currently produces approximately 15,714 to 20,000 gpd of sludge at 1 to 1.5 percent solids (or 1,678 to 1,984 ppd of digested sludge). The belt press has a maximum solids loading rate of 750 pounds per hour (lb/hr). The belt press discharges the solids onto a conveyor which transports the dewatered cake to a roll-off dumpster on the main level of the headworks building. After dewatering, the WWRF produces approximately 83,179 to 98,328 pounds of cake per week at 13 percent solids. The cake is periodically hauled to a landfill; according to staff, the WWRF currently spends approximately $100,000 annually on landfill tipping fees. The pressate from the belt press is drained back to the influent to the oxidation ditches.

The belt press requires substantial operator oversight while it is running. To reduce operator workload and add redundancy to the solids handling system, the WWRF plans to install a single, 460 lb/hr screw press which will become the primary solids handling equipment for the plant. The WWRF will keep the existing belt press as backup. The WWRF submitted a Site Application for this project to the CDPHE in September 2020.

CONDITIONS ASSESSMENT

The WWRF is 12 years old and is largely operating well. Solids handling is the staff's main concern, and it is anticipated that this issue will be resolved with the addition of the new screw press, which is currently under design.

Ongoing maintenance needs include re-lining concrete tanks and channels. At the time of the site visit, the intake channel to the headworks building and Clarifier #1 both needed to be re-coated.

The control board in the headworks building is starting to fail and technical support is no longer covered by manufacturer.

The interchange tanks are currently operated as digesters, which is not what those tanks were designed to do. During the winter, the WWRF experiences bulking and foaming issues in the interchange tanks, digesters, and, to a lesser extent, the oxidation ditches.

The programmable logic controller (PLC) system for the UV disinfection units is not currently working. Staff also has trouble finding replacement ballasts for the UV system.

LIMITING FACTORS

The WWRF is currently operating at an MMADF of 1.03 MGD and a maximum month loading of 2,769 ppd, well below its design capacity of 2 MGD influent flow and 5,421 ppd influent organic loading. The WWRF was planned with an expansion up to 4 MGD; the plans include space for additional pumps and treatment units across all process areas.

The current bottleneck at the WWRF is solids handling and hauling. Adding a screw press will add redundancy and increase operator flexibility. However, the WWRF has used the same contract haulers for at least a decade which can only haul a limited volume of solids every week.

WASTEWATER EFFLUENT QUALITY

In October 2017, the CDPHE Water Quality Control Commission (WQCC) made changes to Colorado's nutrient management control regulations (Regulation 85 and Regulation 31). These changes indicate that over the next decade, from 2017 to 2027, the WQCC will develop or revise water quality standards for total nitrogen, total phosphorus, chlorophyll, ammonia, cadmium, arsenic, selenium, and temperature. Regulation 85 is the current rule, but CDPHE intends to replace Regulation 85 with Regulation 31 in 2027.

CDPHE Regulation 85 limits the total inorganic nitrogen (TIN) and total phosphorus (TP) concentrations of domestic and non-domestic wastewater treatment facilities to annual medians of 15 mg/L and 1 mg/L, respectively. Plants built before May 31, 2012, with design capacities of 2.0 MGD or less, which includes the Rifle WWRF, are subject to Regulation 85's "delayed implementation of effluent limits," as discussed in Section 85.5(1)(a)(ii) of the rule. This means that the WWRF is excluded from the regulation until May 31, 2022. However, any discharge permit issued for the WWRF after May 2022 may include the lower TIN and TP limits. Regulation 85's TIN and TP limits are based on the annual median effluent concentrations and the 95th percentile of all samples. The historical TP effluent concentration, along with the running annual medians, are shown in Figure 11 below.

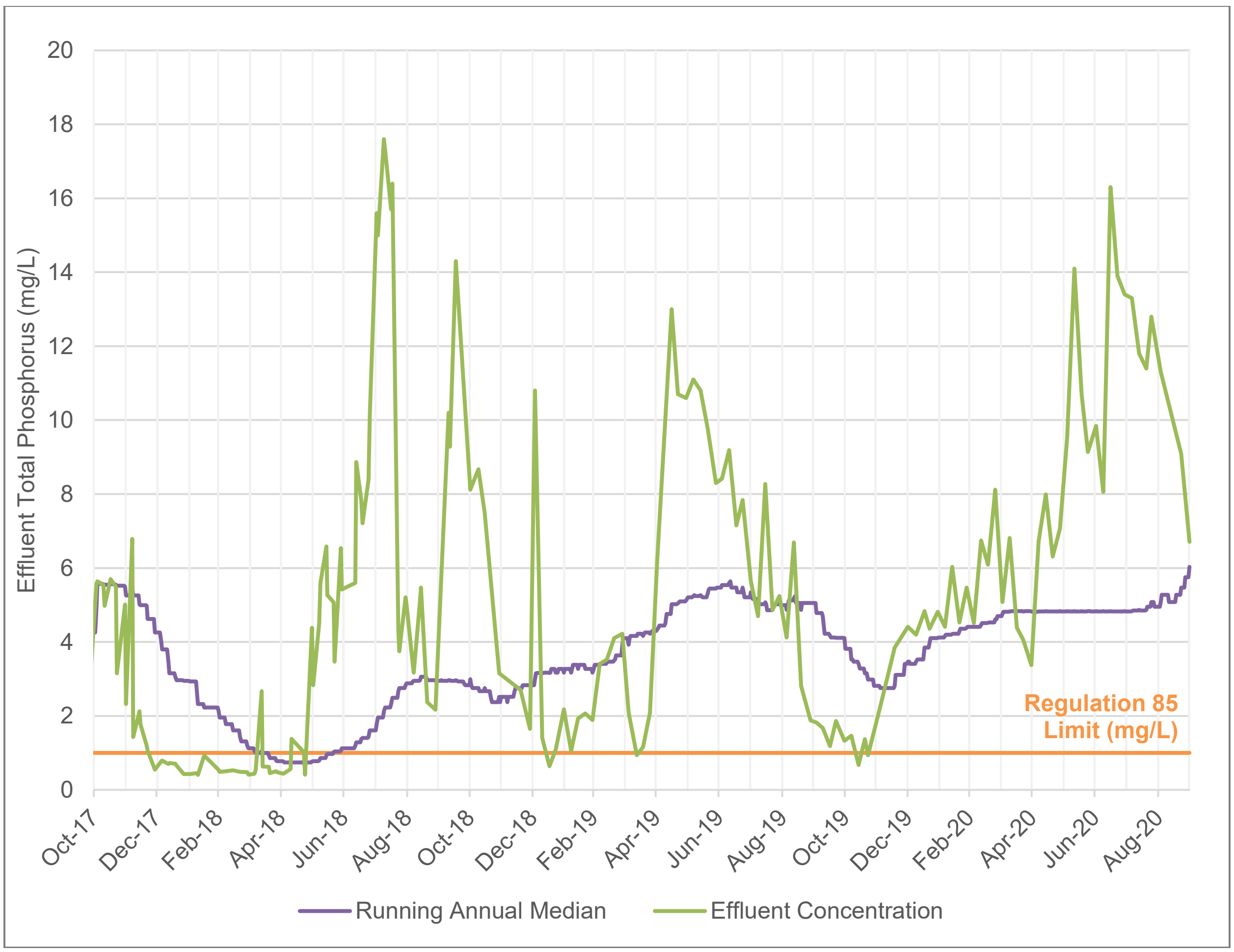


Figure 11. Historical Effluent Total Phosphorus Concentration

The historical TIN effluent concentration, along with the running annual medians, are shown in Figure 12 below.

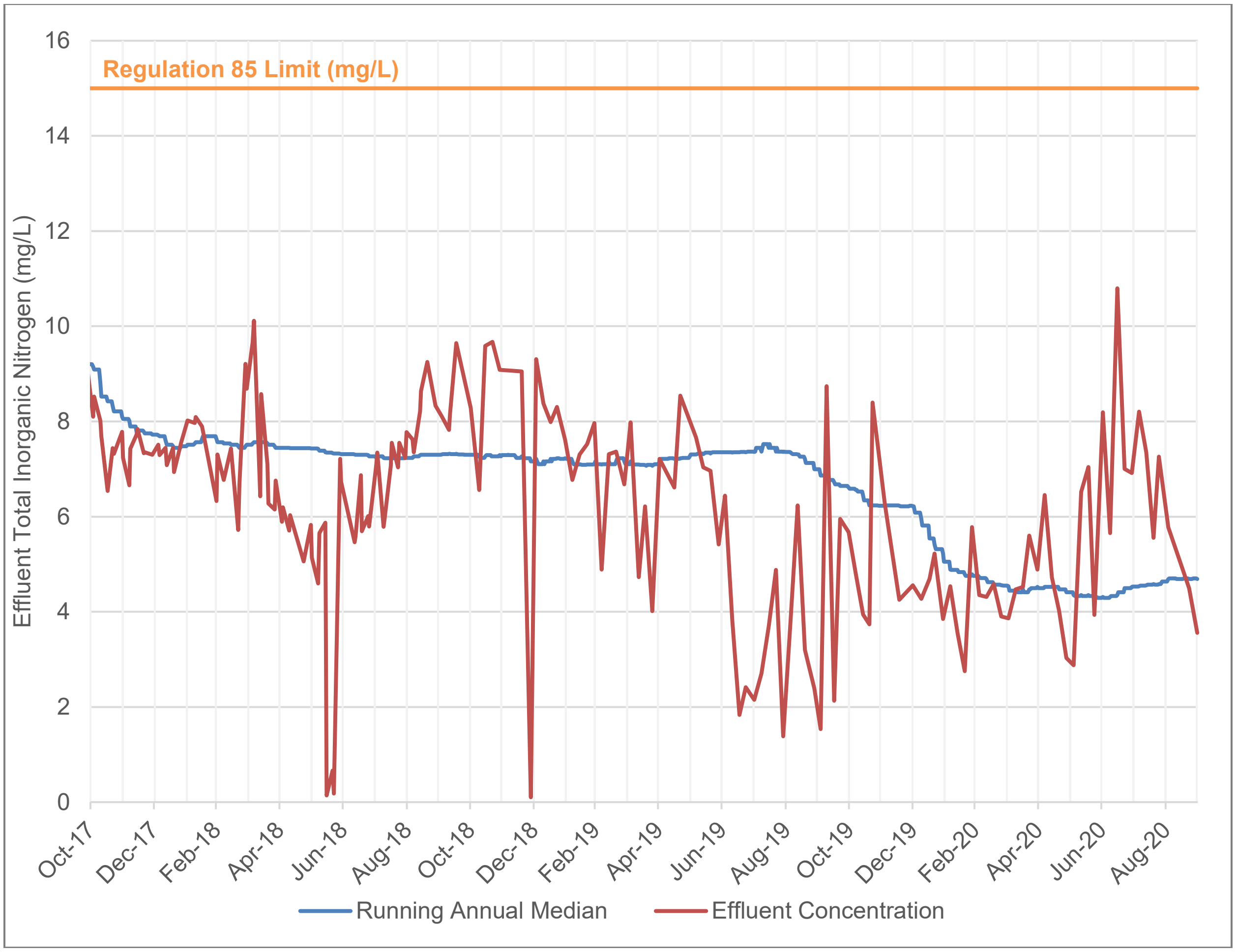


Figure 12. Historical Effluent Total Inorganic Nitrogen Concentration

The Rifle WWRF effluent TP and TIN concentrations from October 2017 through September 2020 are also summarized below in Table 11.

Table 11 – Historical Effluent Water Quality

	Total Phosphorus (mg/L)				Total Inorganic Nitrogen (mg/L)			
Year	Annual Median	Reg. 85 Annual Median Limit	95th Percentile	Reg. 85 95th Percentile Limit	Annual Median	Reg. 85 Annual Median Limit	95th Percentile	Reg. 85 95th Percentile Limit
2017 (Oct-Dec)	4.3	1.0	8.1	2.5	7.7	15	9.6	20
2018	2.8		15.6		7.2		9.6	
2019	3.5		10.8		6.2		8.5	
2020 (Jan-Sep)	6.8		13.9		4.7		8.2	

As shown in Table 11, the Rifle WWRF has not met the Regulation 85 TP guidelines since at least October 2017. The annual median of effluent TP concentrations ranged from 2.8 to 6.8 mg/L, exceeding the Regulation 85 limit of 1.0 mg/L; the 95th percentile of effluent TP concentrations ranged from 8.1 to 15.6 mg/L, substantially exceeding the Regulation 85 limit of 2.5 mg/L. However, the Rifle WWRF met the Regulation 85 limits for TIN on both an annual median and a 95th percentile basis between October 2017 and September 2020.

CDPHE plans to adopt revised nitrogen and phosphorus limits in 2027 as part of Regulation 31. It is possible these limits will be even lower than the existing Regulation 85 TIN and TP limits. Section 85.5(1.5) of Regulation 85, as well as a CDPHE policy document referred to as Policy 17-1, outlines a Voluntary Incentive Program that allows a facility to extend the compliance schedule to adopt the new nutrient limits anticipated in 2027. As discussed in Section VI.1 of Policy 17-1, the Incentive Program grants a facility additional months to comply based on the facility's annual median TP or TIN concentrations. No credit is earned for annual medians above the existing Regulation 85 standards.

The WWRF enrolled in the Voluntary Inventive Program in 2018. As discussed above, Rifle WWRF has not historically met the Regulation 85 TP limit of 1 mg/L. However, it has consistently met the TIN limit of 15 mg/L. Under Policy 17-1, the Rifle WWRF could extend its Regulation 31 compliance schedule up to 1 year for every year it achieves an annual median TIN concentration less than 7 mg/L, as it did in 2019. For years in which the TIN annual median is above 7 mg/L but below 15 mg/L, the WWRF will earn relatively less additional compliance time based on a sliding scale to a maximum of one year.

SALINITY

The renewed NPDES discharge permit issued by CDPHE that took effect in April 2015 identified that the WWRF effluent TDS had exceeded the Colorado River Salinity Standards threshold of 1.0 ton per day or 350 tons per year, based on the results of quarterly samples required by the previous permit. CDPHE calculated the average WWRF TDS value to be 3.7 tons per day. Due to this exceedance, CDPHE required the City to provide a report that determined whether achieving an effluent TDS concentration of less than 1 ton per day is economically feasible. If the cost is demonstrated to be unreasonable, a waiver to the TDS requirement can be granted. In 2015, the City commissioned SGM to conduct a study into the probable costs of developing a TDS removal process as part of the overall WWRF and to produce a report outlining the findings and the implication on utility rates. SGM's report, titled *2015 Salinity Report,* indicated that the estimated cost of the treatment processes needed to meet the salinity threshold of the Colorado River Salinity

Treated Effluent Leaving the Disinfection Room

Standards would require a 93 percent increase in sewer service rates. The conclusion of the report was that it was not economically feasible for the population served by the WWRF to absorb a rate increase of this magnitude. The City submitted the report to the CDPHE Water Quality Control Division (WQCD) on August 31, 2015. CDPHE has not granted the City a TDS waiver but did administratively extend the permit in 2019, which requires only quarterly reporting of effluent TDS concentrations.

Another more site-specific approach that CDPHE takes to regulating salinity in the Colorado River is to allow an incremental increase of 400 mg/L of TDS over the baseline TDS concentration in the source water. This allows systems with particularly high raw water TDS to avoid being penalized for discharging more than 1 ton per day or 350 tons per year due to the high influent loading. The 2015 discharge permit fact sheet indicates that the City had not been collecting raw water TDS data since 2008 and that CDPHE was consequently unable to assess the salinity discharge using the incremental increase approach. According to the WWRF DMRs, the City is currently collecting quarterly influent TDS samples along with the monthly effluent TDS samples. Although quarterly influent samples are all that are required by the permit, more frequent sampling may benefit the City by demonstrating a higher annual average background TDS in the source water resulting in higher allowable effluent concentrations with the 400 mg/L incremental increase.

SECTION 4 – GIS MAPPING AND ASSET MANAGEMENT

GIS MAPPING AND DATA

The ESRI GIS mapping system offers the ability to visually depict and communicate data as it is spatially located. The City has an extensive GIS database that includes the water distribution and sewer collection systems. The database includes water pipes and structures and sanitary pipes and structures with attribute data consisting of installation date, size, material type, and status. Other data such as waterline break locations, identified defects based on closed-circuit television (CCTV) analysis, inflow and infiltration reports, bottleneck locations, high groundwater locations, and background data from Garfield County and the State were used in the creation of the asset management priority grading. The use of GIS allows for organizing, mapping, and selecting features within the shapefiles to populate the condition and criticality grades and create a prioritization of the pipe segments.

PRIORITIZATION SYSTEM BASED ON CONDITION AND CRITICALITY

Prioritization of the City's distribution and collection system pipes can be used to create a proactive evaluation program that uses a calculated priority grade to determine timing on when inspection and ultimately rehabilitation or replacement should occur. The final priority grades distinguish the pipe segments on a scale from 1 to 5 with 5 being the highest priority. A pipe segment can be any length and is dependent on how it is drawn into GIS. For the sewer collection system, a pipe segment is usually from manhole to manhole. For the distribution system, a pipe segment is usually from valve to valve or fitting to fitting.

The priority grades are determined based on a matrix using condition and criticality grading factors. Overall, the priority grades will allow the City to have a better understanding of where within their system they should focus inspections and more in-depth evaluations. The prioritization grading will provide improved estimates of service life. The program should reduce the frequency of emergency repairs, extended service disruptions, restoration costs due to environmental and property damage, and premature pipe replacement or rehabilitation.

The prioritization final grade depends largely on the input data. This input data includes criticality and condition factors. The criticality factors include the pipe's probability of failure and the consequence of failure within the system. The pipes condition is based on the structural condition of the pipe. The probability of failure is the likelihood of failure to occur based on physical characteristics of the pipe, the installation conditions and methods, and environmental conditions. The consequence of failure is based on the impact of failure related to the pipe location, the community effects, and costs for the loss of service and safety.

The condition grade is usually based on a single factor that relates to the overall structural condition of the pipe. Inspection reports from visual inspections or non-destructive inspection techniques for the entire system are the best option for the condition grade. However, not all of the City's collection and distribution systems have inspection records or break and repair history records. Another condition factor that could be used is capacity of the system that would inform where there could be major design issues in the system and would usually be a probability of failure factor. However, this was unavailable for the City's system. In the future, hydraulic modeling could be done to determine capacity of water and sewer pipe segments.

Without complete inspection data records, it was determined to use the age of the system for the collection system condition grade because as the pipe age increases the condition of the pipe typically deteriorates. The material of the distribution system pipe was used for its condition grade because the City indicated that the material of the pipe within their system can contribute greatly to degradation of a pipe. High groundwater along with poor poly-wrapping during installation increases corrosion for some of the pipe materials and requires the pipes to be replaced. Furthermore, pipe materials such as AC should be removed from the system as they are a hazard and could be dangerous if a break occurs. The condition factor can be changed as more information is gathered during rehabilitation, repairs, and replacements.

WATER DISTRIBUTION SYSTEM

CRITICALITY GRADE

The water distribution system has two categories that define the criticality grade: probability of failure and consequence of failure. The probability of failure is based on the physical condition of the pipe. The consequence of failure focuses on the impact a pipe failure will have on the community or environment.

The criticality grade is split into these two categories to allow for specific analysis to be performed on each factor before being combined into the criticality grade. The probability of failure and consequence of failure grades are determined using a weighted percent of the factor grades. The weighted percent allows for the City to determine which factor should have greater emphasis. Table 12 below shows the suggested weighted factors for the distribution system. Note that the more factors that are analyzed for the probability and consequence of failure, the more the weighted percent values need to be spread between the factors.

There are only three probability of failure factors, allowing for greater weight to be placed on any particular factor. Conversely, the consequence of failure grade has nine factors over which to assign percent weights. As the City becomes more accustomed to the consequence of failure factors, the weighted percentages can be adjusted.

Table 12 – Distribution System Weighted Percent Values for Failure Factors

Probability of Failure			
Probability Factor	**Weighted %**	**Grade**	**Note**
Age	50%	0-10	Older Pipe Higher Grade
Proximity to Break	35%	0 or 10	Within 10’
Pressure Zone	15%	0 or 10	10 if Greater than 100 psi
Total	**100%**		
Consequence of Failure			
Criticality Factor	**Weighted %**	**Grade**	**Note**
Non-redundant	10%	0 or 10	Non-Looping Transmission Main
Dead-ends	4%	0 or 10	Pipe dead-ends/smaller non-looping
Type of Customer	15%	0-10	Based on Customer Type
Proximity to Waterway	6%	0 or 10	Within 50’
Pipe Size	20%	0-10	Larger Pipe Higher Grade
Proximity to Road Type	6%	0 or 10	Within 50’
Ease of Access	6%	0 or 10	Further than 50’ from Road
Bottleneck	8%	0 or 10	Identified by City Staff
Road Replacement	25%	0 or 10	10 if on or crosses Road Replacement
Total	**100%**		

Probability of failure factors include the following:

- Age of the pipe
- Proximity to a previous waterline break
- Pressure zone.

The age of the pipe is important and has the highest weighted percent because as the pipe gets older the quality of the pipe usually deteriorates. The proximity to a break has the second highest weighted percent because if a pipe has a record of a break it is highly likely it will have another break in a nearby segment or within that same segment. The pressure zone factor specifically identifies pipes that should have a pressure higher than 100 psi which would cause deterioration of the pipe at a quicker rate due to the pressure on the inner pipe walls and fittings. The grade allocation for the distribution system with suggested ranges is provided in Appendix C.

Consequence of failure factors include the following:

- Located along a future road replacement project
- Size of the pipe
- Type of customer affected
- Non-redundant
- Dead-end
- Proximity to the type of road
- Proximity to a waterway

- Ease of access
- Bottleneck

The highest weighted percentage factor is the road replacement factor because it is important that the pipes that intersect or are parallel to the road replacement project be inspected and rehabilitated or replaced before the roadwork occurs. Otherwise, if a failure in the pipe occurs the new road will be damaged by the repairs. The pipe size has the second highest weighted percentage because the larger the pipe the more connected customers will be affected and the higher the cost for repair.

The type of customer is also a high weighted percent because if a pipe were to break near the airport or medical care facility the effect to the community is high and having the water service down for those facilities for long periods of time is not acceptable. The lowest weighted factor is if the transmission main pipe is non-redundant, meaning there is no parallel pipe or looped pipe for the larger diameter pipes. If that non-redundant pipe fails, there is a high cost for repairs and outages for all that is fed by the pipe. The dead-end factor accounts for areas in the system where there are dead-end lines that do not loop or smaller branch pipes that service mostly residential properties, but will have a cost to that area if there is a pipe break because there would be no service to the area. The roadway types used in are highway, major road, local road paved, and local road gravel and consider it more expensive to have to repair a pipe within a highway than a gravel road.

The final probability of failure grade and consequence of failure grades was calculated by multiplying by the specific weighted percent and summing the factor grades. The criticality grade is then determined based on where the probability of failure grade and consequence of failure grade falls on the criticality matrix, as shown in Figure 13. The criticality grades range from 1 to 10, with the higher the grade indicating the more critical the pipe is in the system.

Probability of Failure Grade											
	10	0	1	0	0	2	0	0	0	0	0
	9	0	2	0	4	1	1	0	0	0	0
	8	4	9	0	3	2	1	0	0	0	0
	7	5	18	15	6	9	0	0	0	0	0
	6	9	5	13	2	2	1	0	0	0	0
	5	7	25	33	7	34	19	2	0	0	0
	4	7	94	83	8	19	4	1	0	0	0
	3	68	268	154	57	37	12	0	0	0	0
	2	9	89	42	14	3	1	0	0	0	0
	1	9	130	115	20	26	2	0	0	0	0
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
		Consequence of Failure Grade									

Figure 13. Distribution System Criticality Grade Color Matrix

The grades associated with the color matrix are the following:

- Red: 5

- Orange: 4
- Yellow: 3
- Blue: 2
- Green: 1

Red represents the most critical grade and green represents the least critical pipes within the system. The count of pipes for each criticality grade is provided in Table 13.

