RJH CONSULTANTS, INC.

GEOTECHNICAL AND
WATER RESOURCES ENGINEERING

FEASIBILITY STUDY REPORT

SAN JUAN HEADWATERS STORAGE PROJECT

ARCHULETA COUNTY, COLORADO

Submitted to
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Project 25127

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SECTION 1 - INTRODUCTION

1.1 Purpose

The purpose of this Feasibility Study Report (Report) is to present the methodology, results, and conclusions of the screening-level water storage evaluation performed by RJH Consultants, Inc. (RJH) for the San Juan Headwaters Storage Project (Project). This report was prepared by RJH on behalf of San Juan Water Conservancy District (SJWCD) to support a Small Storage Grant application from the United States Bureau of Reclamation (Reclamation) to advance planning, permitting, and design of the Project. The Project meets the requirements of Reclamation's Small Storage Program under section 40903 of Pub. L. 117-58 and as amended by Pub. L. 117-328.

1.2 Project Sponsor

The Project sponsor is SJWCD. SJWCD was formed in 1987, in accordance with the Water Conservancy Act, with a decree to conserve, maximize, and utilize the water resources of the San Juan River and its tributaries (Archuleta, 1987). The primary focus of SJWCD is managing the water rights ceded to the district upon its formation and exploring water storage options for the upper San Juan River basin. As an active leader in water resources issues in the upper San Juan River basin, SJWCD is pursuing construction of a new water storage reservoir to address the lack of regional water storage, facilitate water conservation, and ensure a reliable future water supply for the community.

SJWCD is funded through a mill levy that provides approximately $100,000 per year. Their funding is limited compared to other utility districts that provide water directly to municipal users. This limited funding emphasizes the need to work with Federal, State and private partners to find additional funding so SJWCD can fulfill its mission to meet the water needs of the region.

1.3 Study Area

SJWCD is located in Archuleta County in the southwestern portion of Colorado near the border with New Mexico. The SJWCD district boundary is about 100 square miles and generally includes the Town of Pagosa Springs (Pagosa Springs) and surrounding unincorporated areas. The district boundary contains about 90-percent of the County population (SJWCD, 2017).

The study area for constructing a new water storage reservoir is an approximate 10 square mile area located within the SJWCD district boundary, northeast of Pagosa Springs and east of the San Juan River and U.S. Highway 160. This area was selected based on its proximity to Park Ditch and the Dry Gulch site. SJWCD maintains shares in Park Ditch on the Dry Gulch site. Additional information regarding water rights is presented in Section 2.

The Dry Gulch site was jointly purchased by SJWCD and Pagosa Area Water and Sanitation District (PAWSD) in 2008 with the intent of constructing a new water storage reservoir at the site. PAWSD is the municipal water supplier for the Town of Pagosa Springs (Pagosa Springs) and some of the surrounding area. A plan of the study area is presented on Figure 1.1. Additional information on the Dry Gulch site is presented in Section 6.

1.4 Scope of Services

RJH is the prime consultant for the Project and led engineering analyses, alternatives evaluations, facilities layout, and development of cost estimates and provided overall project management and coordination. ERO Resources Corporation (ERO) performed environmental permitting evaluations as a subconsultant to RJH. Bohannan and Huston, Inc. (BHI) performed inflow hydrology analyses as a subconsultant to RJH. The RJH Team performed the following work tasks:

- Participated in a combined kickoff meeting and site visit.
- Performed a literature search to obtain available published information. Reviewed the collected data along with other data provided by SJWCD.
- Developed a topographic base map using publicly available U.S. Geological Survey (USGS) digital elevation mapping.
- Developed a preliminary purpose and need statement.
- Identified potential screening-level alternatives.
- Performed simplified engineering analyses to select sizes and configurations for embankments, spillways, outlet works, pipelines, and other key facilities.
- Developed screening-level figures to illustrate project components.
- Developed an American Society for Testing and Materials International (ASTM) E2516 Class 5 opinion of probable costs for each configuration.
- Performed a screening-level economic evaluation to evaluate life cycle costs for each configuration.

- Prepared a preliminary risk evaluation that includes technical and engineering, construction, environmental, regulatory, economic, water rights, operational, and maintenance.
- Performed a desktop study of existing environmental and cultural resources. Identified potential environmental permitting considerations.
- Identified potential legal requirements that could impact Project development.
- Prepared this Report.

1.5 Project Configurations

RJH evaluated two configurations at the Dry Gulch Site.

- Configuration 1: 11,000 ac-ft reservoir.
- Configuration 2: 4,000 ac-ft reservoir.

Additional information on the configurations is presented in Section 6.