Table 13 – Distribution Criticality Grade Summary

Color	Grade	Count	Pipe Lineal Footage
Green	1	884	191,796
Blue	2	448	164,232
Yellow	3	150	44,400
Orange	4	32	16,995
Red	5	0	0
Total	**-**	**1,514**	**417,423**

CONDITION GRADE

The condition grade accounts for the structural condition of the pipe based on the single factor of the material type. The grades ranges from 0 to 5 based on the material types potential for structural failure. A grade of 0 means that the pipe material has a low concern for degradation or deterioration that would cause a break in the pipe. After talking with the City, it was agreed that the pipes with the material of AC and transite have the highest grade of a 5. DIP and cast iron pipe are the next highest pipe grades due to the concern of poorly installed polywrapping on the pipes and the high groundwater that could easily cause corrosion and deterioration of the pipes. The pipes with grades of 3 are steel and all pipes with unknown material type. The PVC and C900 pipes are likely the same pipe material and have the lowest probability of failure and have a grade of 0. Table 14 provides all types of material known within the system, the condition grade given to the material, the final number count of how many pipes there are for each grade, and the total lineal footage for each grade.

Table 14 – Distribution System Condition Grade Summary

Material	Grade	Count	Pipe Lineal Footage (ft)
AC/Transite	5	67	17,041
Cast iron	4	33	12,992
DIP	4		
Steel	3	430	48,028
Fire	3		
Not C900	3		
Blank	3		
Class	2	188	75,051
HDPE	1	9	2,718
Copper	1		
PVC	0	787	261,593
C900	0		

Collection System

Criticality Grade

The criticality grade for the collection system is calculated using the same method described for the water distribution system. However, the number and type of factors differ.

There are five probability of failure factors and seven consequence of failure factors. As with the water distribution system, the City can adjust the weighted percent for each factor. These are summarized in Table 15. The grade allocation for the collection system with suggested ranges is provided in Appendix C.

Table 15 – Collection System Weighted Percent Values for Failure Factors

Probability of Failure			
Criticality Factor	**Weighted %**	**Grade**	**Note**
Identified I/I	18%	0 or 10	I/I Report/City Info
Material	25%	0-10	Depends on Material Type
High Groundwater	5%	0 or 10	North of River
CCTV Inspected	2%	0 or 10	From City Reports
Defect grade	50%	0-10	From CCTV Inspections
Total	**100%**	--	--
Consequence of Failure			
Criticality Factor	**Weighted %**	**Grade**	**Note**
Distance to WL	5%	0 or 10	Within 50'
Distance to Waterway	5%	0 or 10	Within 50'
Pipe Size	18%	0-10	Large Pipe Higher Grade
Proximity to Road Type	7%	0 or 10	Within 50'
Ease of Access	5%	0 or 10	Further than 50' from Road
Type of Customer	20%	0-10	Based on Customer Type
Road Replacement	40%	0 or 10	10 if on or crosses Road Replacement
Total	**100%**	--	--

Probability of failure factors include the following:

- Pipe was identified to have inflow or infiltration
- Material of the pipe
- Pipe is located in a high groundwater area
- Pipe has been inspected and defects identified using CCTV
- The level of the largest defect rating identified during the CCTV inspection, as based on the national pipe defect rating system

For the pipes that undergo CCTV inspections, the defect rating provides a value from 1 to 5. This value represents how greatly the condition of the pipe is affected by the defect. Defects include roots, offset joints, debris, sags, breaks, cracks, and poorly constructed repairs. The pipes with defect ratings were given a higher weight percent because these are identified condition issues. However, since all of the system has not had CCTV inspections only the portion of the system will be affected by the defect factor. It is important to identify the pipes that have been inspected by CCTV as knowledge of the condition of the pipe is important. Once the entire system is inspected this factor can be removed. The pipe material was also given a high weight percent because the type of material can affect the condition of the pipe. The high groundwater concerns in several areas of the system and identified inflow and infiltration into the system are high concerns for capacity issues.

The consequence of failure factors for the collection system are the same as those for the water distribution system. The list has been included again here for easy reference.

Consequence of failure factors include the following:

- Located along a future road replacement project
- Size of the pipe
- Type of customer affected
- Proximity to the type of road
- Proximity to a waterway
- Proximity to a waterline
- Ease of access

The highest weighted percent factor is the road replacement and as discussed in the distribution section it is imperative to inspect and repair or replace the pipe system before a new road is installed. The other higher weighed percent is the pipe size because as the pipe size increases the cost to repair the pipe increases and the effected service area increases. Just like with the distribution system the type of customer being affected by a break is important to identify especially the health care centers and the airport to ensure the pipes are inspected and mitigated before a break can happen. The pipe segments distance to a waterline has some importance because if the sewer line breaks and leaks sewage near the waterline there is a chance of contamination. This is the same with the proximity to a waterway and the harm that could occur if a sewer were leaking sewage near a waterway.

The criticality grade is based on where the probability of failure grade and consequence of failure grade falls on the criticality matrix, as shown in Figure 14.

Probability of Failure Grade	**10**	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	2	0	0	0	1	0	0
	7	0	2	3	0	0	0	0	0	0	0
	6	0	0	3	2	0	0	1	0	0	0
	5	0	4	5	8	1	0	1	0	0	0
	4	0	10	20	8	0	0	2	1	0	0
	3	2	81	186	98	4	0	5	4	0	0
	2	0	23	34	31	0	2	1	2	0	0
	1	8	252	308	56	0	6	20	16	0	0
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
		Consequence of Failure Grade									

Figure 14. Collection System Criticality Grade Color Matrix

The count of pipes for each criticality grade is provided in Table 16.

Table 16 – Collection System Criticality Grade Summary

Color	Final Grade	Count	Pipe Lineal Footage
Green	1	894	196,810
Blue	2	239	65,538
Yellow	3	72	28,518
Orange	4	7	1,753
Red	5	1	214
Total	--	**1,213**	**292,834**

CONDITION GRADE

The condition grade is the evaluation of the structural condition of the pipe. The age of the pipe was given a grade from 0 to 5; the older the pipe, the higher the condition grade. Pipe ages range from 1936 to 2020 with a small number of pipes lined in 2005. Lined pipes were assigned a condition grade based on the year they were lined. A grade of 5 was given to all pipes that were installed before 1950. A grade of 0 means the pipe has been installed since 2016. There were 168 pipe segments that did not have an installation date and therefore were given a grade of 2. Using the age of the pipe for the condition grade assumes that as the pipe is older there is a greater probability of structural defects, settling, or other damage to the pipe. A summary is provided in Table 17.

Table 17 – Collection System Condition Grade Summary

Final Grade	Count	Pipe Lineal Footage
0	18	3,320
1	165	45,024
2	375	73,638
3	483	120,871
4	66	22,554
5	106	27,427
Total	**1,213**	**292,834**

RESULTS AND RECOMMENDATIONS

The priority grade is the final grade for the pipe segments, determining the order in which the pipes should be investigated further and prioritized for rehabilitation or replacement. The priority grade is dependent on both the condition grade and the criticality grade and is determined by a color matrix. The condition grade has greater emphasis than the criticality grade because the condition of the pipe provides more information on if the pipe is likely to fail due to structural issues. The colors in the color matrix denote the following rehabilitation priority:

- Red: immediate
- Orange: high
- Yellow: medium
- Blue: low

- Green: not required

The distribution system shows 102 pipe segments within the red and orange priority that will need to be investigated immediately or in the near future to determine the condition of the pipe and if there are structural problems that will require rehabilitation or replacement of the pipes. Figure 15 shows the results of the priority grading for the distribution system. There are approximately 17,000 lineal feet of pipe within the red priority with a final grade of 5. The pipes should be considered for replacement since they are AC/transite material. It is important to look at the areas that the pipes are located and determine if there are adjacent segments that can be combined. The orange areas of the matrix that have a priority grade of 4 have approximately 15,800 lineal feet of pipe that should be inspected within the next 5 years. This can be completed with non-destructive inspection techniques such as leak detection, acoustic testing, or spot inspection. Figure C1 in Appendix C provides a map of the distribution system results of the priority grading for each pipe segment throughout the City.

Condition Grade (*Material*)						
	5	19	18	28	2	0
	4	9	10	9	5	0
	3	330	87	11	2	0
	2	87	76	18	7	0
	1	5	4	0	0	0
	0	434	253	84	16	0
		1	**2**	**3**	**4**	**5**
	Criticality Grade (*Probability and Consequence Failure Matrix Results*)					

Figure 15. Distribution System Priority Grade Color Matrix

The count of pipes for each criticality grade for the distribution system is provided in Table 18.

Table 18 – Distribution System Priority Grade Summary

Color	Final Grade	Count	Pipe Lineal Footage
Green	1	796	264,311
Blue	2	181	67,986
Yellow	3	435	52,238
Orange	4	35	15,847
Red	5	67	17,041
Total	--	**1,514**	**417,423**

The collection system has 173 pipe segments within the red and orange priority that will need to be investigated immediately or in the in the near future to determine the deterioration of the pipe and if there are structural problems that will require rehabilitation or replacement of the pipes. Figure 16 shows the results of the priority grading for the collection system. There is approximately 27,400 lineal feet of pipe within the red priority with a final grade of 5. The pipes should be inspected using CCTV methods to determine the structural defects within the pipes identified and those that are in the same area that could potentially be a part of the same project for required rehabilitation or repairs. The orange areas of the matrix that have a priority grade of 4 have approximately 23,100 lineal feet of pipe that should be inspected within the next 5 years. Figure C2 in Appendix C provides a map of the collection system results of the priority grading for each pipe segment throughout the City.

Condition Grade (*Age*)	**5**	46	30	25	5	0
	4	28	31	7	0	0
	3	369	93	20	1	0
	2	315	38	20	1	1
	1	120	45	0	0	0
	0	16	2	0	0	0
		1	**2**	**3**	**4**	**5**
	Criticality Grade (*Probability and Consequence Failure Matrix Results*)					

Figure 16. Collection System Priority Grade Color Matrix

The count of pipes for each criticality grade for the collection system is provided in Table 19.

Table 19 – Collection System Priority Grade Summary

Color	Final Grade	Count	Pipe Lineal Footage
Green	1	183	48,343
Blue	2	373	72,546
Yellow	3	484	121,402
Orange	4	67	23,116
Red	5	106	27,427
Total	--	**1,213**	**292,834**

It is important to understand that the results of the priority grades aid in providing direction on where the City staff should investigate within the system further to verify the actual condition of the pipe system. The collection system can be inspected using CCTV to determine the structural condition of the pipe.

Inspection of the water distribution system is more difficult. External infrared or sonic sensors and internal traveling sensors may provide condition information, but it can be expensive. It is recommended that the pipes with a grade of 5 based on the material should be placed on the schedule to be replaced rather than investigated. A hydraulic water model can provide an update to the condition grades based on demand capacity analysis and bottleneck investigations of the system. This can help narrow down wear future inspection, repairs or replacements, and improvements should be made. Table 20 provides a summary of the priority and when inspection should occur for the condition and criticality grades.

Table 20 – Inspection Schedule Summary

Condition	Criticality	Distribution Count	Collection Count	Implication	Rehab Priority	Time of Next Inspection (year)
0 or 1	5	0	0	Good or Excellent Condition	Not Required	10
	1-4	796	183		Not Required	15 – 25
2	5	0	1	Fair Condition, Minimal Structural Risk	Low	5
	1-4	188	374		Low	10 – 15
3	5	0	0	Poor Condition, Moderate Risk	Medium	3
	1-4	430	483		Low	5 – 0
4	5	0	0	Very Poor Condition, High Structural Risk	Immediate	0
	1-4	33	66		High	2 – 5
5	1-5	67	106	Failed or Imminent Failure	Immediate	0

NEXT STEPS

The next step for the City is to start a CCTV inspection program for the sanitary sewer system based on the priority grades. Since there are future street improvement projects that have been outlined for the next 5 years, it is imperative to inspect and determine which pipes the collection and distribution system are required to be rehabilitated or replaced within the areas of the street improvement projects.

The asset management priority grading program should be re-evaluated on a regular basis: every year as the program gets started and the databases updated and moving to every 3 to 5 years once the program is up in running. The program can also be enhanced if hydraulic models were incorporated into the analysis for capacity within the distribution and collection systems.

DATA COLLECTION FOR SYSTEMS

The existing GIS database system is relatively well populated. However, there is missing information on the installation data, material, and size for both the distribution and collection systems that should be populated based on as-built drawings, staff knowledge, and surrounding area data. For both the distribution and collection systems there is inaccurate spatial data that needs to be cleaned up. This includes using as-built drawings to draw in the pipe system as accurately as possible including removing manholes that have no pipes going to them, add manholes to pipes that do not have manholes at both sides, adding pipes between manholes, separating the water pipes based on water valves rather than having long runs of the pipe, and making sure all water and sewer pipes are in the databases. As this data is populated and the systems are cleaned up the priority grades can be updated.

The naming convention for the pipes, manholes, and valves is not consistent or is incomplete. It is important to be able to identify a pipe or structure based on an identification name that can be viewed not only in the GIS database, but on maps, spreadsheets, and other programs and provide a consistent and easily recognized identification when reviewing and evaluating the systems.

SECTION 5 – MAINTENANCE AND CAPITAL IMPROVEMENT PLAN

INTRODUCTION

The City has completed significant capacity expansions for both the water and wastewater treatment facilities recently enough that future treatment expansions are not anticipated until 2039 or later. Without capacity related projects, the City's focus is on utility maintenance projects and improvements for operations. This is reflected in the below recommended capital improvement plan and additional annual Operation & Maintenance budget items.

Before preparation of the Utility Study, the City had two significant capital projects identified for 2020 through 2023; the water utility RO/GAC Facility project and the wastewater utility Salinity Removal/Mitigation Solution project for an estimated cost of $80M combined. These two projects are no longer included in the CIP as near-term projects due to the uncertainty of the timing of regulatory requirements, limited water quality information available, and to avoid unintended negative impacts of changing the drinking water characteristics. Removing these two projects from the CIP significantly reduced the capital improvement projects total for 2021-2030. While these projects are no longer anticipated within the next ten years, salinity removal will likely be required and should be planned for within the next twenty years.

CAPITAL PROJECTS

Most of the capital improvement projects summarized below are identified in the condition assessment or limiting factors of the existing facilities evaluation. The capital improvements outlined below are arranged by category including:

- Water Purification Facility Improvements
- Water Distribution System Improvements
- Raw Water Improvements
- Wastewater Reclamation Facility Improvements
- Sanitary Sewer Collection System Improvements

The capital improvement projects are described in the same order as presented in the summary table for the 2021-2030 CIP provided in Appendix D. An opinion of probable cost (OPC) has been developed for the major improvement project recommendations presented in this plan. Some project costs were provided by the City. OPCs are also included in Appendix D.

SALINITY RELATED PROJECTS NOT INCLUDED IN THE 10-YR CIP

The RO/GAC Facility project was originally part of the last WPF expansion design but was ultimately removed as a cost savings measure during construction of the WPF. The RO/GAC project was not necessary as part of the expansion to meet water treatment regulatory requirements, but can be added to improve taste, smell, and reduce TDS, including salt, or salinity, in the drinking water. There are no current regulatory requirements that would require the City to treat for taste, odor, or TDS. However, regulatory requirements may be imposed on the City requiring salinity removal at the WWRF to limit salinity discharged to the Colorado River. It is uncertain when these projects would be required, however they are no longer included in the ten-year capital improvement plan.

Before these capital projects are re-entered in the CIP, JVA recommends completing a comprehensive study including a WPF raw water quality analysis to refine the RO/GAC Facility design and to evaluate a comprehensive salinity removal solution that includes RO/GAC salinity removal at the WPF and TDS removal at the WWRF. This study will evaluate cost savings in a comprehensive salinity removal solution including both an RO/GAC Facility at the WPF and Salinity Removal at the WWRF to meet future regulatory requirements when needed. A comprehensive salinity removal solution will likely reduce the total capital cost required, while both meeting regulatory requirements for wastewater treatment and improving the taste and aesthetic of the City's drinking water.

Additional Annual Operation & Maintenance Budget

In addition to the CIP project described in this section, the following annual budget items are recommended to be added to the City's current annual utility Operation & Maintenance budget to help ensure system reliability and performance.

Water Purification Facility Maintenance Projects

Building, equipment, and/or SCADA maintenance, operations improvements, pilot studies, or other project currently not listed in the 10-year CIP.

Years to Complete: Ongoing
Anticipated Cost: $100,000 per year

Distribution System Maintenance Projects

As the asset management program described in Section 4 is implemented, the highest priority pipeline rehabilitation or replacement projects will be identified based on condition and criticality. As the program becomes more sophisticated with additional condition assessment information, and hydraulic modeling results, specific distribution system maintenance projects may be identified and included in future annual budgets based on an engineering estimate. For the purpose of this Utility Study, to recognize an increase in distribution system maintenance projects, an annual budget equivalent to replacement of one percent of the total distribution system at an average cost of $100 per linear foot, and one additional distribution system operator is included.

Years to Complete: Ongoing
Anticipated Cost: $415,000 per year;
plus salary of one additional distribution system operator

Wastewater Reclamation Facility Maintenance Projects

Building, equipment, and/or SCADA maintenance, operations improvements, pilot studies, or other project currently not listed in the 10-year CIP.

> *Years to Complete: Ongoing*
> *Anticipated Cost: $100,000 per year*

Sanitary Sewer Collection System Maintenance Projects

As the asset management program described in Section 4 is implemented, the highest priority pipeline rehabilitation or replacement projects will be identified based on condition and criticality. As the program becomes more sophisticated with additional condition assessment information, specific collection system maintenance projects may be identified and included in future annual budgets based on an engineering estimate. For the purpose of this Utility Study, to recognize an increase in collection system condition assessment, inspections, and maintenance projects, an annual budget equivalent to replacement of one percent of the total distribution system at an average cost of $80 per linear foot, and one additional distribution system operator is included.

> *Years to Complete: Ongoing*
> *Anticipated Cost: $235,000 per year;*
> *plus salary of one additional collection system operator*

Capital Projects

Water Treatment

WPF Project No. 1 – City Maintenance Facility

A 5,000 square foot maintenance facility was originally included in the WPF Expansion project, however was removed from the completed project. This facility is needed for equipment and parts storage including water distribution system meters, hydrants, repair clamps, and condition assessment tools.

> *Years to Complete: 2024-2026*
> *Anticipated Cost: $1,500,000*

WPF Project No. 2 – Fluoridation Project

To allow for fluoride addition to the drinking water at the WPF, a new separate space is required for fluoride dry bulk storage, mixing and feed equipment.

> *Year to Complete: 2027*
> *Anticipated Cost: $975,000*

WPF Project No. 3 – Pall Membrane Replacement

The expected useful life of the existing membrane filters manufactured by Pall is 10 years. Full replacement of the membranes is included in the 10-year CIP. The actual year to complete may be adjusted based on actual performance of the membranes. To improve operator flexibility during clean-in-place and filter maintenance, additional membranes may be purchased at the same time as the replacement membranes and installed in spaces available on the existing skids.

Year to Complete: 2025 (estimate)
Anticipated Cost: $664,000

WPF Project No. 4 – Residual Drying Beds – Concrete

The existing drying beds are lined with a 40-mil polyvinyl chloride (PVC) geomembrane liner under two feet of soil cover and two feet of drying bed sand. Residuals are typically removed once a year. Concrete drying beds will improve the ability and efficiency of removing the residual material without damaging the PVC liner or interfering with the soil and sand layers.

Years to Complete: 2026-2028
Anticipated Cost: $2,945,000

WPF Project No. 5 – Sampling and PELs Application

To improve the secondary water quality characteristics of the City's drinking water, a decrease in the TDS concentration is necessary. Reverse Osmosis (RO) is required to remove TDS. A key consideration when adding RO treatment is the additional brine disposal requirement beyond the typical residuals produced by other treatment processes. Limited water quality data is available for TDS and other parameters that will be disposed with the brine. A sampling program and Preliminary Effluent Limitation (PEL) Application with CDPHE will initiate a comprehensive approach to the water and wastewater salinity removal and mitigation strategy.

Monthly samples of the finished water from the existing treatment plant will be taken to be analyzed for the parameters that would be regulated on a brine discharge permit. Those samples will represent the RO system feed water in order to calculate expected constituent concentrations that would be discharged to the river. These concentrations could then be compared to the WQCC in-stream standards to determine whether the RO concentrate could meet the limitations and what measures would need to be taken to ensure they do so. Depending on the estimated concentrate quality, a mixing zone study may be required to demonstrate compliance

The Colorado River Near the Raw Water Intake Structure

with in-stream standards, as described in WPF Project No. 6 below.

Once the RO feed water quality is characterized and the need for diffusers and/or additional treatment is determined, PELs could be requested from CDPHE.

Year to Complete: 2022
Anticipated Cost: $75,000

WPF Project No. 6 – Mixing Zone Study

The stretch of the Colorado River downstream of the U.S. Highway 24 Bridge is designated as a stream with threatened and endangered species, and therefore have tighter regulations for conformance to stream standards. The proposed RO and GAC Facility would likely be able to discharge some distance upstream of this bridge. However, the city would have to demonstrate to CDPHE that the RO concentrate has fully assimilated into the river before crossing the bridge into that more sensitive stretch. The City would likely have to commission a mixing zone study of proposed discharge points to accomplish this. If the mixing zone study determines that there is inadequate mixing for a single discharge point, a diffuser system would need to be designed. It might also be necessary to treat the RO concentrate further before discharging it to meet the limitations.

Year to Complete: 2023
Anticipated Cost: $150,000

WPF Project Beyond 10-Yr CIP – RO/GAC Facility

The RO/GAC facility is intended to polish the filtered water from the current WPF. Treatment would consist of upflow GAC pressure vessels and three-stage RO filtration systems. The facility would be physically separated from the WPF and a new disinfection contact basin and finished water pump station would need to be constructed as part of the new facility. This basin and pump station would replace the existing infrastructure so that the water could be disinfected and delivered to the distribution system after filtration by the RO and GAC systems. Part of Black & Veatch's design was a modular system that could be built upon, using the same building infrastructure, so that production capacity could be increased as needed and costs could be spread out over time. The report outlines two project schedule alternatives. The first alternative was to construct the whole facility to have a capacity of 16 MGD from startup. The 2016 cost estimate they presented for this approach was $46,856,000. The second alternative presented a phased approach to construction. It involved constructing the building, disinfection contact basin, and finished water pump station according to the 16 MGD design but only including 8 MGD capacity of GAC filtration and 4 MGD capacity of RO filtration at first. This would allow for future expansion as needed. The 2016 cost estimate for this approach was $35,098,000. This facility is not expected to be constructed within the 10-year planning window and, consequently, these costs are not included in the 10-year CIP.

Water Distribution System

Distribution Project No. 1 – Airport Tank No. 2 (Construction Only)

The design and engineering is complete for a 0.5MG Airport Tank No. 2 to provide redundant storage and operational flexibility. Construction of the tank is expected this year.

Year to Complete: 2021
Anticipated Cost: $1,092,000

Distribution Project No. 2 – WPF to 5MG Tank Complex – 24"/30" Distribution Main

The City plans to install a parallel 24-inch or 30-inch water distribution main from the WPF north to the 5MG storage tank complex, a distance of approximately 2.5 miles.

Years to Complete: 2023-2025
Anticipated Cost: $7,917,000

Distribution Project No. 3 – Tank Foundation Monitoring

Continued monitoring for foundation movement of recently installed water storage tanks including professional topographic survey and geotechnical engineering services.

Years to Complete: 2021-2023
Anticipated Cost: $20,000 per year

Distribution Project No. 4 – Recoat Airport Tank No. 1

Tank coatings are recommended every ten years.

Year to Complete: 2022
Anticipated Cost: $417,000

Distribution Project No. 5 – Beaver Creek Tank Improvements – New 8-inch to Rifle Village South and New Booster Station

This project addresses two needs identified by the City; 1) to provide redundancy for the distribution system connection between the Beaver Creek Storage Tank and the City pressure zone, and 2) increase service pressure to the nearby Rifle Village South subdivision north of the Beaver Creek Storage Tank.

Years to Complete: 2023-2024
Anticipated Cost: $3,335,000

Raw Water Supply

An algae control system in the raw water storage and settling pond would increase the flexibility of the raw water supply and improve the water quality and performance of the WPF. An aeration system for algae control would be a good preliminary consideration.