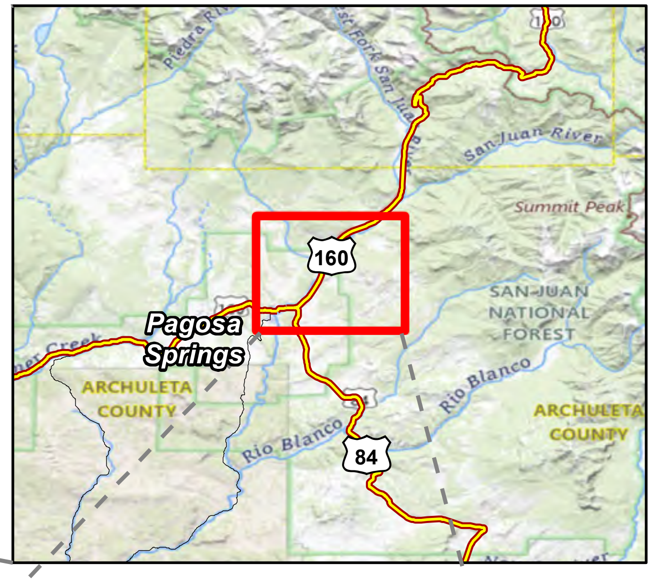
1.6 Project Personnel

The following personnel from the RJH Team are responsible for the technical work contained in this Report:

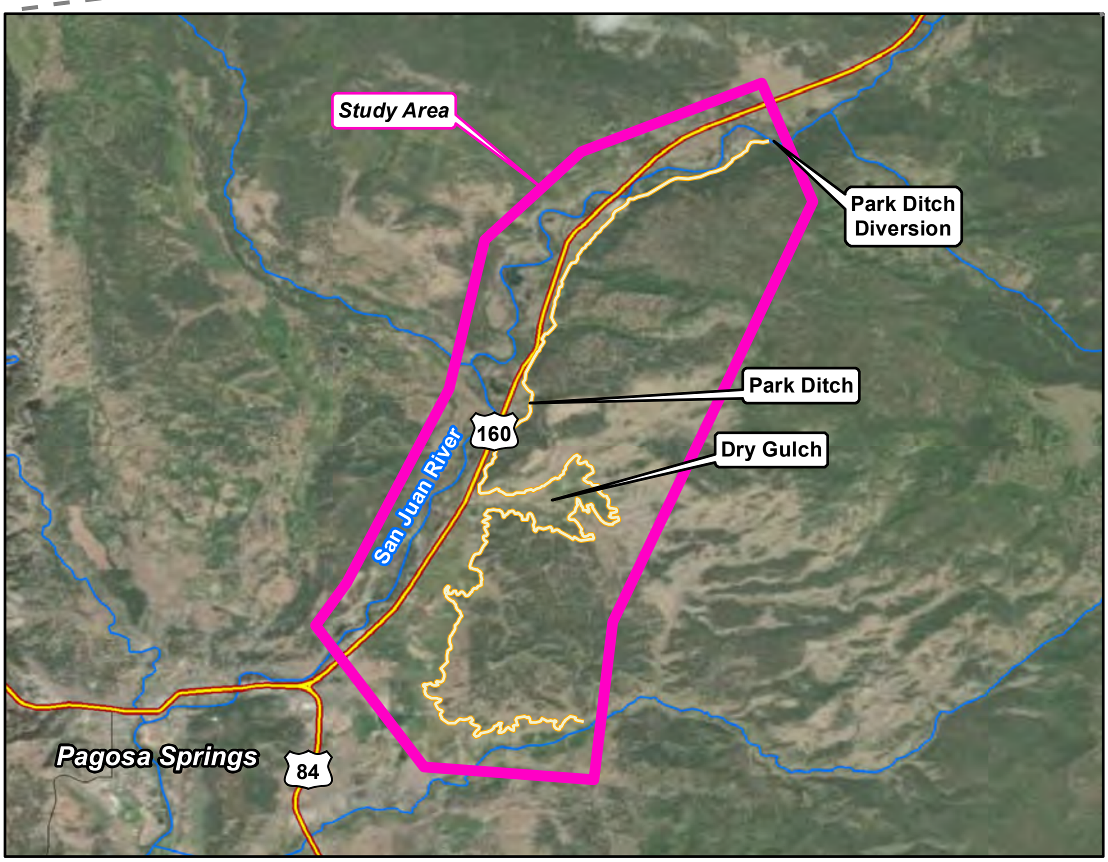
Project Manager	Robert Huzjak, P.E. (RJH)
Engineering Manager	Eric Hahn, P.E. (RJH)
Lead Geotechnical Engineer	Adam B. Prochaska, P.E., P.G. (RJH)
Lead Civil and Hydraulic Engineer	Chris Leclair, P.E. (RJH)
Lead Hydrologic Engineer	Rifka Wine, P.E. (BHI)
Lead Environmental Permitting Specialist	Kathy Croll (ERO)
Staff Engineer	Stephen Gialamas, EIT (RJH)
Technical Review	Craig Hoover, P.E. (BHI)

The work presented in this Report was coordinated and overseen by SJWCD. SJWCD also provided key information for multiple sections of the Report.

PROJECT VICINITY MAP
(NOT TO SCALE)



PROJECT LOCATION MAP
(NOT TO SCALE)



STUDY AREA MAP
(NOT TO SCALE)

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RJH CONSULTANTS, INC.

SAN JUAN HEADWATERS STORAGE PROJECT	STUDY AREA AND LOCATION MAPS
PROJECT NO. 25127	February 2026 **Figure 1.1**

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SECTION 2 - PURPOSE AND NEED

2.1 Project Purpose and Need

Current water uses in the region include municipal, rural residential, agricultural, tourism, recreation, industrial, and environmental. Seasonal demand varies considerably. Water storage in the District is limited, and future population growth, climate change impacts, lack of redundancy, and variable demand are expected to result in water scarcity in the District, adversely impacting the economy and residents.