Raw Water Project No. 1 – Pump Station Upgrade w/ Backup Generator

This project planned by the City includes installation of a fourth pump at the raw water pump station to provide redundancy for the largest of the three existing vertical turbine pumps with a capacity of 2,600 gpm. The project also includes a permanent backup generator to limit water production impacts during a power outage.

Year to Complete: 2022
Anticipated Cost: $1,267,000

Raw Water Project No. 2 – Pond/Storage Improvements

In addition to regular dredging the raw water pond to improve water quality, additional hydraulic improvements and a permanent aeration system is recommended for algae control, increased flexibility in operation, and ultimately higher performance and better water quality leaving the WPF.

Year to Complete: 2023
Anticipated Cost: $1,209,000

Wastewater Treatment

WWRF Project No. 1 – Reg 85 / Reg 31 Compliance – Phosphorus Incentive Improvements

This project includes chemical addition improvements in order to take advantage of the CDPHE incentive program for nutrient removal and to delay future regulatory requirements for phosphorus removal. Chemical addition improvements can be implemented to get the effluent phosphorus concentration below the 1 mg/l target needed to gain incentive program credits. The cost of chemical addition will become a limiting factor as the influent flow to the WWRF increases towards the design capacity. Other permanent improvements will be required.

Years to Complete: 2022-2023
Anticipated Cost: $692,000

WWRF Project No. 2 – Reg 31 Compliance – Phosphorus Improvements

Following the chemical addition improvements in order to take advantage of the CDPHE incentive program for nutrient removal, permanent improvements of either biological treatment with an anaerobic basin ahead of the oxidation ditch OR cloth filters downstream of the clarifiers to provide a physical barrier for precipitated phosphorus. Chemical addition would no longer be required for biological treatment, however is still required in order to precipitate phosphorus ahead of cloth filters. A study is recommended ahead of design and construction to determine which phosphorous treatment solution is recommended and most effective at the WWRF. Depending on the success of chemical addition in achieving a phosphorus concentration below 1 mg/l, this project may be delayed.

Years to Complete: 2024-2027 (could be delayed)
Anticipated Cost: $9,800,000

WWRF Project No. 3 – Headworks Influent Channel Coating

High quality grout and coating to protect the concrete influent channel from hydrogen sulfide gas and other destructive compounds common at the headworks.

Year to Complete: 2024
Anticipated Cost: $366,500

WWRF Project No. 4 – Interchange Tank and Digester Improvements

During the winter, the WWRF experiences bulking and foaming issues in the interchange tanks where solids are held before being hauled offsite. A new digester would replace the interchange tank for solids holding and eliminate the need to hold solids in the interchange tanks long enough to cause bulking and foaming issues.

Years to Complete: 2023-2025
Anticipated Cost: $4,000,000

WWRF Project No. 5 – Headworks Make-Up Air Unit

A new makeup air unit is needed for the main level of the headworks. The current unit control board is damaged. The manufacturer, Mars, has ended support for this model.

Year to Complete: 2022
Anticipated Cost: $130,000

WWRF Project No. 6 – Additional Hoists for Oxidation Ditch Aerators

Additional hoists are recommended for the oxidation ditch aerators to improve access and safety.

Year to Complete: 2021
Anticipated Cost: $195,000

WWRF Project No. 7 – Biosolids Hauling Improvements Study

The City relies on a contract hauler for biosolids removal and off site land application. Delays in biosolids removal due to limits on off site land application, or to limit the cost of frequent trips by the contract hauler, can have operational impacts on the facility. Along with digester improvements, the City may consider long term land application available near the WWRF. This study will provide a life cycle cost analysis of continued use of a contact hauler versus the City hauling biosolids and/or developing a long term land application site.

Year to Complete: 2022
Anticipated Cost: $50,000

WWRF Project No. 8 – UV Disinfection System Improvements

The UV Disinfection system requires regular cleaning and replacement of UV bulbs and ballast to provide proper disinfection. Replacement ballast for the UV system are no longer easily available and the PLC has failed. Replacement of the UV system equipment is recommended.

Years to Complete: 2022-2023
Anticipated Cost: $1,011,000

WWRF Project No. 9 – Salinity Removal/Mitigation Study

A comprehensive study of salinity removal/mitigation at the WWRF if completed with RO/GAC improvements at the WPF. Other impacts such as increased copper due to changes in the drinking water characteristics in the distribution system will also be considered.

Year to Complete: 2022
Anticipated Cost: $75,000

Sanitary Sewer Collection System

Collection Project No. 1 – Southside Pump Station

The Southside Pump Station project includes an automated headworks and screening equipment and building. A temporary or permanent generator should also be considered for this project to replace the existing propane powered backup pump.

Years to Complete: 2022-2023
Anticipated Cost: $1,442,000

SECTION 6 – FUNDING OPTIONS

This section will describe a few funding options available for the projects outlined in this Utility Study. Table 21 below summarizes the available grants and loans, their deadlines and requirements, and how much can be obtained.

Table 21 – Funding Options Summary

Funding Opportunity	Organization(s)	Application Available	Deadline(s)	Amount Available	Requirements
User Fees and Tap Fees	City	-	-	-	-
Existing Bonds and Debt	City	-	-	-	-
State Revolving Fund Loan	CDPHE WQCD, DOLA, & Authority	All Year	March 15th, June 15th, September 15th, December 15th	$2 Million	See SRF section below for all requirements
EIAF Administrative Grant	DOLA	All Year	April 1st, August 1st, December 1st	$25,000	Dollar-for-dollar match
EIAF Tier I Grant	DOLA	All Year	April 1st, August 1st, December 1st	$200,000	25% minimum match
EIAF Tier II Grant	DOLA	All Year	April 1st, August 1st, December 1st	$200,000 to $1 Million	25% minimum match

USER FEES AND TAP FEES

The revenue generated from the water and wastewater user fees and tap fees can be used for necessary improvement projects of each associated system. The rate study completed concurrent to the maintenance and capital study provides a financial plan for meeting the revenue requirements for the next ten years. It is recommended to regularly re-address the residential, commercial, and industrial user fees and tap fees for the water and wastewater systems.

STATE DRINKING WATER REVOLVING FUND (DWRF) – LOW INTEREST LOANS

The Drinking Water Revolving Fund (DWRF) provides low interest loans to governmental entities for the construction of water projects for public health and compliance purposes. The DWRF can support the following types of projects:

- New Water Treatment Plant
- New Regional Water Treatment Facilities
- Improvement / Expansion of Water Treatment Facility
- Consolidation of Water Treatment Facilities
- Connect to Existing Facility Eliminate Individual Private Wells
- Distribution / Transmission Lines Construction / Rehabilitation
- Water Storage Facilities
- Water Supply Facilities (excluding reservoirs, dams and water rights)

The Water Pollution Control Revolving Fund (WPCRF) provides low interest loans to governmental entities for the construction of wastewater, stormwater, and non-point source projects. The WPCRF can support the following types of projects:

- New Wastewater Treatment Facility
- New Regional Wastewater Treatment Facilities
- Improvement / Expansion of Wastewater Treatment Facility
- Consolidation of Wastewater Treatment Facilities
- Connect to Existing Facility
- Eliminate Individual Sewage Disposal Systems
- Improvement / New Biosolids Handling Facility
- Reuse Facility
- Infiltration / Inflow Correction
- Sewer Replacement / Rehabilitation
- New Collector Sewers and Appurtenances
- New Interceptor Sewers and Appurtenances
- Combined Sewer Overflow
- Stormwater Project
- Urban Non-Point Source Project (Including Best Management Practices, Land Purchase, etc.)

Available DWRF and WPCRF loan types include:

- Direct Loans: up to $2 million, current APR of 2.0 percent for 20 years.
- Leveraged Loans: generally provided to investment grade borrowers with larger projects greater than $2 million, bond market interest rate for 20 years.

The CDPHE WQCD, DOLA, and the Colorado Water Resources and Power Development Authority (Authority) jointly administer the State Revolving Fund (SRF). The WQCD administers the environmental reviews; engineering and design approval; and overall project management. The Authority manages the finances and loan approvals. DOLA staff works with applicants on credit reviews and reports.

There are several milestones that need to be met in order for a project to be eligible for both the DWRF and the WPCRF.

- The entity must be included on the most current Drinking Water Intended Use Plan
- A Preliminary Engineering Report (PER) and Environmental Checklist for the project must be submitted to the WQCD Engineering Section for review a minimum of 60 days prior to the loan application.
- WQCD will provide an Environmental Determination (Categorical Exclusion or Environmental Assessment).
- If necessary, an Environmental Assessment shall be submitted and reviewed. If a Finding of No Significant Impact is determined it shall be published with a 30-day comment period.

- A public meeting must be held with a 30-day notice period, notifying the public of the project.
- PER and Environmental Assessment Approval must be obtained.
- A Technical, Managerial, and Financial Capacity review must be completed and submitted to the WQCD a minimum of 30 days prior to the loan application.
- The loan application shall then be submitted.
- The Authority will then approve the loan.

Department of Local Affairs

Energy and Mineral Impact Assistance Fund (EIAF)

The purpose of the Energy and Mineral Impact Assistance Program is to assist political subdivisions that are socially and/or economically impacted by the development, processing, or energy conversion of minerals and mineral fuels. Funds come from the state severance tax on energy and mineral production and from a portion of the state's share of royalties paid to the federal government for mining and drilling of minerals and mineral fuels on federally owned land.

The kinds of projects that are funded include, but are not limited to, water and sewer improvements, road improvements, construction/improvements to recreation centers, senior centers and other public facilities, fire protection buildings and equipment, and local government planning. The EIAF grants are categorized into Administrative Grants, Tier I, Tier II, and Tier III. Application deadlines for each category are on April 1st, August 1st, and December 1st of each year.

Administrative Grants

Administrative Grants are available for planning, preliminary engineering, and architectural design projects. The application process requires the local government to submit a detailed letter about the project to the appropriate DOLA Regional Manager. The letter must be signed by the Chief Elected Official and should include information such as: the project description, budget, financial need, why the project is necessary, urgency of the project, how soon the project can begin, and how soon it can be completed. The maximum award for an Administrative Grant is $25,000, and the total project cost should not exceed $100,000. A dollar-for-dollar match is required for this grant.

Tier I Grants

Tier I grant funds can be used for a variety of public purposes including planning, engineering and design studies, and capital projects requiring a limited level of financial assistance. A Tier I grant awards up to $200,000. Applications for grant consideration will be expected to include a minimum match of 50 percent. Larger matching amounts are generally more competitive. Applications will be reviewed and recommended for funding by DOLA staff. The Executive Director will make funding decisions three times per year.

Tier II Grants

The Tier II grant program is intended to support a wide variety of community development projects to improve quality of life in communities. Tier II grant awards range from $200,000 to $1,000,000. Applications for grant consideration will be expected to include a minimum match of 50 percent. Larger matching amounts are generally more competitive. Applications will be reviewed and recommended for funding by DOLA staff. The Executive Director will make funding decisions three times per year.

Tier III Grants

The Tier III grant program is provided to help political subdivisions with regional or multi-jurisdictional projects intended to mitigate major impacts associated with energy/mineral industries (dependent upon revenue availability). This grant is only available one cycle per year. Tier III grants award multi-million-dollar, multi-year projects ($2 million up to $10 million in size). Expect regional/multi-jurisdictional focus.

SECTION 7 – UTILITY RATE STUDY

RATE STRUCTURE PRICING AND TAP FEE OBJECTIVES

(To be completed by Raftelis)

REVENUE REQUIREMENT PROJECTIONS

(To be completed by Raftelis)

EXISTING BONDS AND DEBT

(To be completed by Raftelis)

COST OF SERVICE

(To be completed by Raftelis)

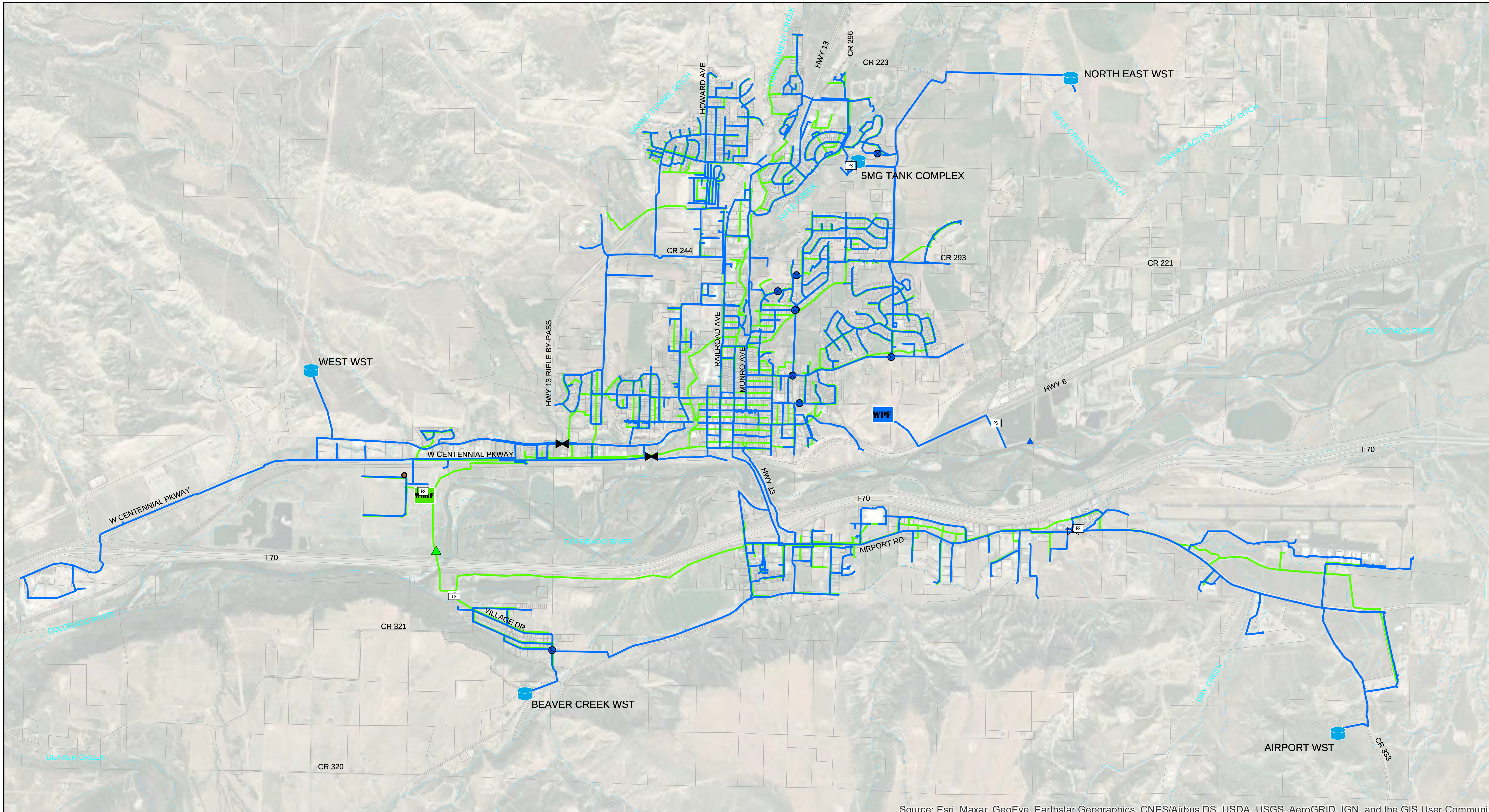
RATE DESIGN

(To be completed by Raftelis)

RATE SURVEY

(To be completed by Raftelis)

Appendix A – Utility System Figures



LEGEND

- DISTRIBUTION PIPES
- COLLECTION PIPES
- LIFT STATION
- WASTEWATER RECLAIMATION FACILITY
- WASTEWATER RECLAIMATION FACILITY DISCHARGE
- WATER STORAGE TANK
- WATER PURIFICATION FACILITY
- PUMP STATION
- BULK WATER
- INTAKE
- PRV
- CONTROL VALVE
- VALVE

FIGURE A1 - OVERALL UTILITY MAP

CITY OF RIFLE - UTILITY MAINTENANCE, CAPITAL, AND RATE STUDY
RIFLE, COLORADO
JOB 1114e
MARCH 2021

0 1,250 2,500 5,000 FEET
1 INCH = 2,500 FEET

N

CONSULTING ENGINEERS

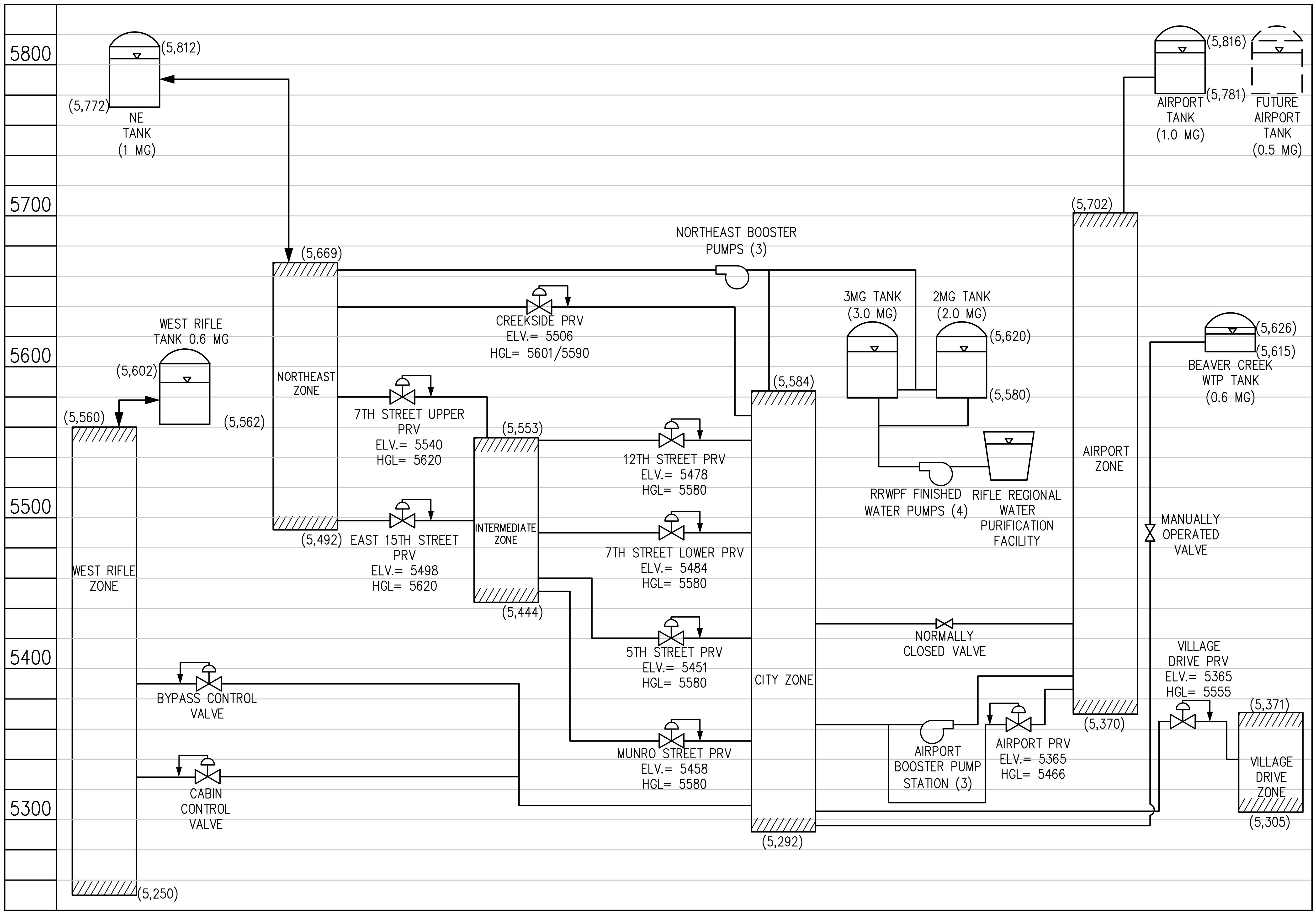


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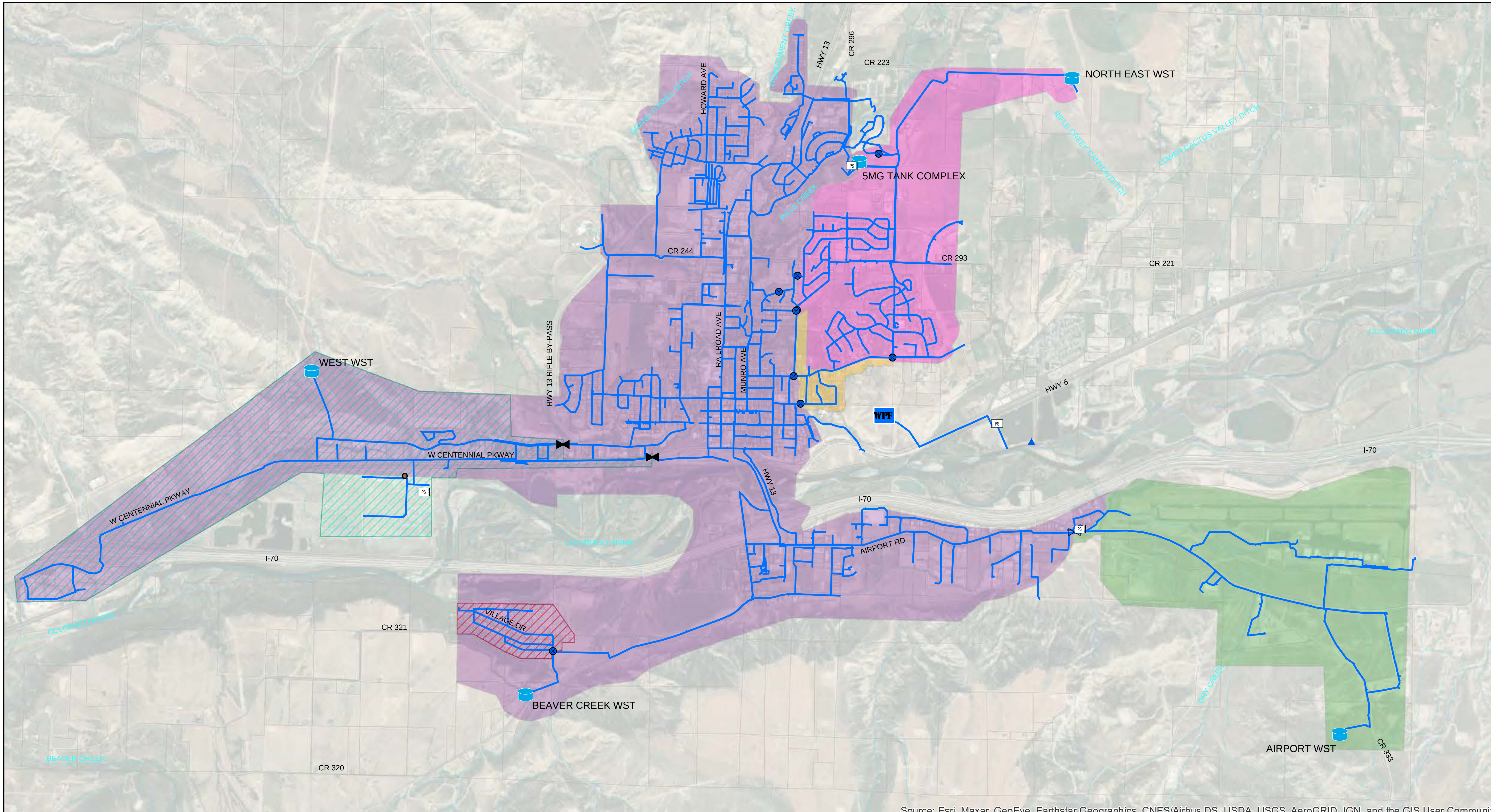
FIGURE A2 - WATER DISTRIBUTION SYSTEM HYDRAULIC PROFILE
CITY OF RIFLE UTILITY MAINTENANCE, CAPITAL, AND RATE STUDY
APRIL 2021



LEGEND

WATER STORAGE TANK	PRV	CITY ZONE
WPF WATER PURIFICATION FACILITY	CONTROL VALVE	INTERMEDIATE ZONE
PS PUMP STATION	VALVE	NORTHEAST ZONE
BULK WATER	DISTRIBUTION PIPES	VILLAGE DRIVE ZONE
INTAKE	AIRPORT ZONE	WEST RIFLE ZONE

FIGURE A3 - WATER DISTRIBUTION SYSTEM PRESSURE ZONE MAP

CITY OF RIFLE - UTILITY MAINTENANCE, CAPITAL, AND RATE STUDY
RIFLE, COLORADO
JOB 1114e
MARCH 2021

0 1,250 2,500 5,000 FEET

1 INCH = 2,500 FEET

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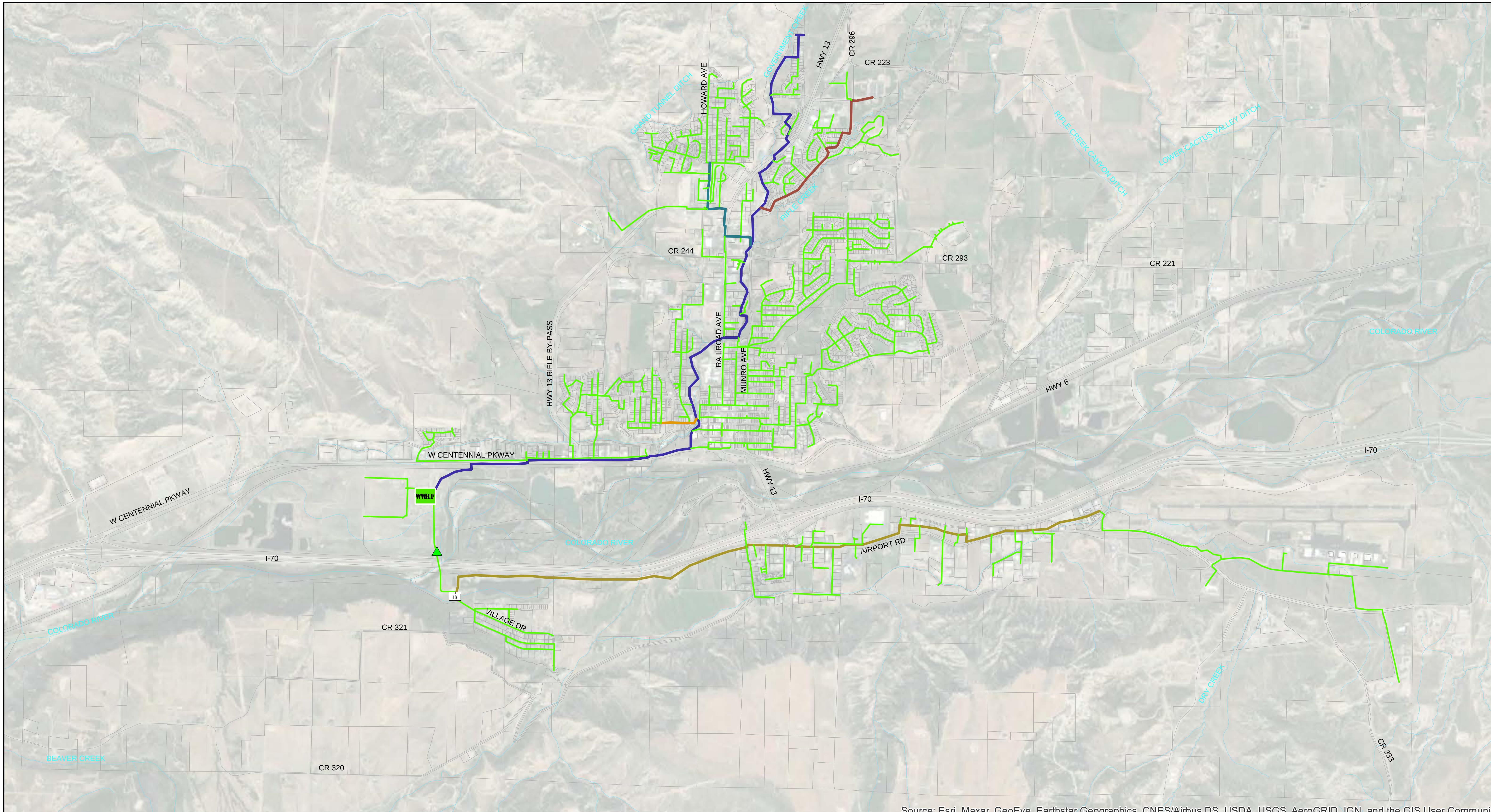
CONSULTING ENGINEERS



LEGEND

- DEERFIELD PARK
- NORTH RIFLE
- PALOMINO PARK
- PARK AVENUE
- SOUTH RIFLE
- COLLECTION
- LIFT STATION
- WASTEWATER RECLAIMATION FACILITY
- WASTEWATER RECLAIMATION FACILITY DISCHARGE

FIGURE A4 - WASTEWATER COLLECTION SYSTEM INTERCEPTOR MAP

CITY OF RIFLE - UTILITY MAINTENANCE, CAPITAL, AND RATE STUDY
RIFLE, COLORADO
JOB 1114e
MARCH 2021

0 1,250 2,500 5,000 FEET

1 INCH = 2,500 FEET

JVA CONSULTING ENGINEERS

APPENDIX B – SUMMARY OF STAFF AND OPERATOR INTERVIEWS

Water				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
Are there any issues with treatment of higher flows in any part of the facility? Existing *known* bottlenecks or short circuiting, process deficiencies?	No higher flow issues at this time.	Sed water channel is to small. Can fill to fast or hit low level depending on what he MF racks are doing. This can cause a plant shutdown. There is no easy fix for this	settled water channel provides operational challenges. low flows cause plant shutdown if membrane strainers wash. at high flows it can cause plant shutdown for high channel level during EFM / CIP processes. a 4th raw water pump would be nice.	No
Are there any specific processes, equipment, or controls that create operational challenges? Any key pumps or process equipment that is difficult to operate?	We have been dealing with issues related to our chlorine injection and our peristaltic pumps.	Winn911 is our dial out software. Its questionable at time. It can stop working with no notice. We have installed a second system to back this up. Our phone that we relay on for after hours operations have poor support. the City IT department has control over our work phones which doesn't see to be a priority to them.	finished water pump control valves. staff is in the process of replacing these with globe style silent check valves	No
Are there any instrumentation and control improvements that could be made more intuitive/easier to operate?	Not at this time	Beavercreek tank has to be manually filled and monitored. If we are not getting rid of that tank a RTU at that location with an automated valve would work. This is not a big problem and should have low priority.	items related to filling the beaver creek tank. at present it is a cumbersome process. installing a pump station and new line up the hill may be cost prohibitive as the tank currently only serves 2 customers.	No
What dictates WTP operation: clearwell level, distribution tank level, etc.?	Distribution tank level	Water usage of the town. The indicator we use for that is tank levels.	distribution tank levels	Distribution tank level
Are there any chemical use, storage, or safety concerns?	Not at this time	No. Safety concerns are taken care of as soon as they are found / brought to our attention.	hydrochloric acid room has lots of rust dust on everything. sodium chlorite tank vent forms solidified chlorite and that can be a safety issue if the solidified product falls onto organic material membrane tank vents form icicles just outside of process building main door. could fall and hit people	No

Water				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
How has your experience been with basin cleaning and accessibility?	Good, we clean both of our sedimentation basins on a quarterly basis. There is always a manageable amount of sludge build up.	The sed and floc basin are cleaned four times a year. The is a system in place for safety and efficiency. With that said i feel i have a good amount of experience.	i have participated twice and it was fine. staff has not expressed any concerns	I have not participated in this process yet.
Do you have any access concerns for maintenance?	Not at this time	Any time you get an engineer involved they are concerns about access to maintain systems. They pay little to no attention on how to keep something running just if it looks good on paper. At this time we have to problems with this at the WTP.	sludge drying beds (see next text field)	No
Has the capacity of the solids handling process been evaluated? Is there interest in improvements to the process?	Yes	Only this that can applie to at the WTP is what we clean out of the drying beds. There is no problem.	the capacity is fine. maintenance is difficult as they are a sand / gravel type on top of a liner. concrete would be preferred.	Yes No
What would be on your operator wish list? Any process changes? Any new equipment or software?	New monitoring equipment for TDS	Start replacing VFD's at the pump stations before they go out. They are aging and are at the end of their expected life. RPS pump four. Another 300 hp just in case for the summer usage if we have pump three go down.	addition of a 4th raw water pump, 5,000 GPM. this will help us to perfect our water rights. bifurcation of raw water pond (we have design) to help address algae issues.	Nothing
Is there anything you want to follow up on that we discussed during the site visit?	Not at this time	No.	not that i can recall	No

Distribution				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
Do you have any access concerns for maintenance?	Not at this time. See above.	water line under highway 13 bypass. it is in a location that we did not anticipate and it is likely 20' or greater bury depth. needs relocated.	No	The lines that serve park hill are transite and/or cast iron and are on very steep slopes and may share the corridor with other utillities which makes boring difficult. Because of the age and vintage of the pipe and the difficulty to access them alternative connections should be a thought.
Was there anything you wanted to follow up on that we discussed during the site visit?	No	not that i can recall	No	
Are there any issues with treatment of higher flows in any part of the system? Existing *known* bottlenecks?	See above about the sed water channel.	no	No	To supply the 2500gpm to the airport that was said to be needed would require a pump pressure of around 90psi which would put the waterline pressure at around 190psi because of this the airport zone cannot be reliably fed from the city zone and a second take is going in to allow service of the existing.
Could you clarify what would be required to take the Beaver Creek tank out of service?	The two users on top of the mesa. Coming to an arrangement with them is only thing holding it up.	2 users are currently served by the tank. 1 currently has a well. it may be an issue of determining cost to build pump station, make minor repairs to tank, install new line from tank to pump station. get with city attorney and discuss options after costs of aforementioned are determined.	Beyond my scope of knowledge	The users of the tank are within the city zone but have little to no pressure. I have not seen the configuration but have been told there are private sisterns and pumps that are fed by the existing tank. With or without the tank some pumping is required either public or private. The tank provides some redundancy to Rifle Village South which has frequent breaks. A newer line may be needed to serve Rifle Village South if the tank went away.
What is the location of the Beaver Creek intake and raw water pipeline alignment? Is that something that we should discuss in the master plan?	Beavercreek head works is about five miles up road. At believe at this time the users rent our water rights from the city and they own the pipe line coming down now.	no. we will be seeking alternate point of diversion for that water right.	N/A	

Distribution				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
Are there any upgrades you'd like to see with the PRVs and tank SCADA?	Second tank at airport location (already in the works). Beavercreek tank if we cant decommission it.	if the beaver creek tank remains in service SCADA improvements would be needed at pump station.	No	The intermediate zone is currently sourced from only one location. The intermediate zone also serves the new care center which is one of the most critical users. A bypass PRV could potentially be a way to add redundancy to the intermediate zone.
What are your typical operation parameters for minimum pressure, maximum pressure, and assumed fire flow?	Please rephrase question. This is to broad to answer.	vary throughout system based on pressure zones	N/A	min=40psi/ max=anything over 100psi should be looked at to make sure we don't have antiquated pipe and 120psi dynamic max/ max fire flow 1500 gpm typical 2500 gpm at the airport
Anything else to add?	No.	none at this time	No	Soils in Rifle are highly corrosive so most ductile and CI pipes are a concern

Wastewater				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
Are there any issues with treatment of higher flows in any part of the facility? Existing *known* bottlenecks or short circuiting, process deficiencies?	The main bottleneck in the process is solids handling. The screw press project is almost underway, which will help with redundancy and reliability of dewatering. However, biosolids hauling is still a bottleneck that we don't have much control over. We have used contract haulers for the past 10 years.	solids handling and i/i issues south of the river staff is addressing both at present	See above.	No
Are there any specific processes, equipment, or controls that create operational challenges? Any key pumps or process equipment that is reaching the end of its useful life or is difficult to operate?	The Aeromod belt filter press and its polymer system are by far the most unreliable pieces of equipment. This will hopefully be remedied with the new screw press.	solids dewatering (being addressed) several components are experiencing failure. it is my opinion that previous supervisors neglected maintenance and we are now playing catch up	See above about VFD's.	No
Are there any instrumentation and control improvements that could be made more intuitive/easier to operate?	SCADA and network upgrades are planned for early 2021. Our old SCADA was erased by ransomware and the emergency rebuild omitted a lot of features.	new SCADA system is being installed in 2021	See above	No
How has your experience been with basin cleaning and accessibility?	We haven't had many access issues.	see responses from Jared Emmert	Already answered	I have not taken part of that process yet
Do you have any access concerns for maintenance?	While not necessarily an access concern, our aerators on the oxidation ditches only came with two hoists to pull motors. The hoists are heavy and difficult to move, even when disassembled. More hoists would make it safer to remove/reinstall the motors.	see responses from Jared Emmert	Already answered	No

Wastewater				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
Any follow up issues from the site visit that you wanted to discuss?	None at this time.	see responses from Jared Emmert	No.	No
Are there any chemical use, storage, or safety concerns?	Polymer coagulant and polysulfide precipitant are the only chemicals in use. Their storage won't be an issue.	none at this time	Already answered	No
What would be on your operator wish list? Any process changes? Any new equipment or software?	1. A complete genset backup at the south lift station. Currently only one pump is driven by a backup propane engine. 2. A tandem dump truck that can haul 12-15 cubic yards of biosolids per trip. This will decrease solids handling bottleneck from contract hauling. 3. A new makeup air unit for main level Headworks. Control board is burning out and Mars has already ended support for this model. 4. Covers or some solution to digester and interchange tank foaming in the winter.	see responses from Jared Emmert	Already answered	Nothing
Anything else you'd like to add?	Nothing at this time.	no	Nope.	No

Collections				
JVA Questions	**Respondent #1**	**Respondent #2**	**Respondent #3**	**Respondent #4**
Do you have any access concerns for maintenance?	typical of older parts of system. manholes with rebar steps. manholes made of corrugated metal pipe.	Already answered	No	Basin G between MH 607 and 710, there is gravel currently in the pipe put it may be too far to jet/MH G614, MHG623/South Interceptor
Do you have any capacity concerns? Have you seen SSOs or do you have concerns about possible SSOs? **Any issues with FOG causing SSOs?**	FOG issues exist, we have been aggressive in grease trap / interceptor cleaning with businesses but most FOG issues seem to occur in residential areas.	NA	No No No	The pevious master plan stated that the Morrow Drive Interceptor was nearing capacity. We do not currently have issues but the capacity may need to be re-looked at whith the development of The Farm.
How often are there power outages at the lift station?	rarely	NA	No	I don’t know about the lift station specificly but the power in this are goes out very rarely.
Can you provide updates on the force main upsizing work from the lift station?	4" and 6" lines are now interconnected. we have a pump out of service for repairs. we believe airlocking may be an issue.	NA	Tie in of the 4" forced main is complete	
Are there known areas where I&I is a concern?	south of the river at an unknown location. deerfield park and along rifle creek likely	NA	No	Deerfield Park (observed at MH J305)/South Rifle possibly manholes on 391 CR 332 and interceptor past MHI803/
Anything else to add?	not at this time	This could have been two pages long.	No	There is backups in the manholes on access road and a 12" coming in from an unknown location. West 2nd has a new line installed at Will Ave that is not in the current GIS that ties into a 4" with an unknown terminous

APPENDIX C – ASSET MANAGEMENT RESULTS AND ADDITIONAL INFORMATION

1. Distribution System Grade Allocation
2. Collection System Grade Allocation
3. Figure C1 - Distribution System Map Priority Grade
4. Figure C2 - Collection System Map Priority Grade

Age	Grade
Blank	5
1956-1960	10
1961-1965	10
1966-1970	8
1971-1975	8
1976-1980	6
1981-1985	6
1986-1990	6
1991-1995	4
1996-2000	4
2001-2005	2
2006-2010	2
2011-2015	1
2016-2020	1

Road Replacement Project	Grade
2021 Railroad Ave	10
2021 3rd Street	10
2021 Whiteriver Ave	10
2022 West 5th Street	10
2022 Railroad Ave	10
2023 Railroad Ave	10
2023 East Ave	10
2023 West Ave	10
2023 Tripp Drive	10
2024 Birch Ave	10
2024 5th Street	10

Type of Customer Impacted	Grade
Vacant/Parking/Agricultural	0
Housing	2
Recreational Facility	2
Industrial	4
Light Industrial	4
Office	4
Civic	6
Commercial	6
Human Service	10
Transportation Center (Airport)	10
Hospital	10

Pipe Size	Grade
24	10
20	10
18	9
16	9
14	8
12	8
10	7
8	6
6	5
4	4
2	3
1	2
0.75	1
Blank	1

Roadway Type	Grade
Highway	10
Major Road	6
Local/paved	4
Local/gravel	2
Not within 25'	0

Material	Grade
AC/TRANSITE	5
CI	4
DIP	4
STEEL	3
FIRE	3
NOT C900	3
Blank	3
CLASS	2
HDPE	1
COPPER	1
C900	0
PVC	0

Job Name:City of Rifle Master Plan and Utility Rate Study
Collection System Grade Allocation
Job Number:1114e
Date: 4/7/2021
By: LAL

Material	Grade
CLAY	10
AC/TRANSITE	8
CONCRETE	6
PVC	2
Blank	5

Road Replacement Project	Grade
2021 Railroad Ave	10
2021 3rd Street	10
2021 Whiteriver Ave	10
2022 West 5th Street	10
2022 Railroad Ave	10
2023 Railroad Ave	10
2023 East Ave	10
2023 West Ave	10
2023 Tripp Drive	10
2024 Birch Ave	10
2024 5th Street	10

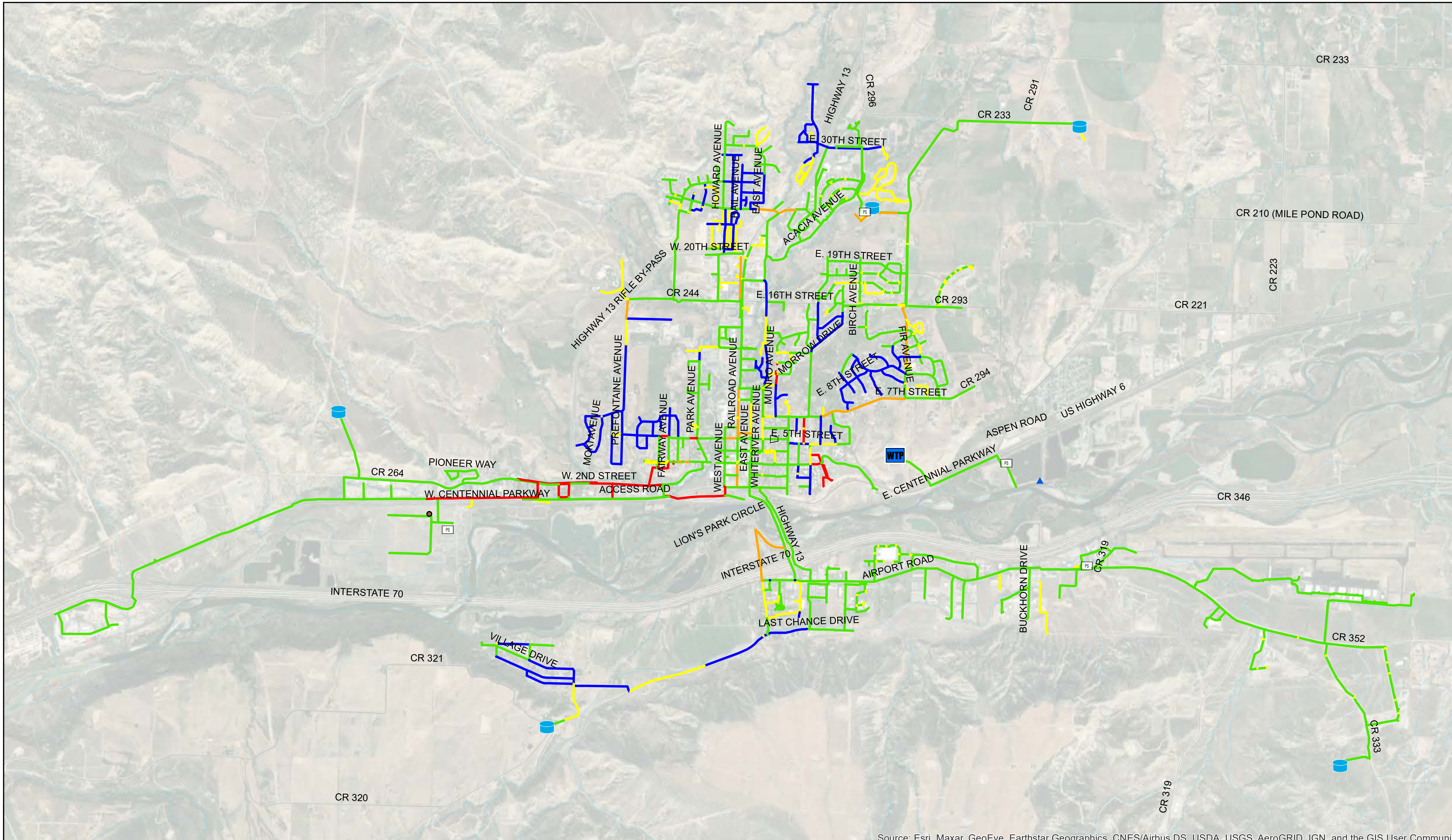
Type of Customer Impacted	Grade
Vacant/Parking/Agricultural	0
Housing	2
Recreational Facility	2
Industrial	4
Light Industrial	4
Office	4
Civic	6
Commercial	6
Human Service	8
Transportation Center (Airport)	10
Hospital	10

Age	Grade
Blank	2
1936-1940	5
1941-1945	5
1946-1950	5
1951-1955	4
1956-1960	4
1961-1965	4
1966-1970	4
1971-1975	4
1976-1980	3
1981-1985	3
1986-1990	3
1991-1995	2
1996-2000	2
2001-2005	2
2006-2010	1
2011-2015	1
2016-2020	0

Pipe Size	Grade
30	10
24	10
18	9
16	9
15	8
12	7
10	6
8	5
6	4
4	2
0	5

Roadway Type	Grade
Highway	10
Major Road	6
Local/paved	4
Local/gravel	2
Not within 25'	0