The economy of the region is heavily reliant on agriculture, tourism, and recreation. These uses result in considerable seasonal spikes in water demand. The existing municipal water supply and distribution system are managed by PAWSD. Most of their current water needs are met by direct flows from a diversion along Four Mile Creek and two along the San Juan River: one on the mainstem and one on the West Fork. Existing raw water storage reservoirs connected to the PAWSD water distribution system can store up to about 4,000 ac-ft. However, not all of this storage is dedicated to water supply. The system currently has inadequate redundancy to provide a reliable water supply for a prolonged drought or if water quality in the source rivers is adversely impacted by wildfires or pollution. In addition, the population growth of Archuleta County was about 13-percent from 2010 to 2023 (Census, 2020) and is expected to continue to grow at a similar rate, which will magnify the demand for water.

Climate change is also reducing the duration of high flows in the rivers, which is shortening the river recreation season and adversely impacting the economy and residents. The frequency and severity of wildfires have also increased in the past decade, and the probability that wildfire will impact the basins above the existing diversion points along the San Juan River and Four Mile Creek is increasing with potentially severe impacts.

These concerns could be mitigated through additional water storage to create redundancy and provide consistent water access to those served by SJWCD. Therefore, SJWCD is proposing a new water storage reservoir within the study area. This reservoir would serve SJWCD's mission and purpose and assist with meeting current and future water needs, provide water to restore a portion of the recreation season, and create redundancy and reliability in the municipal water system to safeguard against impacts resulting from wildfire and drought.

With increased wildfire risk, uncertainty about population growth, changes in water demand, and limited water storage and transportation infrastructure, the lack of long-term storage and a stable water supply is an urgent issue that SJWCD must address.

The Project would allow for the use and continued protection of existing water rights overseen by SJWCD. The Project would provide resiliency against drought and potential contamination, flexibility in meeting demand, and redundancy in water storage in the Upper San Juan River Basin and would allow for stability and continued water availability for varied uses.

2.2 Water Supply

2.2.1 Water Storage Facilities

PAWSD currently maintains a reservoir system that provides approximately 4,000 acre-feet of water storage. However, not all of this storage is dedicated to water supply as houses with boat docks are located around the perimeter of several of the reservoirs. In addition, we understand some of these reservoirs may slowly be filling with sediment and experiencing increased turbidity when the reservoir levels are lowered. These facilities are hydraulically connected to the PAWSD water treatment facilities. Individual reservoirs include:

- Lake Hatcher: 880 ac-ft
- Steven Lakes: 1,730 ac-ft
- Lake Pagosa: 920 ac-ft
- Village Lake: 228 ac-ft
- Lake Forest: 269 ac-ft

We understand that PAWSD does not currently have plans to build a new water storage reservoir. SJWCD is primarily focused on building a new reservoir in the study area described herein.

2.2.2 Water Rights

SJWCD and PAWSD maintain a conditional water right for the Project, Water Rights Case No. 04CW85, which has an appropriation date of December 20, 2004 (SJWCD, 2023). In addition, SJWCD maintains a second conditional water right with a 1967 appropriation date, which would be used together with the 2004 water right. The 2004 water right is for a reservoir at the Dry Gulch site with a 4,700-acre-foot first-fill volume. Stipulations associated with the water right limit annual filling to 11,000 acre-feet and a cumulative 10-year refill volume of 93,000 acre-feet. Approved uses for the water include municipal, recreation, irrigation, exchange, and augmentation. The following additional criteria are included in the water right:

- The stored water can only be used in the SJWCD and PAWSD service areas.
- The reservoir can only be filled from a) native runoff from the Dry Gulch basin, b) Park Ditch flows diverted from the San Juan River, or c) a new pumping station and diversion structure at the confluence of the San Juan River and Dry Gulch. The reservoir fill rate is limited to 50 cfs from these sources.
- The first fill can be made in conjunction with a more senior conditional water right, Decree 73-308D, which is also a storage right in Dry Gulch. This water right has an appropriation date of July 22, 1967.
- Project diversions cannot reduce flows in the San Juan River to below 60 cfs from September to February and 100 cfs from March to August because of CWCB instream flow rights.

2.3 Water Demands and Shortages

In 2022, SJWCD retained Wilson Water Group (WWG) to perform a water supply, demand, and shortage analysis on the upper San Juan River Basin to inform this Project. The analysis considered the following demand categories: municipal, agricultural, environmental, and recreational. A summary of the 2022 WWG analysis is provided in the following sections.

2.3.1 Municipal

PAWSD is the largest municipal water supplier in the San Juan basin, and the PAWSD service boundary generally overlaps with SJWCD. PAWSD serves Pagosa Springs and the surrounding subdivisions and rural areas. A significant portion of the development in and around Pagosa Springs supports a temporary resident population comprised of vacation rental units and secondary homeowners. The area attracts year-round tourism for outdoor activities including skiing, rafting, fishing, hiking, hunting, biking, and the hot springs.

WWG performed a municipal demand forecasting analysis from 2020 to 2050 based on following growth scenarios:

- Low: 1.7 percent growth

- Medium: 2.6 percent growth
- High: 5 percent growth for 10 years and then 2 percent growth for 20 years

WWG used a per capita usage rate of 226 gallons per day to forecast the increase in demand, which included residential, irrigation, commercial, and system water loss. This estimate of per capita water usage was based on historical use data from the 2008 PAWSD Water Conservation Plan. A summary of projected increases in municipal demand is presented in Table 2.1.

TABLE 2.1
2050 PROJECTED MUNICIPAL DEMANDS

Parameter	Current (2020)	2050 Projections		
		Low (1.7% Growth)	Medium (2.6% Growth)	High (5% for 10 Years, 2% After)
Population	10,025	16,623	21,662	24,979
Gallons Per Capita Day (GPCD)	226	226	226	226
Demand (acre-feet)	2,536	4,208	5,481	6,323

The projected 2050 municipal demand ranged from about 70 to 150 percent higher than the 2022 municipal demand.

2.3.2 Agricultural

WWG performed an evaluation of agricultural water shortages based on estimates of demand of irrigated acres in the PAWSD service area and historic consumptive use recorded by Division of Water Resources from 1990 to 2019. Agricultural water shortages occurred every year between 1990 to 2019 and ranged from a low of 50 acre-feet in 2004 to a high of 5,000 acre-feet in 2002. The average agricultural water shortage during this time frame was 1,200 acre-feet. WWG considered that all shortages were caused by physical and legal water limitations, not selective reduction of irrigation for grazing land.

2.3.3 Environmental and Recreational

The 2022 WWG report considered the following environmental and recreational demands:

- CWCB instream flow and bypass flows requirements.

- Recreation needs including fishing (bank fishing, wading, floating) and whitewater activities (rafting, kayaking, tubing).
- Flow requirements to support river health in the San Juan River (i.e., sediment transport, etc.).

WWG developed three scenarios to estimate cumulative environmental and recreational demands:

- Minimum – Meets the minimum instream flow demands in the mainstem of the San Juan River. These flows are sufficient to support recreational flows for tubing but not wade fishing or float fishing. These flows are not sufficient to meet stipulated environmental bypass flows or sediment transport flows.
- Mid-range – Meets stipulated environmental bypass flows. These flows are sufficient to meet recreation for wade fishing and tubing but not float fishing. These flows are not sufficient to meet sediment transport flow requirements.
- Maximum – All flow demands for environmental and recreational are reasonably met. Only the moderate or higher flows required for float fishing cannot be met.

Comparing these demands to USGS stream gauge data from 1990 to 2021, the average annual shortages for each scenario were calculated to be about 1,300 acre-feet, 6,300 acre-feet, and 68,600 acre-feet, respectively, for the minimum, mid-range, and maximum demand scenarios.

2.3.4 Total Demands and Shortages

Based on the analyses described above, WWG developed three scenarios to estimate total projected demands for the Project in 2050:

- Low Demand – Low municipal growth scenario, minimum environmental and recreational scenario, and historical agricultural shortages.
- Mid-range Demand – Medium municipal growth scenario, mid-range environmental and recreational scenario, and historical agricultural shortages.
- High Demand – High municipal growth scenario, high environmental and recreational scenario, and historical agricultural shortages.

A summary of projected average annual shortages in 2050 is presented in Table 2.2.

TABLE 2.2
PROJECTED AVERAGE ANNUAL SHORTAGE IN 2050

	Low-Demand Scenario	Medium-Demand Scenario	High-Demand Scenario
Shortage Volume (acre-feet)	4,100	11,000	73,000

2.3.5 Reservoir Sizing

WWG performed a water availability analysis to develop sizes for potential reservoirs at the Dry Gulch site to meet the water shortages described above. Potential reservoir sizes were developed based on topographic limitations at the site and a 50 cfs inflow rate and are presented in Table 2.3.

TABLE 2.3
RESERVOIR SIZES TO MEET DEMAND SCENARIOS

	Low Demand Scenario	Mid-Range Demand Scenario
Potential Reservoir Size (acre-feet)	1,600	10,000

The high demand scenario described above cannot be met regardless of reservoir size because the required inflow rate would exceed the 50 cfs conditional water right. For this reason, WWG used a 10,000-acre-foot reservoir volume as the benchmark to evaluate capacity to meet the mid-range 2050 demands. This reservoir would be able meet the projected mid-range 2050 municipal demands every year during the evaluated period and could meet all other mid-range demands (environmental, agricultural, recreation) in 19 of 29 years. Using river flow data from 1990-2019 does not account for decreases in flow that could occur because of climate change.

The 2022 WWG study substantiates the need for additional storage in the upper San Juan basin. The WWG study report is provided in Appendix A.

2.4 Water Quality and Wildfire Resiliency

Increasing wildfire risk is a primary concern for SJWCD and Colorado, more broadly. Eight of the 10 largest wildfires in Colorado state history have occurred since 2012, and the statewide wildfire quantity and average size have increased dramatically since the 1990s (Barbier, 2025). In 2012, the Little Sand Fire ignited in Archuleta County under extreme drought conditions and burned nearly 25,000 acres (NOAA, 2025). About 50-percent of the Archuleta County land area is the San Juan National Forest, which is generally at very high fire danger levels during warmer and drier months. Several forest fires including the 2013 West Fork Fire, 2022 Plumtaw Fire, and 2023 Quartz Ridge Fire have impacted or threatened SJWCD and PAWSD resources directly (SJWCD, 2025).