Identified Defect Grade	Grade
None	0
1	2
2	4
3	6
4	8
5	10



LEGEND

PRIORITY GRADE

- 1
- 2
- 3
- 4
- 5
- WATERWAY

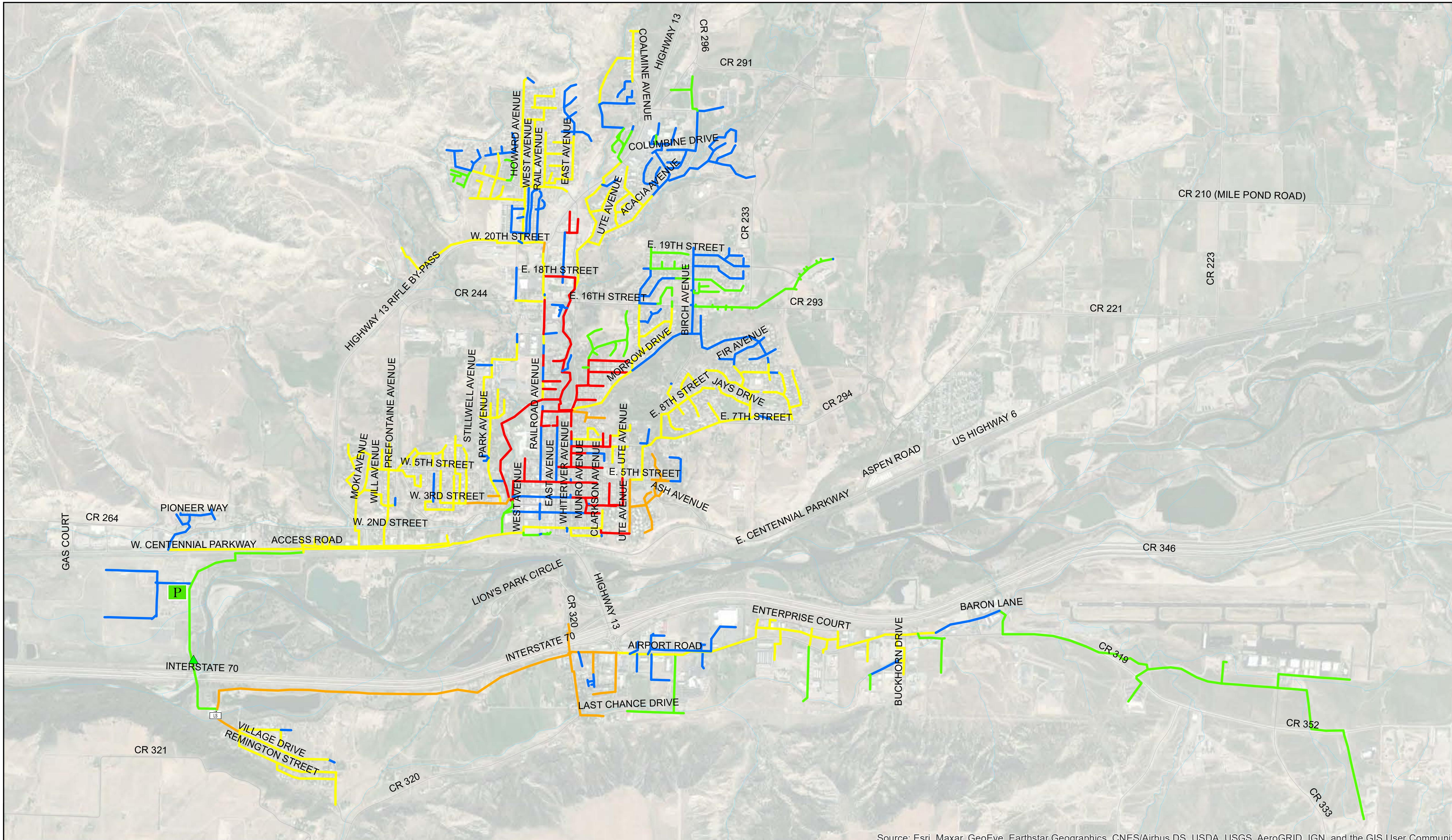
FIGURE C1 - DISTRIBUTION SYSTEM PRIORITY GRADE MAP

CITY OF RIFLE - MASTER PLAN AND UTILITY RATE STUDY
RIFLE, COLORADO
JOB 1114e
FEBRUARY 2021

0 1,250 2,500 5,000 FEET

1 INCH = 2,500 FEET

CONSULTING ENGINEERS



LEGEND

PRIORITY GRADE

- 1
- 2
- 3
- 4
- 5
- WATERWAY

FIGURE C2 - COLLECTION SYSTEM PRIORITY GRADE MAP

CITY OF RIFLE - MASTER PLAN AND UTILITY RATE STUDY
RIFLE, COLORADO
JOB 1114e
FEBRUARY 2021

0 1,000 2,000 4,000 FEET

1 INCH = 2,000 FEET

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Appendix D – Capital Improvement Plan Summary and Opinion of Probable Costs

1. Utility CIP Summary 2021 - 2030
2. Additional Annual Operation and Maintenance
3. Opinion of Probable Costs – Water System Near Term (10-yr)
4. Opinion of Probable Costs – Wastewater System Near Term (10-yr)

Utility Capital Improvement Plan Projects

		CITY OF RIFLE 2021 - 2030 Capital Improvement Plan Projects Projected Capital Expenditures									
Water Purification Facility Improvements		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
No.	**Description**										
1	City Maintenance Facility	$ -	$ -	$ -	$ 180,000	$ 660,500	$ 660,500	$ -	$ -	$ -	$ -
2	Fluoridation Project	$ -	$ -	$ -	$ -	$ -	$ -	$ 975,000	$ -	$ -	$ -
3	Pall Membrane Replacement	$ -	$ -	$ -	$ -	$ 664,000	$ -	$ -	$ -	$ -	$ -
4	WTP Residual Drying Beds - Concrete Drying Beds Design and Construction	$ -	$ -	$ -	$ -	$ -	$ 353,000	$ 1,296,000	$ 1,296,000	$ -	$ -
5	Salinity Removal/Brine Disposal Study - PELs and Sampling	$ -	$ 75,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	Salinity Removal/Brine Disposal Study - Mixing Zone Study	$ -	$ -	$ 150,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Water Purification Facility Improvements Subtotal		**$ -**	**$ 75,000**	**$ 150,000**	**$ 180,000**	**$ 1,324,500**	**$ 1,013,500**	**$ 2,271,000**	**$ 1,296,000**	**$ -**	**$ -**
Distribution System Water System Improvements		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
No.	**Description**										
1	Airport Tank No. 2 Construction with Interior and Exterior Coating and CP - Construction Only	$ 1,092,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	RRWPF (Penwill) to 5MG Tank Complex - Upgrade to 24"/30" Design and Construction	$ -	$ -	$ 950,000	$ 3,483,500	$ 3,483,500	$ -	$ -	$ -	$ -	$ -
3	Tank Foundation Monitoring	$ 20,000	$ 20,000	$ 20,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	Recoat Airport Tank No. 1 (last coating in 2002)	$ -	$ 417,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	Beaver Creek Tank Imps - New 8" to Rifle Village South and new booster station - Design and Const.	$ -	$ -	$ 400,000	$ 2,935,000	$ -	$ -	$ -	$ -	$ -	$ -
Water Distribution System Improvements Subtotal		**$ 1,112,000**	**$ 437,000**	**$ 1,370,000**	**$ 6,418,500**	**$ 3,483,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Raw Water Improvements		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
No.	**Description**										
1	Raw Water Pump Station Upgrade (300 hp) w/ Portable Generator Design and Construction	$ -	$ 1,267,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	Raw Water Pond/Storage Improvements (aeration, hydraulics, dredging) Design and Construction	$ -	$ -	$ 1,209,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Raw Water Improvements Subtotal		**$ -**	**$ 1,267,000**	**$ 1,209,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Water Capital Improvement Projects Total		**$ 1,112,000**	**$ 1,779,000**	**$ 2,729,000**	**$ 6,598,500**	**$ 4,808,000**	**$ 1,013,500**	**$ 2,271,000**	**$ 1,296,000**	**$ -**	**$ -**
Recommended Wastewater Reclamation Facility Improvements		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
No.	**Description**										
1	Reg 85 / Reg 31 Compliance - Phos Incentive Improvements (biological improv. and chemical addition)	$ -	$ 83,000	$ 609,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	Upgrade for Phos/Reg 31 Compliance - Study, Design and Construction (could be delayed with credits)	$ -	$ -	$ -	$ 50,000	$ 1,170,000	$ 4,290,000	$ 4,290,000	$ -	$ -	$ -
3	Headworks Influent Channel Coating - BioSan Grout / H2S resistant coating	$ -	$ -	$ -	$ 366,500	$ -	$ -	$ -	$ -	$ -	$ -
4	Interchange Tank and Digester Improvements	$ -	$ -	$ 480,000	$ 1,759,000	$ 1,759,000	$ -	$ -	$ -	$ -	$ -
5	Headworks Make-up Air Unit	$ -	$ 130,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	Additional Hoists for Oxidation Ditch Aerators	$ 195,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7	*Biosolids Hauling Improvements Study - long term land application*	$ -	$ 50,000	$ -		$ -	$ -	$ -	$ -	$ -	$ -
8	UV Disinfection System Improvements	$ -	$ 121,000	$ 890,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
9	Salinity Removal/Mitigation - Study	$ -	$ 75,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Wastewater Treatment Plant Improvements Subtotal		**$ 195,000**	**$ 459,000**	**$ 1,979,000**	**$ 2,175,500**	**$ 2,929,000**	**$ 4,290,000**	**$ 4,290,000**	**$ -**	**$ -**	**$ -**
Sanitary Sewer Collection System Improvements		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
No.	**Description**										
1	Southside Pump Station - Design and Construction (does not include FM Connection)	$ -	$ 173,000	$ 1,269,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary Sewer Collection System Improvements Subtotal		**$ -**	**$ 173,000**	**$ 1,269,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Wastewater Capital Improvement Projects Total		**$ 195,000**	**$ 632,000**	**$ 3,248,000**	**$ 2,175,500**	**$ 2,929,000**	**$ 4,290,000**	**$ 4,290,000**	**$ -**	**$ -**	**$ -**
Total Water and Wastewater Projections		**$ 1,307,000**	**$ 2,411,000**	**$ 5,977,000**	**$ 8,774,000**	**$ 7,737,000**	**$ 5,303,500**	**$ 6,561,000**	**$ 1,296,000**	**$ -**	**$ -**

Annual Maintenance Projects and Additional Distribution System and Collection System Operations Staff

Water Purification Facility Maintenance Projects		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Project No.	**Description**										
1	Various - annual budget amount	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Distribution System Water System Maintenance Projects		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Project No.	**Description**										
1	Various - annual budget amount (use asset management priority system)	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000	$ 415,000
2	Additional Distribution System Operator	$ 75,000	$ 76,500	$ 78,030	$ 79,591	$ 81,182	$ 82,806	$ 84,462	$ 86,151	$ 87,874	$ 89,632

Wastewater Reclamation Facility Maintenance Projects		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Project No.	**Description**										
1	Various - annual budget amount	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Sanitary Sewer Collection System Maintenance Projects		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Project No.	**Description**										
1	Various - annual budget amount (use asset management priority system)	$ 235,000	$ 235,000	$ 235,000	$ 235,000	$ 235,000	$ 235,000	$ 235,000	$ 235,000	$ 235,000	$ 235,000
2	Additional Collection System Operator	$ 75,000	$ 76,500	$ 78,030	$ 79,591	$ 81,182	$ 82,806	$ 84,462	$ 86,151	$ 87,874	$ 89,632

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OPINION OF PROBABLE COSTS
WATER SYSTEM NEAR TERM (10-YR) IMPROVEMENTS

Project Description	Quantity	Units	Unit Cost	Total
Water Purification Facility Improvements				
City Maintenance Facility				
Mobilization/Demolition	1	LS	$20,000	$20,000
Building Construction	5,000	SF	$150	$750,000
			Subtotal	**$770,000**
			Contingency (30%)	$231,000
			Contractor's OH&P (20%)	$200,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$180,000
			Bidding and Construction Administration (10%)	$120,000
			Project Total	**$1,501,000**
Fluoridation Project				
Fluoride Building/Room	250	SF	$500	$125,000
Fluoride Storage	1	LS	$100,000	$100,000
Fluoride Feed Equipment	1	LS	$200,000	$200,000
Electrical, Instrumentation and Controls	1	LS	$75,000	$75,000
			Subtotal	**$500,000**
			Contingency (30%)	$150,000
			Contractor's OH&P (20%)	$130,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$117,000
			Bidding and Construction Administration (10%)	$78,000
			Project Total	**$975,000**
Pall Membrane Replacement				
Membrane Replacement - 90 per skid	270	EA	$1,500	$405,000
Additional Membranes - 18 per existing skid	54	EA	$1,500	$81,000
			Subtotal	**$486,000**
			Contingency (30%)	$146,000
			Contractor's OH&P (N/A)	
			Professional Engineering Fees - Permitting for Additional Membranes (5%)	$32,000
			Bidding and Construction Administration (N/A)	
			Project Total	**$664,000**
WTP Residual Drying Beds - Concrete Drying Beds Design and Construction				
Mobilization/Demobilization	1	LS	$50,000	$50,000
Demolition of Existing Drying Beds	1	LS	$60,000	$60,000
Misc. Earthwork	1	LS	$300,000	$300,000
Concrete and Piping	1	LS	$1,100,000	$1,100,000
			Subtotal	**$1,510,000**
			Contingency (30%)	$453,000
			Contractor's OH&P (20%)	$393,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$353,000
			Bidding and Construction Administration (10%)	$236,000
			Project Total	**$2,945,000**
Salinity Removal/Brine Disposal Study - PELs and Sampling				
Sampling and PELs development	1	LS	$75,000	$75,000
			Subtotal	**$75,000**
			Contingency (N/A)	
			Contractor's OH&P (N/A)	
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total	**$75,000**

Salinity Removal/Brine Disposal Study - Mixing Zone Study				
Mixing Zone Study	1	LS	$150,000	$150,000
			Subtotal	**$150,000**
			Contingency (N/A)	
			Contractor's OH&P (N/A)	
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total	**$150,000**

Distribution System Water System Improvements

Airport Tank No. 2 Construction with Interior and Exterior Coating and CP - Construction Only				
Mobilization/Demobilization	1	LS	$50,000	$50,000
Steel Tank Construction	1	LS	$650,000	$650,000
			Subtotal	**$700,000**
			Contingency (30%)	$210,000
			Contractor's OH&P (20%)	$182,000
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total	**$1,092,000**

WPF (Penwill) to 5MG Tank Complex - Upgrade to 24"/30" Design and Construction				
Mobilization/Demobilization	1	LS	$100,000	$100,000
30-inch Water Distribution Main	13,200	LF	$300	$3,960,000
			Subtotal	**$4,060,000**
			Contingency (30%)	$1,218,000
			Contractor's OH&P (20%)	$1,056,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$950,000
			Bidding and Construction Administration (10%)	$633,000
			Project Total	**$7,917,000**

Tank Foundation Monitoring				
Annual Geotech/Survey	1	LS	$20,000	$20,000
			Subtotal	**$20,000**
			Contingency (N/A)	
			Contractor's OH&P (N/A)	
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total (After 3 Years)	**$60,000**

Recoat Airport Tank No. 1 (Last Coating in 2002)				
Tank Coating (35 ft tall x 75 ft diameter)	30,000	SF	$10	$300,000
			Subtotal	**$300,000**
			Contingency (10%)	$30,000
			Contractor's OH&P (10%)	$33,000
			Professional Engineering, Geotechnical, and Surveying Fees (10%)	$36,000
			Bidding and Construction Administration (5%)	$18,000
			Project Total	**$417,000**

Beaver Creek Tank Imps - New 8" to Rifle Village South and New Booster Station - Design and Construction				
Mobilization/Demobilization	1	LS	$50,000	$50,000
Sitework and Site Piping	1	LS	$100,000	$100,000
8-inch HDD Parallel Distribution Main	6,000	LF	$150	$900,000
Building Construction - Package Booster Station with PRV	1	EA	$500,000	$500,000
Building Electrical	1	LS	$60,000	$60,000
Instrumentation and Controls	1	LS	$100,000	$100,000
			Subtotal	**$1,710,000**
			Contingency (30%)	$513,000
			Contractor's OH&P (20%)	$445,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$400,000
			Bidding and Construction Administration (10%)	$267,000
			Project Total	**$3,335,000**

Raw Water Improvements

Raw Water Pump Station Upgrade (300 hp Pump) w/ Backup Generator Design and Construction				
Raw Water Pump (300 hp)	1	LS	$250,000	$250,000
Backup Generator	1	LS	$400,000	$400,000
			Subtotal	**$650,000**
			Contingency (30%)	$195,000
			Contractor's OH&P (20%)	$169,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$152,000
			Bidding and Construction Administration (10%)	$101,000
			Project Total	**$1,267,000**

Raw Water Pond/Storage Improvements Design and Construction (Aeration, Hydraulics, Dredging)				
Mobilization/Demolition	1	LS	$20,000	$20,000
Dredging	1	LS	$300,000	$300,000
Raw Water Pond Aerators	4	EA	$50,000	$200,000
Pond/River Hydraulic Improvement	1	LS	$100,000	$100,000
			Subtotal	**$620,000**
			Contingency (30%)	$186,000
			Contractor's OH&P (20%)	$161,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$145,000
			Bidding and Construction Administration (10%)	$97,000
			Project Total	**$1,209,000**

Near Term Improvements Project Grand Total	**$21,607,000**

CONSULTING ENGINEERS

OPINION OF PROBABLE COSTS
WASTEWATER SYSTEM NEAR TERM (10-YR) IMPROVEMENTS

Project Description	Quantity	Units	Unit Cost	Total
Wastewater Reclamation Facility Improvements				
Reg 85 / Reg 31 Compliance - Phosphorus Incentive Improvements (Biological Improvements and Chemical Addition)				
Coagulant Building/Room	200	SF	$500	$100,000
Coagulant Storage	1	LS	$80,000	$80,000
Coagulant Feed Equipment	1	LS	$100,000	$100,000
Electrical, Instrumentation and Controls	1	LS	$75,000	$75,000
			Subtotal	**$355,000**
			Contingency (30%)	$107,000
			Contractor's OH&P (20%)	$92,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$83,000
			Bidding and Construction Administration (10%)	$55,000
			Project Total	**$692,000**
Upgrade for Phos/Reg 31 Compliance - Design and Construction (Could be Delayed with Incentive Credits)				
Anaerobic Basins OR Phosphorous Filter Improvements	1	LS	$5,000,000	$5,000,000
			Subtotal	**$5,000,000**
			Contingency (30%)	$1,500,000
			Contractor's OH&P (20%)	$1,300,000
			Engineering Alternatives Analysis	$50,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$1,170,000
			Bidding and Construction Administration (10%)	$780,000
			Project Total	**$9,800,000**
Headworks Influent Channel Coating - BioSan Grout / H2S Resistant Coating				
Coating Material and Application	2,500	SF	$75	$187,500
			Subtotal	**$187,500**
			Contingency (30%)	$57,000
			Contractor's OH&P (20%)	$49,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$44,000
			Bidding and Construction Administration (10%)	$29,000
			Project Total	**$366,500**
Interchange Tank and Digester Improvements				
Mobilization/Demobilization	1	LS	$50,000	$50,000
Site Piping	1	LS	$60,000	$60,000
Misc. Earthwork and Site Improvements	1	LS	$300,000	$300,000
Interchange Tank Improvements	1	LS	$250,000	$250,000
Digester Construction	1	LS	$1,500,000	$1,300,000
Electrical, Instrumentation, and Controls	1	LS	$90,000	$90,000
			Subtotal	**$2,050,000**
			Contingency (30%)	$615,000
			Contractor's OH&P (20%)	$533,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$480,000
			Bidding and Construction Administration (10%)	$320,000
			Project Total	**$3,998,000**
Headworks Make-Up Air Unit				
MUAU and Installation	1	LS	$100,000	$100,000
			Subtotal	**$100,000**
			Contingency (30%)	$30,000
			Contractor's OH&P (N/A)	
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total	**$130,000**

Additional Hoists for Oxidation Ditch Aerators				
Materials	1	LS	$20,000	$20,000
Installation	1	LS	$80,000	$80,000
			Subtotal	**$100,000**
			Contingency (30%)	$30,000
			Contractor's OH&P (20%)	$26,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$23,000
			Bidding and Construction Administration (10%)	$16,000
			Project Total	**$195,000**

Biosolids Hauling Improvements Study - Long Term Land Application				
Study	1	LS	$50,000	$50,000
			Subtotal	**$50,000**
			Contingency (30%)	$15,000
			Contractor's OH&P (N/A)	
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total	**$65,000**

UV Disinfection System Improvements				
Mobilization/Demobilization	1	LS	$50,000	$50,000
New UV Equipment	1	LS	$390,000	$390,000
Installation	1	LS	$78,000	$78,000
			Subtotal	**$518,000**
			Contingency (30%)	$156,000
			Contractor's OH&P (20%)	$135,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$121,000
			Bidding and Construction Administration (10%)	$81,000
			Project Total	**$1,011,000**

Salinity Removal/Mitigation - Study				
Study	1	LS	$75,000	$75,000
			Subtotal	**$75,000**
			Contingency (30%)	$23,000
			Contractor's OH&P (N/A)	
			Professional Engineering, Geotechnical, and Surveying Fees (N/A)	
			Bidding and Construction Administration (N/A)	
			Project Total	**$98,000**

Sanitary Sewer Collection System System Improvements

Southside Lift Station - Design and Construction (Not Including FM Connection)				
Mobilization/Demobilization	1	LS	$50,000	$50,000
Headworks	1	LS	$400,000	$400,000
Building Construction	1	LS	$200,000	$200,000
Electrical, Instrumentation, and Controls	1	LS	$90,000	$90,000
			Subtotal	**$740,000**
			Contingency (30%)	$222,000
			Contractor's OH&P (20%)	$192,000
			Professional Engineering, Geotechnical, and Surveying Fees (15%)	$173,000
			Bidding and Construction Administration (10%)	$115,000
			Project Total	**$1,442,000**

Near Term Improvements Project Grand Total	**$17,797,500**

COLORADO RIVER OUTFITTERS ASSOCIATION

2023 YEAR END REPORT

COMMERCIAL RIVER USE in the STATE of COLORADO 1988-2023

Garfield - 3

EXECUTIVE SUMMARY COMMERCIAL RIVER USE IN COLORADO 2023

Year End Report

In contrast to the drier conditions of the 2022 rafting season, the 2023 season had a much higher-than-normal snowpack. This led to a sustained and extended runoff which allowed most outfitters to enjoy a full rafting season on Colorado rivers. During runoff many reservoirs were replenished at higher levels which made water available for release in the late season. Knowing sufficient water was available for the season, outfitters staffed accordingly. Employing skilled labor was easier in 2023 than had been the case in the prior few years.

The 2023 river use in the State of Colorado totaled 542,511 user days, a reduction of 6,972 user days or a decline of 1.26% when compared to 549,483 user days in 2022. The highest year historically for river use was 2021. User days were 622,186 in 2021. Compared to 2021, there was a 12.8% reduction for 2023 user days. It may be some time before the industry achieves the 2021 numbers again. One river that benefited from the abundant snowfall was the Dolores. Because of the increased snowpack, the Dolores River ran for the first time in several years. Outfitters worked quickly to promote the river. Dolores user numbers were the highest since 2005. Other river sections that showed a surprising increase include the Ruby Horsethief section of the Colorado River, the Upper and Lower Eagle River, North Platte, Piedra, Rio Grande, Roaring Fork, and San Juan.

In reviewing why rafting user numbers showed a slight decrease, we attribute the decline to a few factors. Overall summer tourism to Colorado trended down in 2023 and rafting numbers reflected this trend. The first part of the season was quite rainy for many weeks, and many outfitters noticed a reduction in reservations during this part of the season. Additionally, the economy played a part in decreased user numbers. The industry depends on consumer discretionary spending and tighter spending patterns were reflected in the user numbers. Over the past three years, inflationary pressures have resulted in trip price increases. As inflation is easing currently, we are hopeful pressures on pricing will begin to moderate.

The total industry-wide economic impact for 2023 was $214,715,634 and accounted for many full-time and seasonal jobs.

The Colorado River Outfitters Association (CROA) compiled this study. Copies are available by contacting David Costlow at dcostlow@croa.org or Caitlin Wyman at caitlin@croa.org. The report can also be downloaded from the web at: https://www.croa.org/media.html.

Members of CROA adhere to a Code of Ethics and offer quality trips on Colorado's rivers.