SJWCD is concerned that a wildfire could significantly impact water quality at PAWSD's direct diversions at Four Mile Creek and the San Juan River, which is their primary source of water supply. In addition, a wildfire could impact water quality in the existing PAWSD's water storage reservoirs, which all receive direct runoff from the Martinez Creek watershed (SJWCD, 2025) and are therefore vulnerable to a single wildfire event. Significant post-fire mitigation may be required to reclaim supply reservoirs, treatment facilities, and conveyance infrastructure following a wildfire in the Four Mile Creek, San Juan River, and Martinez Creek drainages.

The Project would improve wildfire resiliency in the region in the following ways:

- The reservoir would provide surface water storage in the upper San Juan River drainage, lessening reliance on the direct diversions and the existing reservoirs in the Martinez Creek basin, and provide a suitable water supply if a wildfire impacts these resources.
- The Project reservoir is not on the mainstem of the San Juan River and would only receive direct runoff from Dry Gulch Watershed, which is a relatively small (approximately 3.3 square mile) drainage basin tributary to the main San Juan River; this reduces the potential for direct wildfire runoff to impact the Project reservoir.

SECTION 3 - SMALL STORAGE OPPORTUNITIES

3.1 General

This section provides information about storage opportunities and the basis for the Project. The opportunity is primarily based on conditional water rights that enable water diversion and storage in a new reservoir at the Dry Gulch site, which is already co-owned by SJWCD. The stored water has a basis for use in the local water market, especially considering future growth and demand in the region.

3.2 Beneficial Uses

SJWCD anticipates that the additional water storage provided by the Project would provide the following benefits:

- Water supply reliability: The Project would increase the community's water storage by 11,000 ac-ft, lessening reliance on the direct diversions. The Project would also provide significant wildlife resiliency benefits by providing a water storage reservoir that would not be impacted by a wildfire in the Four Mile Creek, San Juan River, or Martinez Creek watersheds.
- Environmental: Strategic releases could be made to the San Juan River to offset shortages needed to achieve desired peak flow rates for sediment transport issues. Also, the stored water would provide additional sources to meet shortages for required environmental inflows and bypass flows.
- Agriculture: Strategic releases could be used for irrigation in dry years.
- Recreation and tourism: The reservoir could be used for boating and fishing. Strategic reservoir releases could be performed to provide increased water in the San Juan River for fishing and whitewater activities.

3.3 Potential Stakeholders

We have developed a list of potential stakeholders that could either be impacted or could benefit from advancement of the Project. Statements of support from these stakeholders have not been solicited at this stage of the Project. We anticipate potential stakeholders would advocate for the Project within the community, provide input and some potential ideas, and potentially assist with funding.

- PAWSD and PAWSD Customers: As the municipal water supplier for Pagosa Springs, PAWSD could benefit substantially from the Project with increased water supply reliability and wildfire resiliency for its customers.
- Colorado Parks and Wildlife (CPW): CPW is a state agency that manages 43 Colorado State Parks and 350 State Wildlife Areas. CPW has been a project stakeholder for new dam projects in the State of Colorado in recent years. For example, CPW has a significant stakeholder position in Northern Water's Chimney Hollow Reservoir Project, which is nearing completion and includes a new dam with an approximately 90,000-acre-foot capacity. CPW's stakeholder position generally focuses on environmental stewardship, wildlife and habitat protection, and public access and recreation (Northern, 2025). CPW could possibly assume a similar role for this Project. The closest CPW facilities to this Project include:
    - Echo Canyon Reservoir – This reservoir is a State Wildlife Area about five miles south of Pagosa Springs with a surface area of about 211 acres (CPW, 2025b).
    - Navajo Reservoir – This is an approximately 15,600 surface acre reservoir in both Colorado and New Mexico and owned by Reclamation (Reclamation, 2025). CPW operates the portion of the reservoir in Colorado as a State Park. This State Park is located about 35 miles southwest of Pagosa Springs.

There is a basis for CPW support in this area of the state and likely the recreational demand to support an additional reservoir facility, possibly motivating CPW interest in the project.

- Colorado Water Conservation Board (CWCB): CWCB is a state agency dedicated to the conservation, development, protection, and management of Colorado's water for future generations. SJWCD has a working relationship with CWCB and has received financial support in the past, including to purchase the Dry Gulch site. CWCB is aware of this project and has an incentive to construct the project to support their instream environmental water right in the San Juan River.
- Upper San Juan Watershed Enhancement Program (WEP): Upper San Juan WEP is a community group that works to improve water supply and quality in the San Juan basin for various agricultural, environmental, municipal, and recreational water users. San Juan WEP may consider supporting the project if environmental and water quality benefits are demonstrable and could assist with marketing the project to other potential stakeholders by performing studies to evaluate Project benefits.
- Pagosa Springs: Outdoor tourism is an established aspect of the region's economy, and this Project would provide an additional opportunity for water

recreation close to Pagosa Springs. The reservoir could also be used to augment water supplies in the San Juan River and maintain river recreation during periods of drought. Archuleta County and Pagosa Springs is likely to have strong interest in the Project because the reservoir would add a recreational amenity that could generate additional revenue from recreation and tourism.

- Park Ditch Company: The Park Ditch Company serves several older ranch properties on the east side of the San Juan River with irrigation water. The landowners cooperatively maintain the ditch. Water rights date back to the early 1890s (Hudson, 2023). A new reservoir at the Dry Gulch site would intersect the existing ditch, and additional facilities on the ditch would be required to fill the reservoir and bypass ditch flows around the reservoir.

3.4 Water Market

Water markets studies have not been performed for this Project yet. We anticipate that PAWSD would be a major purchaser of water in the future. We also anticipate that the reservoir could be used to generate money from recreation.

If the Project design is advanced, SJWCD plans to engage developers in discussions regarding a private-public partnership to develop potentially develop the site around the reservoir to generate funding for construction. Additional information on this concept is presented in Section 10.

3.5 Regulatory Agencies

Design and construction of the Project would require obtaining dam safety, environmental, cultural, and local permits. Anticipated regulatory agencies and corresponding permits are described below.

- Colorado Office of the State Engineer (SEO): The Project would involve construction of a jurisdictional dam. The SEO is responsible for regulatory oversight of design and construction of dams in Colorado. A dam safety permit for construction of a new dam would be required from the SEO.
- Federal Nexus: The project has two potential federal nexuses:
  - A Special Use Permit (SUP) from the USFS will be required.
  - The project may receive funding from the Bureau of Reclamation (Reclamation).

Projects on federal lands or federally funded projects require compliance with the National Environmental Protection Act (NEPA), the Clean Water Act (CWA), the Endangered Species Act (ESA), and the National Historic Preservation Act (NHPA) at a minimum. If both agencies are involved, coordination between the agencies to determine which agency is lead would be required. Additional information on federal permitting process is provided in Section 8.

- U.S. Army Corps of Engineers: The Clean Water Act (CWA), under the jurisdiction of the Environmental Protection Agency, establishes a program to protect the chemical, physical, and biological quality of Waters of the United States (WOTUS) including wetlands. The U.S. Army Corps of Engineers' (Corps) Regulatory Program administers and enforces Section 404 of the CWA. Under Section 404, a Corps permit is required for the discharge of dredged or fill material into wetlands and other WOTUS (streams, ponds, and other waterbodies). Consultation with the Corps would determine which wetlands, if any, in the project area are jurisdictional based on the most recent definition of WOTUS and, therefore, what mitigation could be required for implementation of the project.
- Colorado Parks and Wildlife (CPW): Coordination with CPW would be required for high potential habitat (HPH) species (mule deer and elk) at the site and potential mitigation.
- Archuleta County: The Project site is in unincorporated Archuleta County. The county may decide to require a 1041 permit. A 1041 permit has been required in other parts of the state for construction of new reservoirs. Public notices and public hearings would likely be required as part of the 1041 permitting process. Other requirements to obtain a 1041 permit would be determined by the county as part of the permitting process.
- State Historic Preservation Office (SHPO): Cultural resources have previously been identified at the Project site. SHPO would require a Class III cultural resources survey of the Project site and likely a mitigation plan.

3.6 Other Regional Projects

We are not aware of any other water storage projects that are currently being considered in the region.

SECTION 4 - ALTERNATIVES

4.1 Previous Alternative Evaluations

Since the formation of SJWCD in 1987, the District has performed several formal and informal evaluations of potential reservoir sites that have identified the Dry Gulch Reservoir Site as a primary viable reservoir site in the SJWCD boundary. Harris Water Engineering evaluated potential reservoir sites and identified two sites: the Hidden Valley Reservoir site to store diversions from Four Mile Creek; and the Dry Gulch Reservoir site to store diversions from the San Juan River (Harris, 1989). The Hidden Valley site was purchased by a private entity and is no longer available. In 2003, Harris Water Engineering and Davis Engineering prepared another report to evaluate future water supply demands and evaluate water storage alternatives. The 2003 report considered 13 potential reservoir sites within SJWCD and again identified Dry Gulch as the most effective reservoir site. The most recent feasibility study was performed in 2017 to provide technical support for a loan application from CWCB for this Project. The 2017 report, prepared by SJWCD, identified the selected alternative for the project as the development of a 11,000 acre-foot reservoir and 50 cfs diversion at the Dry Gulch site as provided in a settlement resolving Water Court Case No. 04CW85.

4.2 Criteria

Based on the 2022 WWG study, an 11,000 ac-ft reservoir would meet the 2050 projected mid-range demand scenario and would also maximize the existing water right, which allows an annual refill up to 11,000 ac-ft. For this reason, an 11,000 ac-ft reservoir at the Dry Gulch was selected as the baseline alternative for the screening-level study presented in this Report.

In theory, other locations could be developed using this water right; however, any other site would be constrained by the following criteria:

- Capable of providing up to 11,000 ac-ft of storage.
- Located within the SJWCD boundary.
- Located near Park Ditch to accommodate ditch diversions to fill the reservoir.
- Located at or near the Dry Gulch site because the water rights diversion for the reservoir must be located near the confluence of Dry Gulch and the San Juan River.

In addition, RJH considered the following alternatives as required by Reclamation:

- No Federal Funding Alternative – This alternative represents the status quo for SJWCD, including any actions the District would take if federal funding was not available to construct a storage project.
- Non-Structural Alternative – This alternative considers actions to solve water supply deficiencies without constructing a small storage project.