COMMERCIAL USER DAYS IN THE STATE OF COLORADO 1999 - 2010

River	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Animas	45,000	29,000	42,000	12,000	34,500	35,470	52,700	42,500	44,322	42,250	41,921	41,000
Animas - Upper	989	700	721	300	690	658	872	167	598	533	500	411
Arkansas	243,709	250,861	252,213	139,178	214,555	203,840	228,091	237,160	239,887	214,234	205,876	211,150
Blue	2,100	2,347	14	0	264	788	1,212	760	2,038	2,906	3,089	1,181
Clear Creek	16,887	13,616	20,798	7,498	24,495	20,115	32,357	36,889	49,190	52,340	50,167	51,301
Colorado - Glenwood	60,191	57,265	55,829	42,581	56,876	58,751	57,712	62,652	65,502	52,738	52,737	61,890
Colorado - Upper	40,000	42,933	34,381	37,801	32,188	33,224	29,449	36,280	37,068	34,769	33,077	40,730
Colorado - Horsethief - Ruby	4,410	4,508	4,188	2,324	3,222	3,383	3,318	2,810	2,761	3,283	3,090	2,718
Colorado - Westwater	7,208	6,859	6,858	6,626	7,352	7,548	7,043	7,233	7,632	7,624	6,833	7,621
Dolores	439	921	0	0	214	174	936	81	195	868	536	194
Eagle - Upper	7,290	3,830	3,702	0	1,239	858	3,630	4,621	4,390	4,390	1,374	1,640
Eagle - Lower	2,500	2,167	594	446	1,153	820	1,419	1,441	1,369	1,369	1,369	1,710
Gore Creek - Vail											300	1,000
Green/Yampa	7,360	8,539	7,825	5,617	7,134	6,826	6,627	6,500	5,813	6,235	4,309	4,803
Gunnison Gorge	3,169	3,928	3,401	3,292	2,328	3,010	3,016	3,800	2,826	4,342	3,956	1,390
Gunnison - Upper (Town Run)	1,720	1,400	2,690	1,334	1,590	1,982	2,112	2,212	2,500	2,669	2,669	2,669
Gunnison - Escalante	1,011	1,884	1,887	1,044	2,113	2,988	3,363	2,265	3,272	2,106	2,549	1,784
Gunnison - Forks to Austin												
Gunnison - Lake Fork	1,848	1,310	1,543	0	160	177	195	165	126	369	203	149
North Platte	882	165	137	0	312	191	566	511	372	851	712	482
Piedra	305	50	650	0	210	454	725	400	500	547	547	190
Poudre	32,446	29,012	34,192	26,004	34,164	31,042	36,088	34,533	37,824	37,566	36,991	37,392
Rio Grande	3,100	1,950	3,300	92	1,300	2,800	3,246	1,605	1,402	2,345	2,313	1,229
Roaring Fork - Above Basalt	5,000	4,500	2,500	0	2,000	1,500	2,215	2,609	2,834	6,187	4,248	2,404
Roaring Fork - Below Basalt	2,000	1,500	1,000	0	500	500	10	79	100	2,500	1,263	1,366
San Juan - Pagosa	3,400	2,200	2,000	138	1,586	2,550	2,500	1,900	1,900	2,280	4,107	4,986
San Miguel	3,442	1,379	3,625	120	1,959	2,212	4,493	2,800	2,943	5,969	3,782	1,762
South Platte	1,306	2,035	2,055	453	935	836	901	655	690	1,150	750	383
Taylor	15,367	13,989	14,287	11,176	14,734	14,750	14,972	15,127	15,112	14,332	14,332	14,332
Total User Days	**513,079**	**488,848**	**502,390**	**298,024**	**447,773**	**437,447**	**499,768**	**507,755**	**533,166**	**506,752**	**483,600**	**497,867**
User Day Change From Previous Year	**6,783**	**-24,231**	**13,542**	**-204,366**	**149,749**	**-10,326**	**62,321**	**7,987**	**25,411**	**-26,414**	**-23,152**	**14,267**

Sources: National Park Service
US Forest Service
Bureau of Land Management
Local Outfitters
Colorado Parks & Wildlife

Colorado River Outfitters Assoc.
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720-260-4135

Revised: 3/21/2024

COMMERCIAL USER DAYS IN THE STATE OF COLORADO 2011 - 2023

River	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Animas	45,000	38,000	33,659	37,000	34,117	35,991	34,069	28,495	37,553	33,120	52,967	36,132	37,139
Animas - Upper	411	603	600	678	No report	615	536	71	326	12	387	286	227
Arkansas	208,329	169,486	179,535	191,307	196,998	223,878	223,271	218,120	190,246	182,005	256,650	247,721	224,700
Blue	6,580	0	0	6,571	6,651	5,301	2,771	1,086	11,006	636	0		1,856
Clear Creek	60,644	35,422	61,172	72,224	65,617	77,783	87,077	66,174	95,063	52,044	100,203	80,364	81,674
Colorado - Glenwood	44,007	64,086	60,757	56,857	57,785	61,880	64,208	62,181	65,302	55,228	70,753	63,222	64,940
Colorado - Upper	39,012	41,811	40,420	40,337	41,352	37,071	47,915	50,681	35,777	46,375	45,433	33,866	32,866
Colorado - Horsethief - Ruby	2,907	3,099	754	3,535	2,787	1,112	3,978	993	1,122	1,268	820	943	1,158
Colorado - Westwater	6,069	5,623	6,992	6,432	6,522	6,478	6,522	6,654	7,324	4,190	6,369	5,299	3550
Dolores	515	35	0	58	26	74	558	0	350	0		75	940
Eagle - Upper (Dowd Chutes)	1,286	13	359	1,134	570	606	745	428	399	1,076	266	88	669
Eagle (Below Edwards)	4,362	227	2,032	5,174	4,971	6,443	6,088	3,549	8,851	4,129	5,233	7,507	8,776
Gore Creek - Vail	2,500	900	900	500	404	601	500	0	324	98	0		0
Green/Yampa	4,218	7,983	9,694	11,581	11,476	10,196	13,917	15,645	No Report	3,755	5,132	3,085	5,846
Gunnison Gorge	2,148	1,579	3,431	2,152	3,205	3,584	3,861	4,787	4,039	4,553	6,110	6,096	5,054
Gunnison - Upper (Town Run)	2,669	1,150	3,387	3,387	3,083	3,276	3,548	3,276	2,129		4,170	2,883	827
Gunnison - Escalante	2,749	3,028	1,434	1,936	1,154	868	1,088	187	149	27	144	241	376
Gunnison - Forks to Austin		1,100	303	302	484	305	731	991	1,254	1,617	2,326	2,276	2,162
Gunnison - Lake Fork	284	1,123	221	193	304	259	318	267	245	425	348	169	217
North Platte	850	143	265	230	336	179	305	No Report	34	5			301
Piedra	190	54	25	285	No report	337	318	17	249	41	173	36	438
Poudre	37,869	22,780	37,214	37,225	37,934	41,192	38,134	38,741	37,707	21,481	39,877	33,008	29,921
Rio Grande	1,589	2,103	596	3,691	2,511	2,387	2,694	131	No Report	156	221	1,469	2,415
Roaring Fork - Above Basalt	6,672	112	1,696	5,210	5,038	4,377	4,420	560	6,751	1,045	948	1,541	2,639
Roaring Fork - Below Basalt	912	736	458	1,070	895	410	869	831	7,245	338	221	655	3,691
San Juan - Pagosa	6,171	778	3,475	3,764	4,949	4,850	3,948	1,012	5,517	0		4,000	9,340
San Miguel	1,900	1,828	1,235	3,921	5,438	5,064	8,097	2,061	9,778	4,899	8,201	5,547	7,173
South Platte	430	484	713	371	473	788	No Report	No Report	No Report	No Report	No Report	No Report	No Report
Taylor	14,130	9,891	12,998	13,244	13,648	14,956	15,069	13,279	13,665	11,652	15,234	12,974	13,616
Total User Days	**504,403**	**414,177**	**464,325**	**510,369**	**508,728**	**550,861**	**575,555**	**520,217**	**542,405**	**430,175**	**622,186**	**549,483**	**542,511**
User Day Change From Previous Year	**6,536**	**-90,226**	**50,148**	**46,044**	**-1,641**	**42,133**	**24,694**	**-55,338**	**22,188**	**-112,230**	**192,011**	**-72,703**	**-6,972**

Sources: National Park Service
US Forest Service
Bureau of Land Management
Local Outfitters
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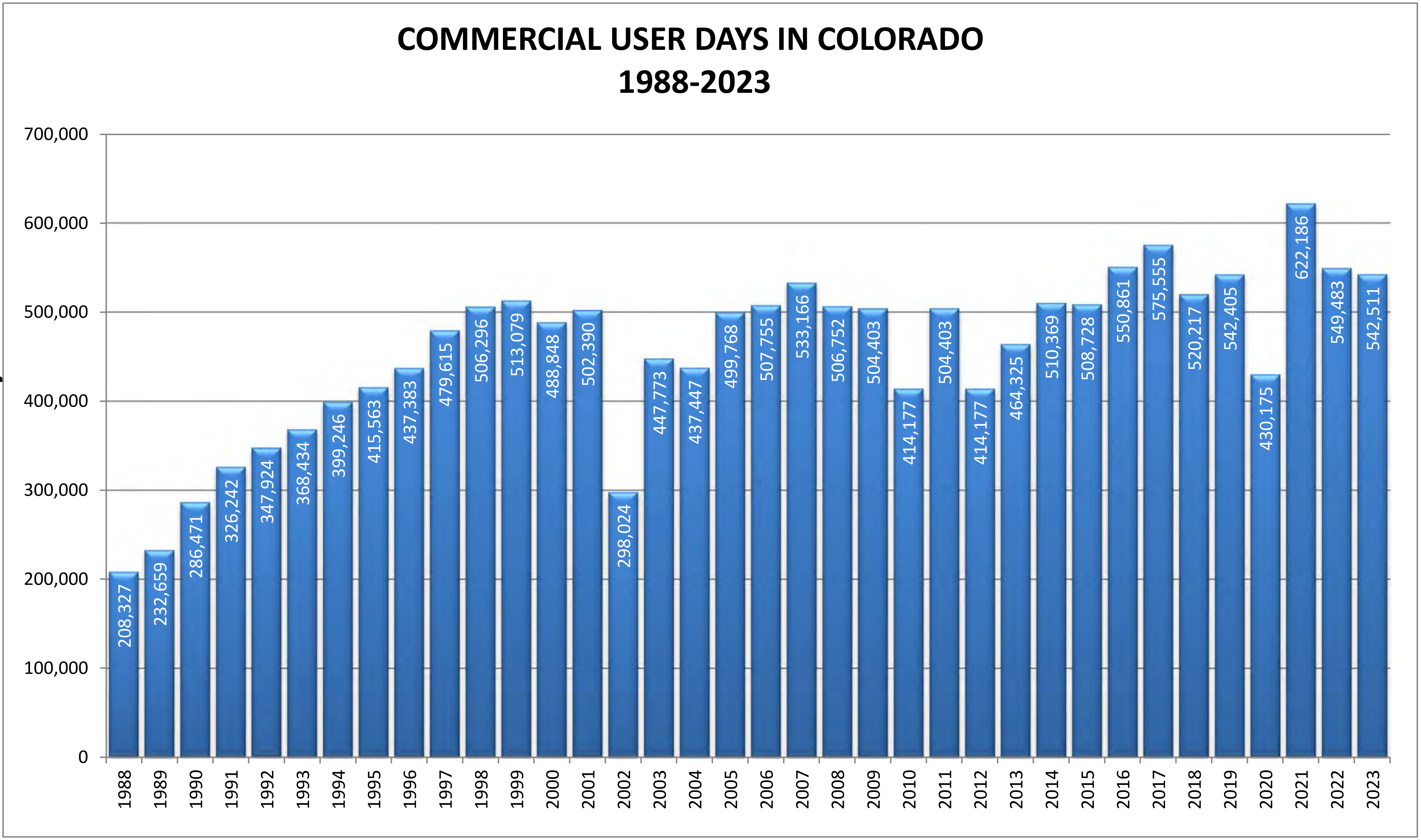
Revised: 11/4/2024



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2023 ECONOMIC IMPACT OF COMMERCIAL RIVER RAFTING IN COLORADO

YEAR	TOTAL USER DAYS	INFLATION RATE (CPI)	EXPENDITURES-INFLATION ADJUSTED	DIRECT EXPENDETURES	ECONOMIC IMPACT	% CHANGE
1988	208,327		rt	$14,166,236	$36,265,564	
1989	232,659	4.6%	$66.73	$15,526,325	$39,747,392	9.6%
1990	286,471	6.1%	$70.81	$20,283,592	$51,925,995	30.6%
1991	326,242	3.1%	$73.00	$23,815,666	$60,968,105	17.4%
1992	347,924	2.9%	$75.12	$26,135,007	$66,905,618	9.7%
1993	368,434	2.7%	$77.15	$28,422,900	$72,762,623	8.8%
1994	399,246	2.7%	$79.23	$31,631,493	$80,976,623	11.3%
1995	415,563	2.5%	$81.21	$33,747,364	$86,393,253	6.7%
1996	437,383	3.3%	$83.89	$36,691,478	$93,930,184	8.7%
1997	479,615	1.7%	$85.31	$40,918,247	$104,750,712	11.5%
1998	506,296	1.7%	$86.77	$43,928,838	$112,457,824	7.4%
1999	513,079	2.7%	$89.11	$45,719,334	$117,041,496	4.1%
2000	488,848	3.4%	$92.14	$45,041,209	$115,305,495	-1.5%
2001	502,390	1.9%	$93.89	$47,168,424	$120,751,166	4.7%
2002	298,024	2.2%	$95.95	$28,596,476	$73,206,978	-39.4%
2003	447,773	1.9%	$97.78	$43,781,775	$112,081,344	53.1%
2004	437,447	3.3%	$101.00	$44,183,613	$113,110,049	0.9%
2005	499,768	3.4%	$104.44	$52,194,503	$133,617,928	18.1%
2006	507,755	2.0%	$106.53	$54,089,218	$138,468,398	3.6%
2007	533,166	4.1%	$110.89	$59,124,798	$151,359,483	9.3%
2008	506,752	0.1%	$111.00	$56,251,845	$144,004,723	-4.9%
2009	504,403	2.7%	$114.00	$57,502,855	$147,207,308	2.2%
2010	414,177	1.5%	$115.71	$47,925,181	$122,688,464	-16.7%
2011	504,403	3.0%	$119.18	$60,116,359	$153,897,880	25.4%
2012	414,177	1.7%	$121.21	$50,202,107	$128,517,393	-16.5%
2013	464,325	1.5%	$123.03	$57,124,719	$146,239,279	13.8%
2014	510,369	0.8%	$124.01	$63,291,709	$162,026,776	10.8%
2015	508,728	0.7%	$124.88	$63,529,824	$162,636,349	0.4%
2016	550,861	2.1%	$127.50	$70,236,001	$179,804,163	10.6%
2017	575,555	2.1%	$130.18	$74,925,616	$191,809,578	6.7%
2018	520,217	1.9%	$132.65	$69,008,441	$176,661,609	-7.9%
2019	542,405	2.3%	$133.17	$72,234,191	$184,919,528	4.7%
2020	430,175	1.4%	$135.04	$58,090,117	$148,710,699	-19.6%
2021	622,186	7.5%	$145.17	$90,320,385	$231,220,186	55.5%
2022	549,483	6.5%	$154.60	$84,951,180	$217,475,020	-5.9%
2023	542,511	3.4%	$159.86	$86,724,986	$222,015,965	2.1%

See glossary for above economic impact formulas and sources

Sources: National Park Service
US Forest Service
Bureau of Land Management
Local Outfitters
Colorado Parks & Wildlife

Colorado River Outfitters Assoc.
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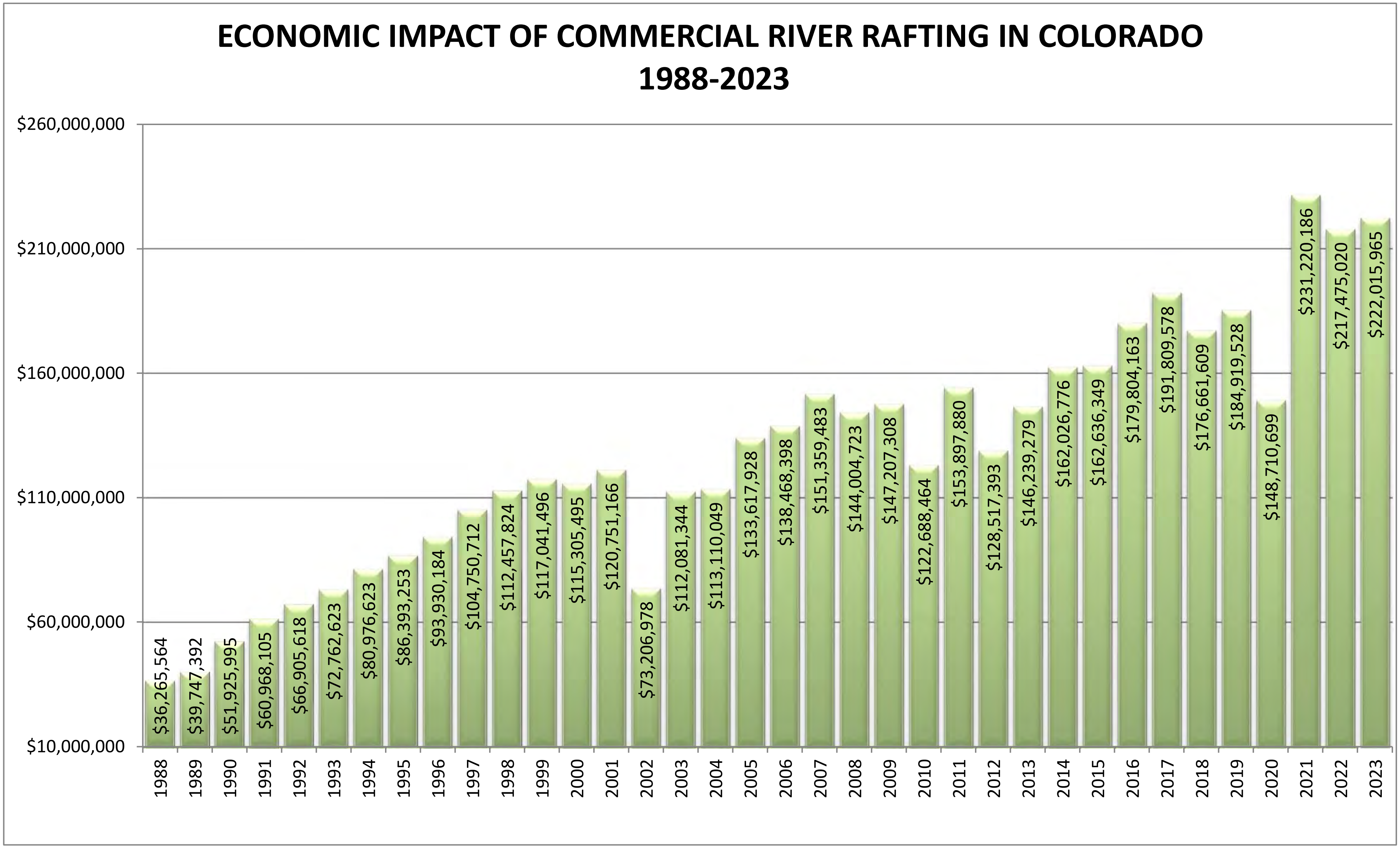
Idaho Springs, CO 80452
720-260-4135



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2023 ECONOMIC IMPACT OF COMMERCIAL RIVER RAFTING IN COLORADO

RIVER	USER DAYS	DIRECT EXPENDITURES	ECONOMIC IMPACT
Animas	37,139	$5,741,764	$14,698,917
Animas - Upper	227	$35,095	$89,842
Arkansas	224,700	$34,739,073	$88,932,027
Blue	1,856	$286,941	$734,570
Clear Creek	81,674	$12,626,965	$32,325,031
Colorado - Glenwood	64,940	$10,039,855	$25,702,029
Colorado - Upper	32,866	$5,081,150	$13,007,744
Colorado - Horsethief - Ruby	1,158	$179,029	$458,315
Colorado - Westwater	3,550	$548,837	$1,405,023
Dolores	940	$145,326	$372,034
Eagle - Upper	669	$103,429	$264,778
Eagle - Lower	8,776	$1,356,787	$3,473,375
Gore Creek - Vail	0	$0	$0
Green/Yampa	5,846	$903,803	$2,313,737
Gunnison Gorge	5,054	$781,359	$2,000,278
Gunnison - Upper (Town Run)	827	$127,856	$327,311
Gunnison - Escalante	376	$58,130	$148,814
Gunnison - Forks to Austin	2,162	$334,250	$855,679
Gunnison - Lake Fork	217	$33,549	$85,885
North Platte	301	$46,535	$119,130
Piedra	438	$67,716	$173,352
Poudre	29,921	$4,625,847	$11,842,168
Rio Grande	2,415	$373,364	$955,812
Roaring Fork - Above Basalt	2,639	$407,995	$1,044,466
Roaring Fork - Below Basalt	3,691	$570,636	$1,460,828
San Juan - Pagosa	9,340	$1,443,983	$3,696,596
San Miguel	7,173	$1,108,960	$2,838,938
South Platte	No Report	Not Available	Not Available
Taylor	13,616	$2,105,061	$5,388,956
Totals	**542,511**	**$83,873,294**	**$214,715,634**

See glossary for above economic impact formulas and sources

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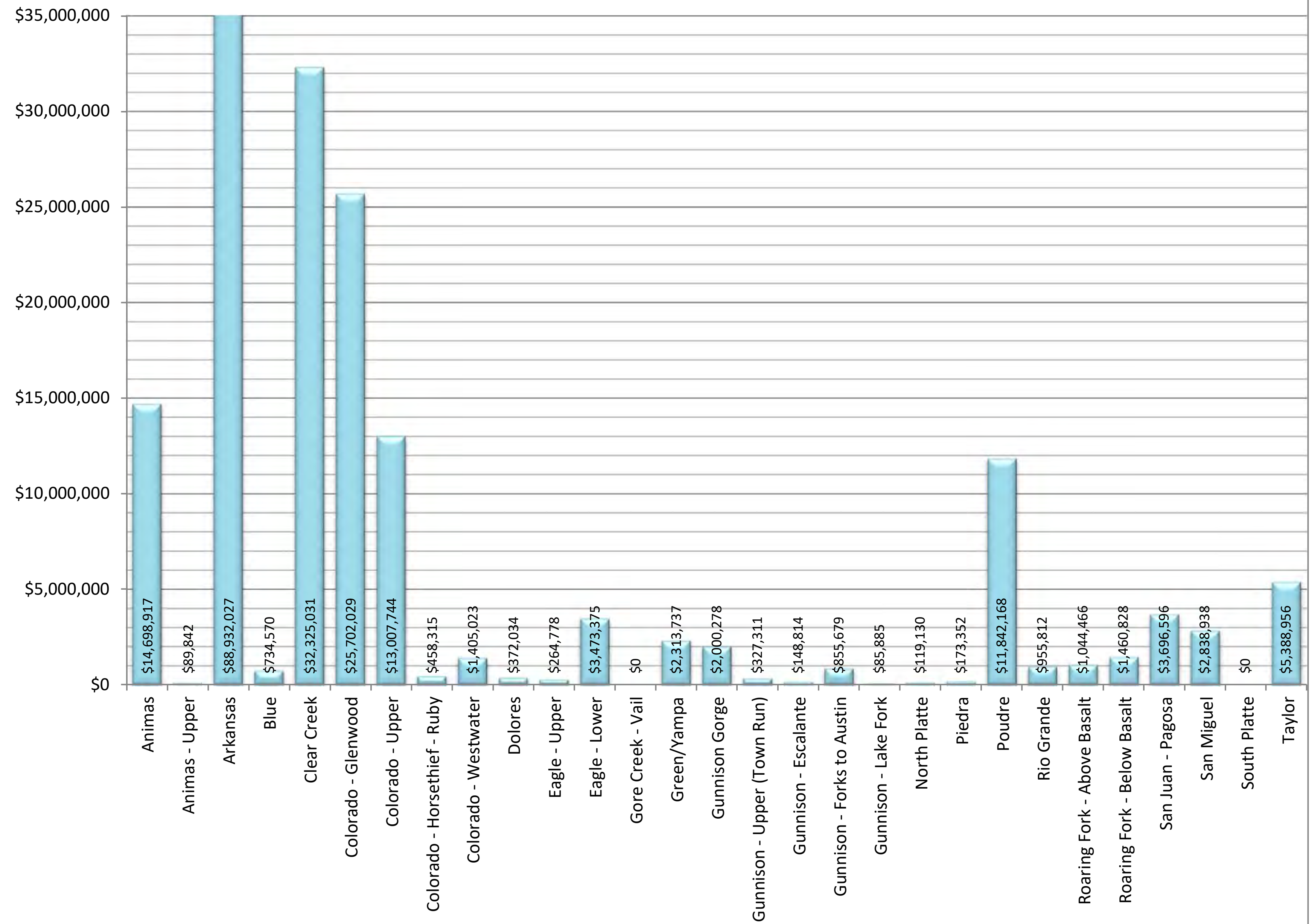
ECONOMIC IMPACT OF COMMERCIAL RIVER RAFTING IN COLORADO - 2023