4.3 Storage Alternatives

4.3.1 General

RJH considered potential sites within the study area shown on Figure 1.1. We performed a desktop review of topographical data and aerial imagery along Park Ditch within the study area. Based on this review, we identified only one feasible reservoir site (other than the Dry Gulch site) about 0.5 miles south of Dry Gulch. This site is accessible from US Highway 160 by Paul Hood Place and is referred to as the Hood Site herein. A plan of both reservoir sites is provided on Figure 4.1.

4.3.2 Dry Gulch Site

Dry Gulch is an approximately 3.3 square mile ephemeral drainage located about three miles northwest of Pagosa Springs along Highway 160 on the east side of the San Juan River Valley. The Dry Gulch drainage basin would not yield adequate supply to fill and maintain a reservoir at the Dry Gulch site. A reservoir at this site would be filled primarily by water from Park Ditch or the San Juan River as described in the preceding sections.

The reservoir site is intersected by Park Ditch, which is an irrigation ditch that diverts from the San Juan River about three miles north of Dry Gulch and delivers water to rural shareholders downstream of Dry Gulch. Development of a reservoir at Dry Gulch would require maintaining continuity of Park Ditch across Dry Gulch.

4.3.3 Hood Site

The Hood Site does not have a prominent drainage channel and would primarily store water that was diverted from Park Ditch or the San Juan River. Park Ditch intersects this site, but the topography does not accommodate gravity inflows from the ditch. A pump station would be required for reservoir filling.

RJH used 1-meter resolution digital elevation mapping for the site to perform a screening-level layout of an embankment across the valley and estimate the storage capacity of a reservoir at this site. The storage efficiency of an embankment at the Hood Site is significantly lower than Dry Gulch. A 190-foot-tall earthen embankment would only store about 2,900 acre-feet of water, which is only about 15 acre-feet of storage per foot of embankment height, compared to an estimated 100 acre-feet per foot for an 11,000 acre-foot reservoir at the Dry Gulch site. The Hood site could potentially store a maximum of about 8,100 acre-feet.

This site was dismissed from further evaluation because it has a low storage efficiency and does not have any apparent advantages over the adjacent Dry Gulch Site. In RJH's opinion, the Dry Gulch site is the most effective reservoir storage site currently available to SJWCD for storing water in the study area, and it is already owned by SJWCD with PAWSD and financial support having been provided by CWCB.

4.3.4 Groundwater Storage

Groundwater storage was considered and dismissed as a feasible alternative for this Project because it does not utilize the existing water right and does not meet the purpose and mission statement of SJWCD, which is focused on the management and preservation of the San Juan River as a surface water resource. In addition, groundwater storage is not technically impractical for the following reasons:

- Bedrock at the Dry Gulch site is anticipated to be relatively shallow and surficial soils are predominantly fine-grained (i.e., low hydraulic conductivity and low storage capacity). These characteristics would severely limit the groundwater storage capacity.
- The San Juan River valley west of the dam and reservoir site has the potential to contain coarse alluvium (sand and gravel) that could be suitable for groundwater storage; however, we considered groundwater storage in the San Juan River valley to be impractical. The San Juan River alluvial valley is relative narrow, and an aquifer storage facility would need to encompass a significant length of valley to provide meaningful storage. This length of facility is impractical because it would significantly affect groundwater hydrology in the river valley and require excessive land acquisition.

4.4 Non-structural Alternative

A non-structural alternative for this project would likely require the following actions to increase water supply in the project area:

- Purchasing water or water rights from other entities.
- Municipal and agricultural water conservation.
- Water accounting projects to improve measurement at existing diversions.
- Developing improved water augmentation plans for the project area.
- Increasing taxes, levies, and fees to perform the above actions to a greater extent.
- Addressing leaks and other deficiencies in the conveyance system.

SJWCD routinely considers opportunities for non-structural actions to improve the water supply and management in the District. For example, Colorado's Diversion Measurement Installation Program recently worked with SJWCD to provide funding to install new measurement devices (such as a flume or weir) at diversions for agricultural users (SJWCD, 2024). While diversion improvements and similar non-structural actions are beneficial, they do not address several aspects of the purpose and need of this project, such as water supply redundancy, drought preparation, and wildfire resiliency.