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INDIVIDUAL RIVER COMMERCIAL RAFTING STATISTICS - 4 YR RANGE

RIVER	2021 USER DAYS	2022 USER DAYS	2023 USER DAYS	% CHANGE '20 - '21	% CHANGE '21 - 22	% CHANGE '22 - 23	2021 % MARKET SHARE	2022 % MARKET SHARE	2023 % MARKET SHARE
Animas	52,967	36,132	37,139	59.9%	-31.8%	2.8%	8.5%	6.6%	7.0%
Animas - Upper	387	286	227	N/A	-26.1%	-20.6%	0.1%	0.1%	0.0%
Arkansas	256,650	247,721	224,700	41.0%	-3.5%	-9.3%	41.2%	45.1%	42.4%
Blue	0	0	1,856	-100.0%	N/A	N/A	0.0%	0.0%	0.3%
Clear Creek	100,203	80,364	81,674	92.5%	-19.8%	1.6%	16.1%	14.6%	15.4%
Colorado - Glenwood	70,753	63,222	52,914	28.1%	-10.6%	-16.3%	11.4%	11.5%	10.0%
Colorado - Upper	45,433	33,866	32,866	-2.0%	-25.5%	-3.0%	7.3%	6.2%	6.2%
Colorado - Horsethief - Ruby	820	943	1,158	-35.3%	15.0%	22.8%	0.1%	0.2%	0.2%
Colorado - Westwater	6,369	5,299	3550	52.0%	-16.8%	-33.0%	1.0%	1.0%	0.7%
Dolores	0	75	940	N/A	N/A	1153.3%	0.0%	0.0%	0.2%
Eagle - Upper	266	88	669	-75.3%	-66.9%	660.2%	0.0%	0.0%	0.1%
Eagle - Lower	5,233	7,507	8,776	26.7%	43.5%	16.9%	0.8%	1.4%	1.7%
Gore Creek - Vail	0	0	0	-100.0%	N/A	N/A	0.0%	0.0%	0.0%
Green/Yampa	5,132	3,085	5,846	36.7%	-39.9%	89.5%	0.8%	0.6%	1.1%
Gunnison Gorge	6,110	6,096	5,054	34.2%	-0.2%	-17.1%	1.0%	1.1%	1.0%
Gunnison - Upper (Town Run)	4,170	2,883	827	N/A	-30.9%	N/A	0.7%	0.5%	0.2%
Gunnison - Escalante	144	241	376	433.3%	67.4%	56.0%	0.0%	0.0%	0.1%
Gunnison - Forks to Austin	2,326	2,276	2,162	43.8%	-2.1%	-5.0%	0.4%	0.4%	0.4%
Gunnison - Lake Fork	348	169	217	-18.1%	-51.4%	28.4%	0.1%	0.0%	0.0%
North Platte	0	0	273	N/A	N/A	N/A	0.0%	0.0%	0.1%
Piedra	173	36	438	N/A	-79.2%	1116.7%	0.0%	0.0%	0.1%
Poudre	39,877	33,008	29,921	85.6%	-17.2%	-9.4%	6.4%	6.0%	5.6%
Rio Grande	221	1,469	2,415	41.7%	564.7%	64.4%	0.0%	0.3%	0.5%
Roaring Fork - Above Basalt	948	1,541	2,639	-9.3%	62.6%	71.3%	0.2%	0.3%	0.5%
Roaring Fork - Below Basalt	221	655	3,691	-34.6%	196.4%	463.5%	0.0%	0.1%	0.7%
San Juan - Pagosa	0	4,000	9,340	N/A	N/A	133.5%	0.0%	0.7%	1.8%
San Miguel	8,201	5,547	7,173	67.4%	-32.4%	29.3%	1.3%	1.0%	1.4%
South Platte	No Report	No Report	No Report	N/A	N/A	N/A	No Report	No Report	No Report
Taylor	15,234	12,974	13,616	30.7%	-14.8%	4.9%	2.4%	2.4%	2.6%
Totals	**622,186**	**549,483**	**530,457**	**44.6%**	**-11.7%**	**-3.5%**	**100.0%**	**100.0%**	**100.0%**

Sources: National Park Service
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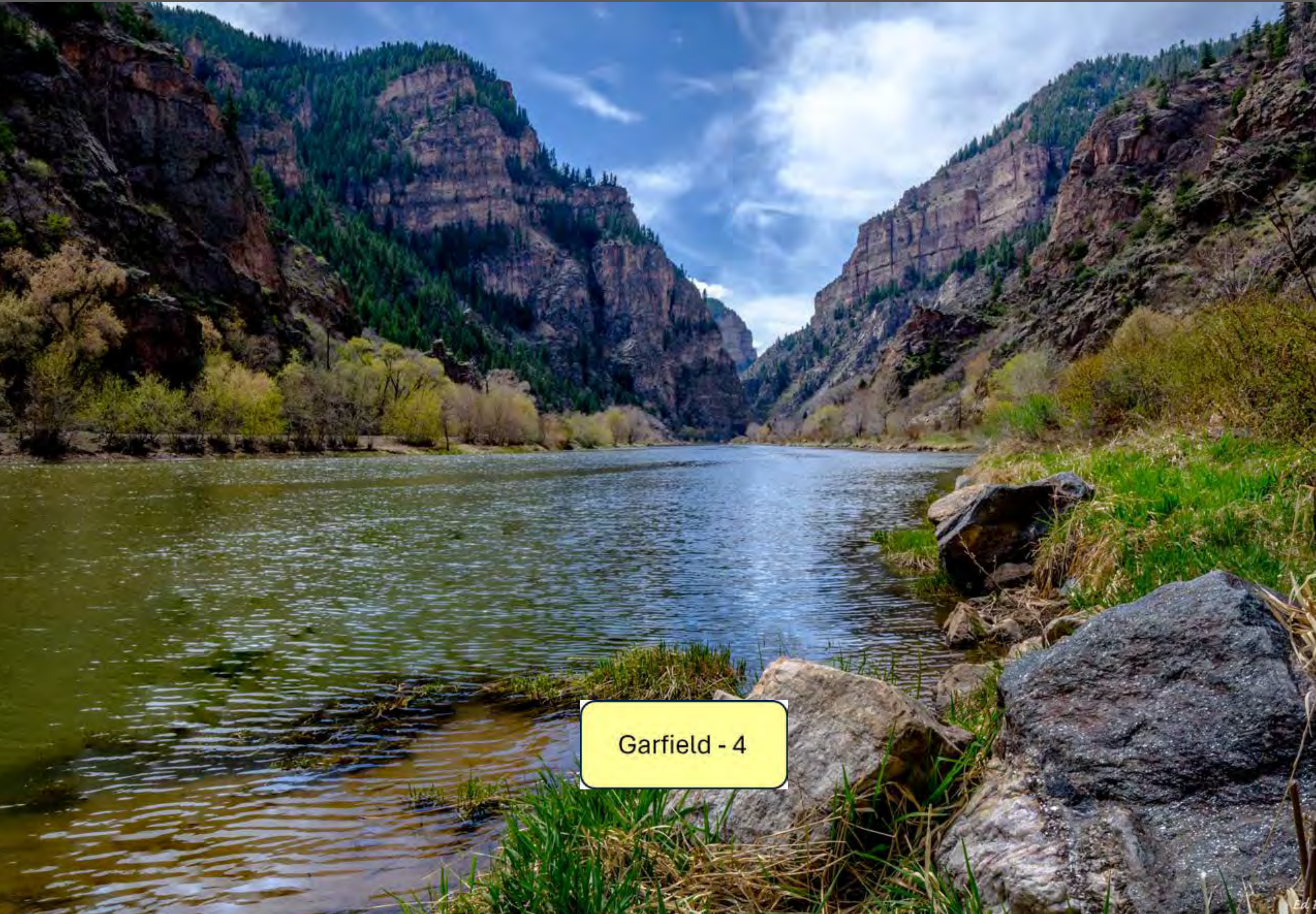
Middle Colorado
Watershed Council

THE ECONOMIC CONTRIBUTION OF RECREATION IN THE MIDDLE COLORADO WATERSHED



Garfield - 4

Baseline Assessment: The Economic Contribution of Recreation in the Middle Colorado Watershed

Preface

The Middle Colorado Watershed – from De Beque to Glenwood Springs - is a premier location for outdoor recreation. Whether it's hiking the national forests, rafting the Colorado River, fishing in the area's Gold Medal Waters, or hunting on the Roan Plateau, recreation is a strong driver of the area economy. However, until now, the size of that contribution has remained unknown.

A new report by Earth Economics estimates the economic contribution of outdoor recreation within the Middle Colorado Watershed. The information it provides is a great first step in painting a clear picture of the value of recreation to the region. With this new understanding, future resource management and economic decisions can be based on the current and potential value of the outdoor recreation industry.

The analysis found that recreation use within the Middle Colorado Watershed supports over 950 jobs in Garfield County each year, with $140 million spent on recreation for an annual contribution of $43 million to the GDP and $6 million in tax revenue.

While the results are impressive, more work needs to be done. Intuitively, we know the numbers are likely much greater that are portrayed in this report. For example, the report enumerates a long list of recreation types that occur throughout the watershed on publicly owned land. However, the list is not exhaustive. Recreation activities not considered in the report include rock climbing, snowmobiling, Nordic skiing and commercial fishing, to name a few, because data is lacking in these areas.

Further, the existing data which provided the basis for the study were widely variable. The more reliable and consistent data such as user days for state park recreation areas is valuable. Parks staff are able to count the number of users who enter the parks or camp at its facilities. On the other hand, data for Bureau of Land Management lands are less robust given the difficulty of tracking disparate uses across unpatrolled federal lands. Also, recreation use on private lands, such as hunting and fishing on agricultural properties - a significant economic contributor in the region – was not included.

Finally, future updates to this work should include the Roaring Fork River since it is a critically important economic and recreational resource. Even as it stands, the data and results of this report will be useful in many respects. It can support investments in clean water, for example, in maintaining healthy streamflows, and in conserving working ranches and open spaces.

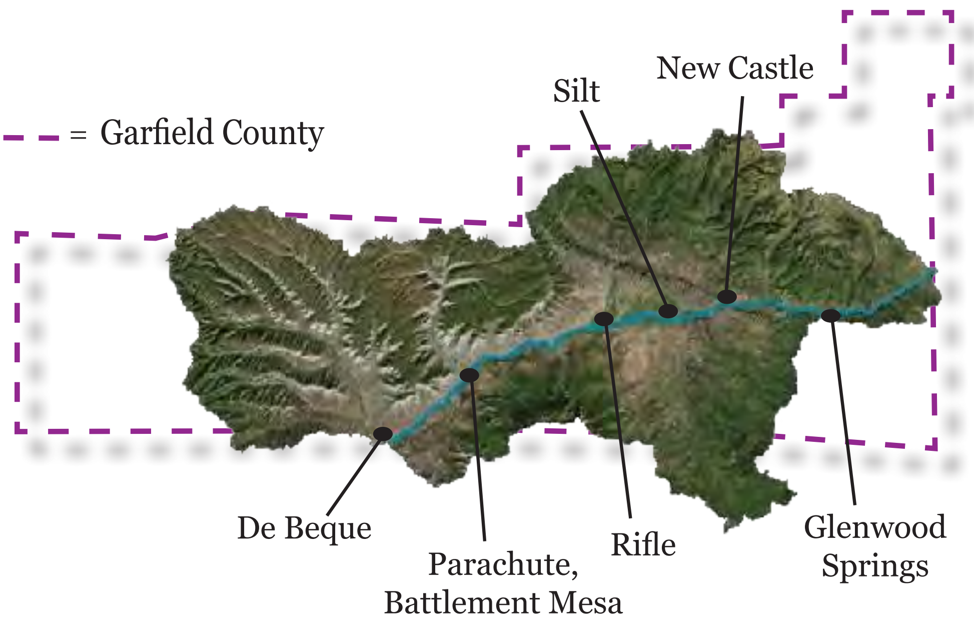
Local communities will find this analysis to be of value because it begins to quantify the economic contribution of outdoor recreation, which is an important driver for the middle Colorado River. Hopefully, it can be the basis of further study. With this information in hand, we can develop a blueprint for wise investment of our time and money in keeping outdoor recreation a viable industry.

Donna Gray
Board of Directors, Middle Colorado Watershed Council
May 2018

EARTH ECONOMICS

VALUE of OUTDOOR RECREATION in the MIDDLE COLORADO WATERSHED

The Watershed **supports**



850K
acres of open space

430K
state park visits

71K
big game hunting days

521K
river recreation days

33
river guiding outfits

$140M
spent annually on recreation activities

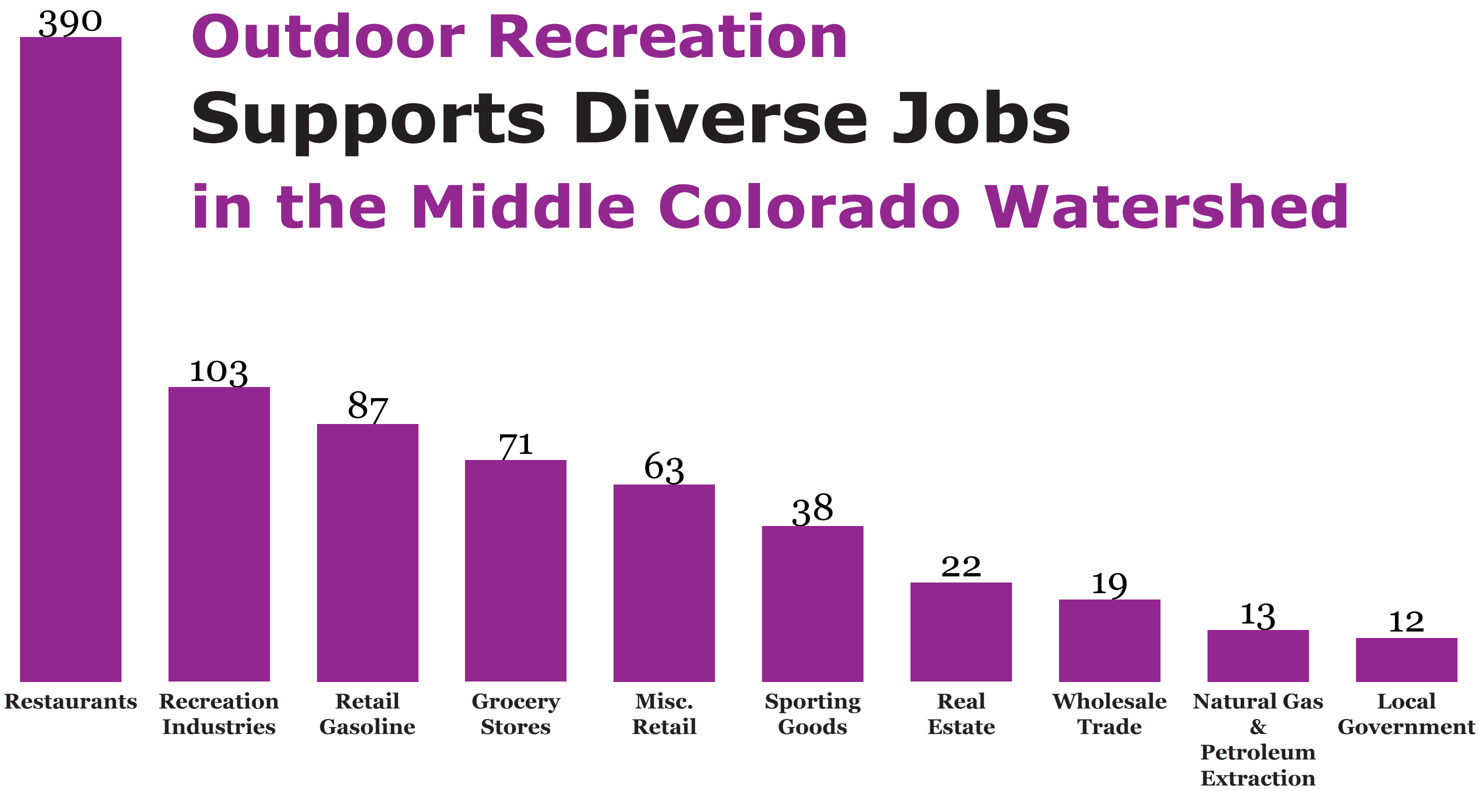
972
jobs supported annually within Garfield County

$43M
contributed to GDP

$6M
generated for state and local taxes

www.eartheconomics.org

Outdoor Recreation Supports Diverse Jobs in the Middle Colorado Watershed



Top 10 Garfield County Industries with Jobs Supported by Outdoor Recreation

Healthy Lands, Thriving Economies

Maintaining healthy lands and waters is key to attracting outdoor recreationists, who in turn contribute to sustainable local economies.

The Colorado River forms the heart of the state's outdoor industry. Within the Middle Colorado River Watershed, the river is responsible for at least:

$32M spent annually on recreation activities

321 jobs supported annually within Garfield County

$15M contributed to GDP

$2.5M generated for state and local taxes

EARTH ECONOMICS

Baseline Assessment:
The Economic Contribution of Recreation in the Middle Colorado Watershed

Earth Economics

www.eartheconomics.org

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Report Version 1.1

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Johnny Mojica, Research Lead, Earth Economics

Year
2018

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The Middle Colorado Watershed Council: Laurie Rink

Earth Economics: Cyrus Philbrick (factsheet design), Greg Mireles (GIS analysis and maps)

We would also like to thank Earth Economics' Board of Directors for their continued guidance and support: support: Alex Bernhardt, David Cosman, Elizabeth Hendrix, Greg Forge, Ingrid Rasch, Molly Seaverns, and Sherry Richardson.

The authors are responsible for the content of this report.

Contents

This report highlights the methods, data sources, and detailed results supporting Earth Economics' factsheet entitled "Economic Contribution of Recreation in the Middle Colorado Watershed", and is organized into the following sections:

Section 1. Introduction

Recreation opportunities abound in the Middle Colorado River Watershed, from the Flattop Wilderness and Glenwood Canyon in the east to expanses of Bureau of Land Management (BLM) land in the west. Visitors and locals enjoy access to stunning outdoor recreation areas within the watershed. Intact wilderness and healthy lakes and rivers provide many benefits for recreationists, improving mental and physical health through connections with nature and opportunities to hike, run, paddle, and bike. In addition to individuals' mental and physical health, thriving outdoor recreation lands contribute to the economic health of surrounding communities through the recreation-related spending of visitors and residents. While it is acknowledged that recreation is an economic engine in the Middle Colorado River Watershed, until now the size of its contribution has remained unknown, because it is not measured in traditional economic indicators like the Gross Domestic Product (GDP).

This analysis estimates the economic contribution of outdoor recreation within the Middle Colorado River Watershed, specifically the direct and secondary effects of recreational spending – jobs, GDP contribution, and tax revenue – realized in Garfield County. By highlighting this sector, future resource management and economic decisions can be made with an appreciation of the current and potential value of the local outdoor recreation industry.

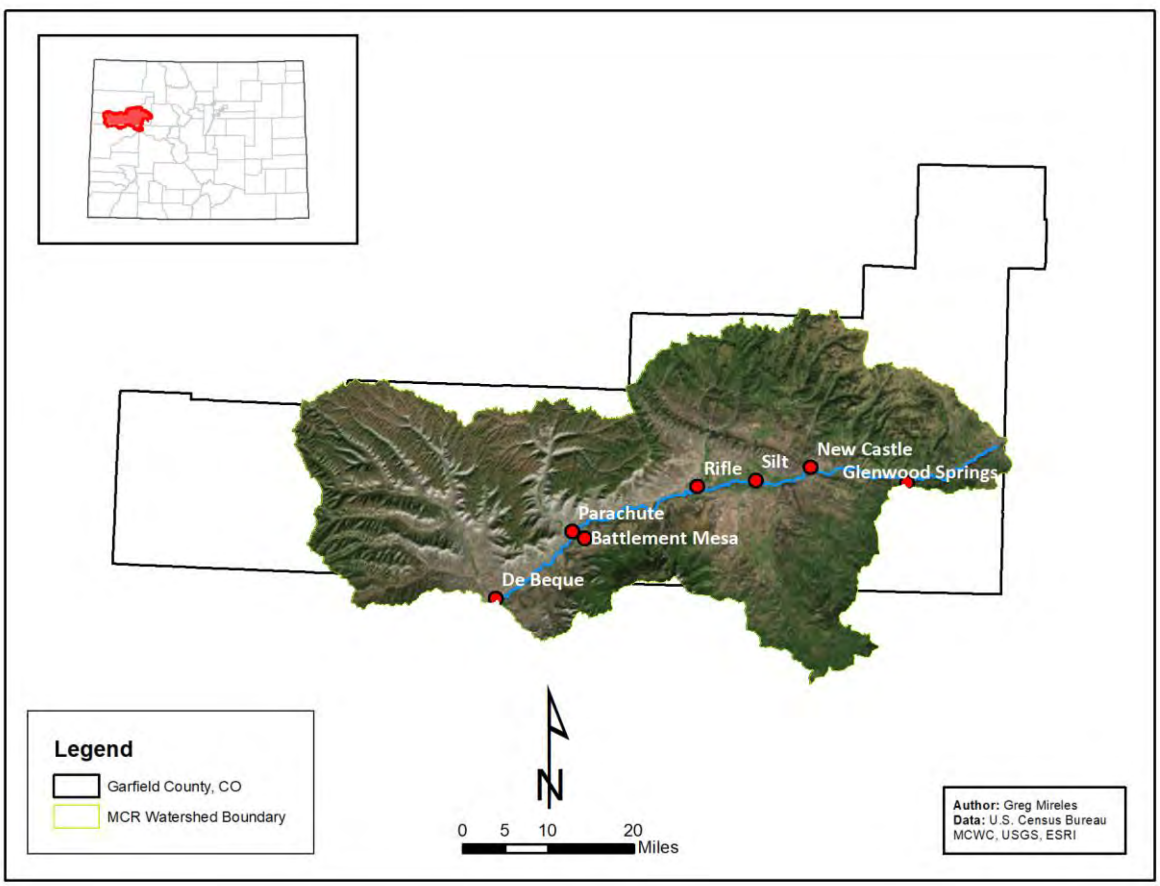

Figure 1. The Middle Colorado Watershed

Section 2. Recreation Participants

The Middle Colorado River Watershed provides recreation opportunities for all types of outdoor enthusiasts. Rafting through Glenwood Canyon, hiking in the White River National Forest, picnicking at a local park, jet boating on the Colorado, running along waterfront trails, and fishing at Rifle Gap State Park are just a handful of the possibilities available to local residents and out-of-town visitors. The beautiful mountains, canyons, and iconic Colorado River provide an ideal backdrop for these activities.

To quantify the economic contribution of outdoor recreation activities, this analysis begins with estimates of recreational use within the watershed. Recreation participation data varies in availability and quality, and depends on the collection methods of individual agencies and municipalities. The Middle Colorado River Watershed encompasses lands managed by multiple Federal, State, and Local agencies, including the United States Forest Service (USFS), BLM, Colorado Parks and Wildlife (CPW), and local parks districts. This analysis primarily quantifies recreation occurring on these public lands, but also includes activities spanning ownership such as big game hunting and river use.

Further complicating participation estimates, the waters within the watershed, and specifically the Colorado River, are not consistently monitored. Without direct river ownership, federal land managers and local park personnel track boat launches and river use inconsistently. River use monitoring for the Upper Colorado Wild and Scenic application provides insight for this analysis by surveying recreation in Glenwood Canyon in greater detail. Based on these considerations the following estimates can be considered a low estimate for visitation and could be improved on as additional recreation use is captured.

Standardizing data from sources discussed above, this analysis presents an estimation of total annual *visits* for outdoor recreation in the Middle Colorado River Watershed. Where available, a five-year average was used to calculate annual visits for recreation activities. Otherwise visitation data represents the most recent monitoring year, which may vary between agencies. A visit is defined as a single trip to recreational lands and/or waters, participating in one or more recreational activities. Visits are then aggregated across agencies by primary recreation activity type. Table 1 displays all visits for recreation in the Middle Colorado River Watershed.

Table 1. Annual Recreation Visits in the Middle Colorado River Watershed

Recreation Type	Visits	Recreation Type	Visits
National Forests		**Local Parks**	
General Recreation	903,094	Walking	263,492
Camping	3,124	Picnicking	18,005
BLM Lands		Jogging/Running	153,637
Mountain Biking	5,650	Golf	36,872
Target Practice	617	Team or Individual Sports	22,964
OHV - ATV, Motorcycle	6,192	**Various Public and Private Lands**	
Picnicking	1,167	Big Game Hunting	71,448
Camping	20,844	**Rivers**	
Boat Launching	2,458	Rafting Commercial	57,824
Hiking/Walking/Running	28,655	Rafting Private	107,387
Social Gathering	11,462	Kayak/Dory/Float	77,746
Guided Hunting	700	Fishing	217,320
State Parks		Jet Boating	1,400
Hiking/General	413,589		
Camping In-State	12,540		
Camping Out-of-State	2,816		
	Total Visits	**2,441,004**	

Section 3. Consumer Expenditures

When individuals participate in outdoor recreation activities, they spend money in the local economies surrounding their recreation destination. Estimating these trip-related expenditures is an important component of this analysis, linking recreation participant days detailed above to dollars spent in local economies.

In this analysis, visits are assigned trip-related expenditures (both total and by economic sector) depending the primary activity of the visit. Depending on the location and choice of recreation activity, participants spend money on a range of goods and services. Based on economic literature the average per-visit expenditures can be estimated for different kinds of trips, such as visiting a state park or kayaking on the river.[1] These participant expenditures are summed for all visits to arrive at total spending resulting from outdoor recreation in the Middle Colorado River Watershed. Table 2 provides a breakdown of visits, per visit expenditures, and total expenditures by activity type in the Middle Colorado River Watershed.

Table 2. Outdoor Recreation Expenditures by Activity Type

Activity	Visits	Per Visit Expenditures[i]	Total Expenditures
Wilderness Recreation	983,963	$78.71	$77,450,678
State Park Recreation	428,945	$35.17	$15,086,644
Local Park Recreation	494,971	$16.14	$7,990,120
Big Game Hunting	71,448	$89.82	$6,417,666
Rafting, Commercial	57,824	$117.78	$6,810,548
Rafting, Private	107,387	$79.25	$8,509,905
Kayaking, Rowing, Floating	77,746	$51.28	$3,987,117
Fishing	217,320	$58.48	$12,709,580
Jet Boating	1,400	$117.78	$164,893
Total	**2,441,004**		**$139,127,151**

[1] Expenditures on "equipment" (e.g. clothes, binoculars, boots, and cameras) were not included in this analysis as it is difficult to separate equipment purchases made for exclusive use in the Middle Colorado River Watershed. Expenditures by public institutions for construction and maintenance were also not included.

Section 4. Economic Contribution Analysis

Outdoor recreation expenditures circulate through local economies – in this case, Garfield County – and result in economic effects. Economic effects can be described as the economic activity resulting from initial expenditures made within an economy. This analysis assesses economic effects, stated in terms of their contributions to GDP, state and local taxes, and jobs.

This economic contribution analysis was conducted using input-output modeling with an industry standard platform, IMPLAN[ii] (IMpacts for PLANing). Given a level of expenditures in a region, the model generates economic contributions from a particular industry. Although outdoor recreation is not a separate industry in IMPLAN, Earth Economics created custom expenditure profiles for the different activity types within the model, as described in Section 2 above. The following are components generated through county-specific modelling:

1. **Direct Contributions:** Dollars spent at businesses by consumers while they engage in outdoor recreation. For example, visitors are likely to spend money at a restaurant in Glenwood Springs or New Castle after a day on the Colorado River.

2. **Indirect Contributions:** Payments made to supporting businesses by businesses who receive direct contributions. When visitors eat out at a restaurant as in the example above, a portion of the money that a restaurant charges its customers is used to pay the businesses that supply and transport its food.

3. **Induced Contributions:** Dollars returned to the economy by employees of businesses who benefit from direct and indirect contributions. Employees of a restaurant – and the businesses that supply that restaurant – earn an income, a portion of which is spent at other businesses in the local economy.

Total Economic Contribution (whether GDP, taxes, or jobs) is the sum of direct, indirect, and induced contributions. The economic structure of Garfield County, used to determine expenditure flows, is based on economic information from the U. S. Department of Commerce, the U.S. Bureau of Labor Statistics, and other agencies. These estimates are specific to Garfield County and have not been transferred from another region.

Indirect and induced economic effects vary in magnitude based on the sector of expenditures and composition of local or regional economies. Outdoor recreation expenditures generate high levels of secondary (local) spending compared to other industries, circulating dollars within the local economy. Additionally, economies that are less dependent on external resources overall see greater economic effects, as a higher proportion of expenditures remain circulating within the economy. For instance, take a restaurant that purchases vegetables from a local farmer. After the farmer recovers costs, a portion of the profit may be re-spent locally within the economy, creating additional economic effects. The same dollar may be re-spent several times within the economy depending on the diversity of industries present in the region.

On the other hand, if vegetables are purchased from outside the region, money leaves the economy and will not be re-spent locally. The regional economic effects end here, though they may continue at the state or national level. IMPLAN also calculates these "leakages" from the local economy, or money that exits the local economy. Money spent by local businesses in Garfield County to import goods from another region, such as Denver, would be considered leakages in this analysis.

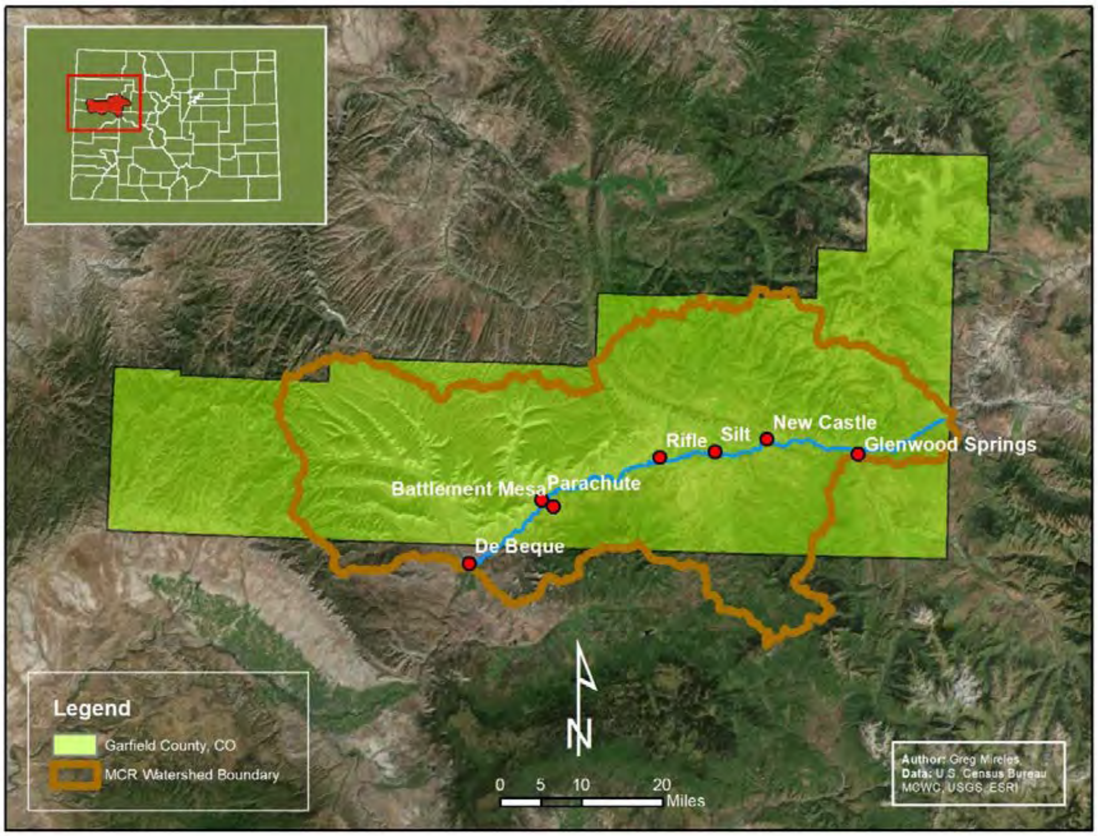

Figure 2. Spending effects of recreation activities occurring within the Middle Colorado Watershed are assessed at the scale of Garfield County, highlighted in this figure.

The economic effects associated with all recreation expenditures, $140 million, are outlined in Table 3. These results are specific to Garfield County, not including leakages to the larger economy.

Table 3. Total Economic Effects from Middle Colorado River Watershed Recreation Expenditures.

All Watershed Outdoor Recreation Expenditures	**$139,127,000**
Garfield County Jobs Supported	**972 jobs**
GDP Contribution	**$42,927,000**
State and Local Tax Revenue	**$5,967,000**

In addition, this analysis segmented the portion of recreation expenditures related to river recreation activities in the Middle Colorado River Watershed. Table 4 displays these results, which are a subset of Table 3 and should not be added to the above results.

Table 4. Economic Effects of River Recreation Expenditures, Subset of Table 3.

River Recreation Expenditures	**$32,182,000**
Garfield County Jobs Supported	**321 jobs**
GDP Contribution	**$15,189,000**
State and Local Tax Revenue	**$2,472,000**

Section 5. Discussion of Results

Outdoor recreation is a significant industry in the state of Colorado and in Garfield County. A recent Outdoor Industry Association (OIA) analysis attributed $28 Billion in consumer spending to recreation in the state of Colorado, resulting in 229,000 direct jobs.[iii] The Middle Colorado River Watershed analysis presented here works to provide local context to these contributions, assessing the spending effects on the Garfield County economy.

This analysis finds that Middle Colorado River Watershed recreation opportunities support over 950 jobs in Garfield County each year, in addition to $43 million in GDP contribution and $6 million in tax revenue. Acknowledging these contributions is an important component of sustaining and growing the local recreation industry in the face of competing priorities. This analysis likely underestimates the economic contribution of recreation, as estimates of participation are unable to capture the full population of recreationists. In addition, this analysis does not consider the overall economic impact of the current and future residents who move Garfield County because of the abundant outdoor recreation opportunities, spurring new businesses, jobs, innovation, and supporting tax revenue.

The state of Colorado is known nationwide as a premier destination and home for all manner of outdoor enthusiasts. Positioned uniquely to draw both east-west travelers as well as visitors to local resort destinations, the Middle Colorado River Watershed supports a vibrant outdoor recreation industry with continued growth potential. As surrounding populations grow, more individuals will venture to recreation destinations in the Middle Colorado River Watershed to enjoy the outdoors. Maintaining healthy lands and waters for recreation is critical to keeping and attracting outdoor recreationists, who in turn contribute to sustainable local economies.

References

[i] Per Visit Expenditure Profiles:

Wilderness Recreation:
White, Eric M. 2017. Spending patterns of outdoor recreation visitors to national forests. Gen. Tech. Rep. PNW-GTR-961. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p.

State Parks Recreation:
Corona Research, Inc., 2009. Colorado State Parks Marketing Assessment. Visitor Intercept Survey.

Local Park Recreation:
Corona Research, Inc., 2009. Colorado State Parks Marketing Assessment. Visitor Intercept Survey. [Used lowest State Park Expenditure Profile – Bar Lake]

Big Game Hunting:
White, Eric M. 2017. Spending patterns of outdoor recreation visitors to national forests. Gen. Tech. Rep. PNW-GTR-961. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p. [Used hunting expenditure profile]

Rafting, Commercial:
English, D., Bowker, J., 1996. Economic Impacts of Guided Whitewater Rafting: A Study of Five Rivers. Water Resources Bulletin. American Water Resources Association 32:6

Rafting, Private:
Shultz, S., 2009. Economic & Social Values of Recreational Floating on the Niobrara National Scenic River. University of Nebraska at Omaha.

Kayak, Rowing, Floating:
White, Eric M. 2017. Spending patterns of outdoor recreation visitors to national forests. Gen. Tech. Rep. PNW-GTR-961. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p. [Used non-motorized water expenditure profile]

Fishing:
White, Eric M. 2017. Spending patterns of outdoor recreation visitors to national forests. Gen. Tech. Rep. PNW-GTR-961. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p. [Used fishing water expenditure profile]

Jet Boating:
English, D., Bowker, J., 1996. Economic Impacts of Guided Whitewater Rafting: A Study of Five Rivers. Water Resources Bulletin. American Water Resources Association 32:6 [Assumed to be the same as commercial rafting]

[ii] IMPLAN V3.1.1001.12, 2013. Impacts for PLANing. Minnesota Implan Group, Inc. Accessible at: www.implan.com

[iii] Outdoor Industry Association, 2017. Accessible at: www.outdoorindustry.org/state/Colorado/

Gregory M. Cowan

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Education

J.D., University of Denver Sturm College of Law, Denver, CO
- Managing Editor, *DU Water Law Review* (2012 – 2013)

B.S. in Geography, Portland State University, Portland, OR

Professional Experience

Owner/Operator – Defiance Rafting Company, Glenwood Springs, CO 2018 - Present
- Offer guided commercial river trips and rentals on the Colorado River through Glenwood Canyon.
- Hire and oversee a staff of roughly forty seasonal employees.
- Permitted to host up to thirteen thousand participants each season.

Staff Attorney – Wyoming County Commissioners Association (WCCA), Cheyenne, WY 2013 - 2017
- Facilitated dialogue among local elected officials and federal public land management agencies.
- Provided formal comments on behalf of Wyoming's twenty-three counties regarding energy, natural resources, wildlife, and air quality during the federal rulemaking process.
- Submitted briefs in federal court supporting the WCCA and the State of Wyoming's stance during litigation.
- Provided commissioner testimony to state legislative and federal congressional committees.

Law Clerk – Carlson, Hammond, & Paddock, LLC, Denver, CO Summer 2012
- Drafted legal and informational memoranda on issues related to water, home rule, real estate, and public land-use law in Colorado.

Legal Intern – The Honorable Gregory Lammons, 8th JD, Fort Collins, CO November 2011 – May 2012
- Reviewed motions, researched relevant caselaw, prepared summaries of legal arguments, and assisted in the preparation of court documents.
- Researched and prepared orders for the judge's signature.

Research and Policy Analyst – Colorado Senator Irene Aguilar, Denver, CO February 2011 – May 2011
- Created fact sheets on upcoming legislation that outline legal history, statutory effects, and the plain language of a proposed law.
- Supplied background details on various topics to assist the Senator's policymaking process.
- Synthesized constituent questions and concerns related to legislation for the Senator's review.

Glazer – Commercial Glass Incorporated, Loveland, CO January 2009 – July 2010
- Worked in a fast-paced, deadline-driven environment, often under adverse conditions.

Sales Associate – Recreation Equipment Incorporated, Portland, OR August 2007 – February 2008
- Used years of outdoor experience to inform customers about different products.

Guide – Good Times Dogsled Tours, Breckenridge, CO Winters 2004 – 2006
- Led and instructed clients on independent dog sled tours in Arapahoe National Forest backcountry; ensured client and dog team safety; assisted in training new staff.

Pipefitter – Raytheon Polar Services; South Pole, ANT September 2002 – February 2003
- Completed contract goals ahead of deadline while working in extreme climate.

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Gregory M. Cowan

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Head Boatman – Rock Gardens Rafting, Glenwood Springs, CO Summers 2000 – 2005

- Managed logistics and daily operations for the rafting company.
- Supervised guide staff, including hiring and termination procedures.
- Led a team-building program for Colorado Outward Bound.
- Conducted training and certification courses alongside team members for new guide staff.

Civic Involvement

- **Commissioner –** City of Glenwood Springs Planning and Zoning Commission 2023 – Present
- **Chair –** USFS & Outfitter Shoshone Partnership 2019 – 2020
- **Volunteer –** Small Acreage Management Program, CSU Extension, Boulder County, CO 2009 - 2011
- **Coordinating Volunteer –** Willamette Watershed Council, Portland, OR June – September 2008

Matthew R. Langhorst, P.E., CFM

EDUCATION

Bachelor of Science (1999)
Michigan Technological University, Houghton, MI.
Major: Civil Engineering

EXPERIENCE

Assistant City Engineer/Public Work Director (August 2016 - Present)
City of Glenwood Springs, CO

- Hired as the Assistant City Engineer in 2016, completed infrastructure projects including storage building design and construction, concrete trail and pedestrian bridge design and construction, multiple grant applications and grant processing including the a local FMLD grant and DOLA utility grant.
- Promoted to Assistant Public Works Director in 2017 and took over a majority of the current Public Works Directors duties so that he could complete several long-term projects prior to his retirement in 2019.
- Promoted to full Public Works Direction duties in March of 2018 prior to current directors' retirement. Current Departments in charge of are Electric, Water, Wastewater, Broadband, Streets, Fleet and the Landfill. We as a City are working toward infrastructure rebuilding to include water, wastewater and roadways. New projects in the works are an additional substation, new electric department building, complete revamp of the existing landfill CD plan to include planning for the next 15 years, water plant disinfection system change over, complete subdivision redesigns, removal and replacement projects and we are working on multiple sustainability projects such as a new in town recycle center.

Project Manager (March 2014 – August 2016)
High Country Engineering, Glenwood Springs, CO

- Project Manager for Ironbridge Subdivision Phase 3 – Responsible for coordinating utility design, roadway profiling, site grading, cost estimate calculations, final plan submittal and county review/meeting attendance.
- Project Manager on multiple million dollar residential site plans, utility layouts and drainage reports for the City of Aspen and Pitkin County areas.
- Project Manager for Ironbridge and Lakota Canyon Ranch individual site plot plans for production home construction. Creation of grading, drainage, utility and site placement of spec home designs on individual lots as owners contract the work to be completed. Submittal packets to Town of New Castle and Garfield County.

Owner/General Contractor (October 2006 – March 2014)
Roaring Fork Civil Consultants, Inc. – Thunder Construction, Basalt and Aspen, CO

- Owner of RFCC, Inc., continuing design and management on multiple million dollar residential site plans, utility layouts and drainage reports for the City of Aspen and Pitkin County areas.
- Project Manager/Site Supervisor for Thunder Construction in Aspen Colorado in charge of construction of multi-million dollar homes. From preliminary budgeting of project cost, contract negotiations all the way through final CO on homes and handover of residences to the owners. I was in charge of up to 50 subcontractors at any one time the construction projects.

Project Manager-Project Engineer (August 2001 – October 2006)
High Country Engineering, Glenwood Springs, CO

- Project Manager for Ironbridge Subdivision – Responsible for coordinating utility design, roadway profiling, site grading, cost estimate calculations, final plan submittal and county review/meeting attendance.
- Project Manager Stillwater Subdivision – In charge of re-entitlement of the existing

plan set from 2002, coordination with the Town of Silt for changes in plan and water/sewer system layouts and final platting for Phase I of the project.

- Project Manager on the rezoning, annexation, exemption platting, and sketch plan submittal of a 122 acre commercial/residential parcel within the Town of Gypsum and Eagle County. Coordination with sub-consultants to complete the feasibility study for the site and coordination with the Town of Gypsum was vital to meet the required closing date of the property for the client.
- Project Manager on multiple million dollar residential site plans, utility layouts and drainage reports for the City of Aspen and Pitkin County areas.
- Project Engineer for Coal Ridge High School, Garfield County, Colorado - Responsible for onsite and offsite utility design, roadway profiling, site grading, surcharge grading, cost estimate quantities and final plans.

Project Engineer (September 1999 – August 2001)
J.F. Sato and Associates, Denver, CO

- Project Engineer for Powers Corridor Feasibility Study - Central Section: Responsible for preliminary interchange designs, cost estimates, and feasibility study report for a 11.5 mile stretch of Powers Boulevard in Colorado Springs including 17 interchange alternatives.
- Project Engineer for Platte/Powers - Partial Clover Interchange: Responsible for the coordination and relocation of all utilities, design of sanitary sewer relocate and cost estimate calculations.
- Project Engineer - Eagle-Vail ½ Diamond Interchange, responsible for 1000’ of sanitary sewer trunk line re-design, utility location and relocation, ramp design and cost estimate calculations.

Tom Harrington

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Carbondale, CO
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crystalriverranch@icloud.com

EXPERIENCE

General Manager

Crystal River Ranch-Carbondale, CO
December 2008-present (August 2025)

- General management responsibility for ranching properties of Crystal River Ranch in Garfield, Pitkin and Eagle Counties includes irrigation water and systems; hay and pasture ground on headquarters and Dry Park property, summer pasture at Cottonwood property and USFS grazing
  - Manage 500-750 Commercial Angus cross Hereford cows including breeding, marketing and culling decisions
  - Develop and manage ranch income, expense, purchasing and capital budgets

General Manager

Dearborn and N Bar Ranches-Wolf Creek and Grass Range, MT
December 2006-December 2008

- General management responsibility for two large cow-calf ranches totaling 140,000 acres
  - 3200 Commercial Angus cows combined between the two ranches
  - Develop and manage ranch income, expense, purchasing and capital budgets with total revenue in excess of $2.3m with profit margin of 20% in 2007
  - Develop and monitor expense and capital budgets for personal enterprises of owners horse program, bird hunting and habitat development
  - Monitor construction projects of houses, fences, improvements
  - Implement and manage horse breeding program for raising ranch horses
  - Manage guest services for owners and their guests, up to 40 people at a time
  - Oversee maintenance and upkeep on main residence and 6 guest houses, indoor arena
  - Implemented a retained ownership feeding enterprise with development of markets for premium branded beef products
  - Manage and supervise daily work of 14 employees: cowboys, wildlife habitat, horse trainers, ranch hands, maintenance, landscape and housekeepers

General Manager

Double RL Ranch—Ridgway, Colorado
April 2001 to October 2006

- Management responsibility for a 17,000 acre high mountain cattle and recreational ranch for absentee owner
  - 150 registered Angus and South Devon cows, 750 commercial cows
  - Developed customer base for private treaty bull sales of 25 head, generating $60,000 in seedstock enterprise revenue annually

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- Raised 80% of ranch bull needs, cut capital expenditures by $50,000 annually
- Retained ownership feeding of 600 head with development and marketing of premium branded beef products. Expanded market to Telluride and Chicago restaurants
- Experienced in Colorado water rights for domestic, irrigation and recreational uses
- Managed and supervised daily work of 10 employees: cowboys, ranch hands, maintenance, landscape and housekeepers
- Developed and managed ranch income, expense, purchasing and capital budgets
- Managed guest services and maintenance of main lodge and 8 guest houses
- Managed trophy big game hunting enterprise with 40 annual clients, generating $250,000 in annual revenue

General Manager

Jolly Roger Angus Ranch—Belt, MT
June 1998 to April 2001

- Working management responsibility for a 10,000 acre foothills to mountain range operation
    - 350 registered Angus seedstock, with annual seedstock sales in excess of $500,000
    - Bull and heifer development, production sale planning/management of on-site sales, record keeping and database analysis
    - Conducted reproductive work including AI and embryo transfer
    - Managed four employees on daily work schedule
    - Developed marketing, built customer relations, rebuilt several working facilities,
    - Developed and managed income, expense, purchasing and capital budgets
    - Implemented an elk, whitetail deer and mule deer hunting enterprise on the ranch

Seedstock Manager

Bar T Bar Ranch—Winslow, AZ
October 1996 to June 1998

- Management of 400,000 acre public lands and range operation
    - 300 head seedstock herd of Angus, Black Angus, Gelbvieh and Composite
    - Record keeping, database analysis and labor management
    - Conducted reproductive work included AI, embryo transfer, and pregnancy testing
    - Intensive grazing, range management and private treaty marketing
    - Managed 400 registered and commercial first calf heifers from AI breeding through first calving and weaning

General Manager

Buffalo Creek Red Angus—Leiter, WY
December 1994 to October 1996

- Management responsibility for a 35,000 acre foothills range operation
    - 850 cow registered herd with annual production sale of 250 yearling bulls and 100 yearling heifers
    - All reproductive work, labor management, private treaty sales and customer relations

VOLUNTEER SERVICE

Colorado Cattlemen's Association

- NW Quarter Representative
- Property Rights Committee Chair
- State Association President 2024-25

ACADEMIC EDUCATION

Colorado State University, Ft. Collins, CO

- B.S. Animal Science December 1992
- Concentration: Industry Management

Colorado State University, Ft. Collins, CO

- M.S. Animal Science December 1994
- Concentration: Ranch Systems Management and Beef Cattle Reproduction