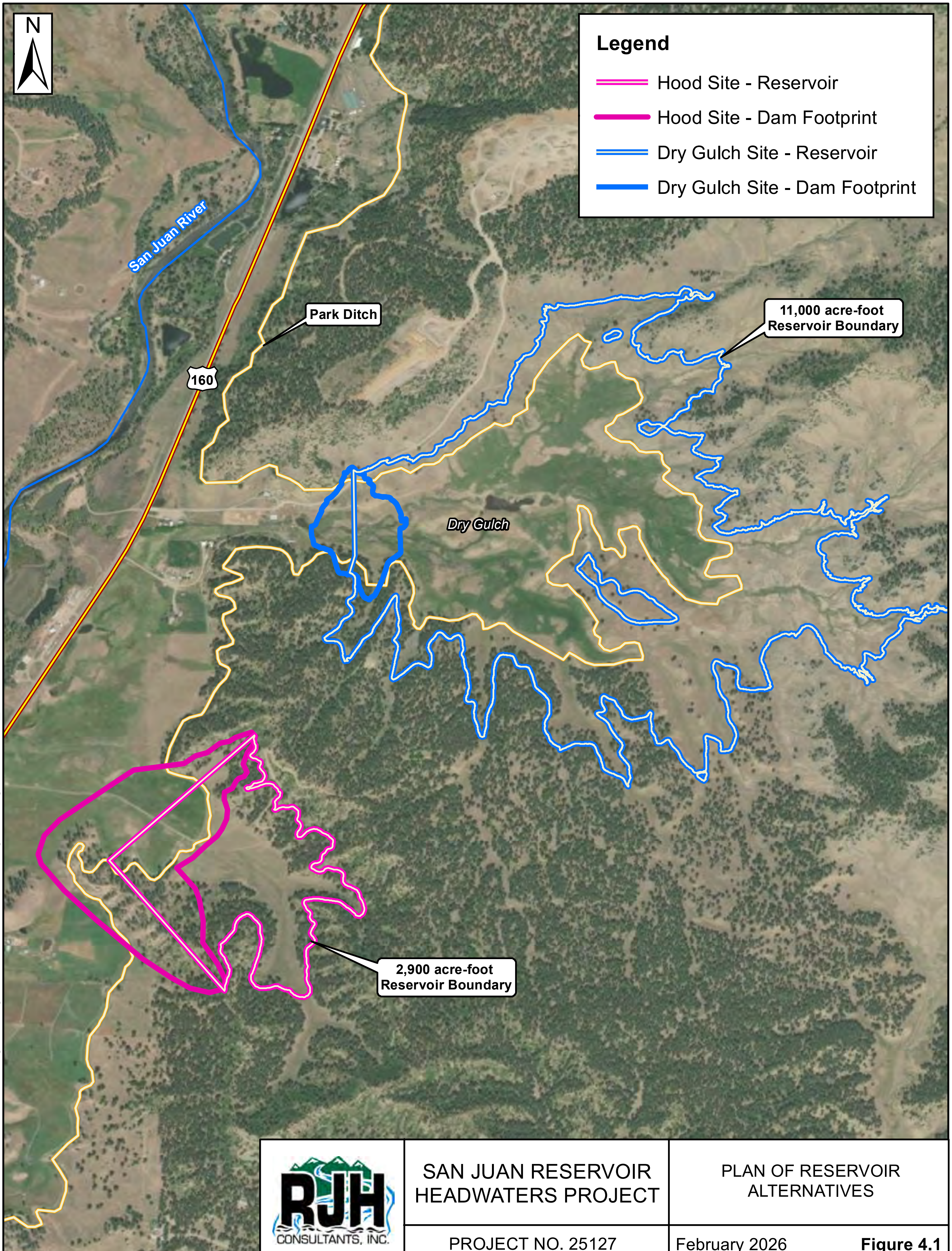
Moreover, the Pagosa Springs area is geographically isolated from other prominent water districts, limiting water purchase opportunities. A non-structural alternative is unlikely to address the purpose and need of this Project and the formulation criteria provided in Section 4.2.

4.5 No Federal Funding Alternative

The "No Federal Funding" Alternative is the baseline alternative to which all other alternatives are compared and represents the status quo of SJWCD operations. The projected water shortages and vulnerability to climate change and wildfires would not be addressed. In addition, if the project is not advanced, SJWCD's conditional water rights will expire, and the conditions of the financing agreement with CWCB to purchase the land would not be met, which may require selling the property.

4.6 Selected Alternative

The preferred alternative for this Project is a reservoir at the Dry Gulch site because it is the only alternative that meets the purpose and need in Section 2 and the formulation criteria in Section 4.2. Additional information about the proposed Project at Dry Gulch is provided in Section 6, and an economic evaluation of this alternative is provided in Section 5.



RJH CONSULTANTS, INC.

SAN JUAN RESERVOIR HEADWATERS PROJECT	PLAN OF RESERVOIR ALTERNATIVES	
PROJECT NO. 25127	February 2026	**Figure 4.1**

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SECTION 5 - ECONOMIC ANALYSIS

5.1 Cost Opinion

RJH developed a Class 5 Opinion of Construction Project Costs (OPCC) as defined by ASTM E2516-11: Standard Classification for Cost Estimate Classification Systems. This class designation is used when the design is less than 2 percent complete. The reliability of a Class 5 OPCC is between about minus 30 to plus 50 percent. Costs are in February 2026 dollars. Cost opinions were developed by estimating quantities of primary elements of the work based on the concepts presented and unit costs developed from the following sources:

- Published and non-published bid price data for similar work.
- R.S. Means Heavy Construction Cost Data for 2025.
- Local suppliers' budgetary price quotes.
- Our previous experience and judgment.

The "Base Construction Subtotal" (BCS) component is the sum of construction costs for primary work elements. The OPCC is the sum of the BCS, construction contingencies, and engineering and administration costs and includes the following allowances:

- 2 percent of the BCS for the construction contractor's costs for bonds and insurance.
- 5 percent of the BCS for permitting.
- 15 percent of the BCS to account for design engineering and management including investigations; surveys; analyses; design documents; and construction observation, engineering, and testing.
- 15 percent of the BCS for construction engineering and testing.
- 40 percent of the BCS for design and construction contingencies. This includes an allowance for items that cannot be defined at the concept phase, unit price and quantity variations, and variable market conditions. This percentage will decrease as the Project is better defined in subsequent stages of design.

The OPCC for each configuration is presented in Table 5.1. Additional information on construction costs is provided in Appendix E.

TABLE 5.1
OPCC SUMMARY

Description	Configuration 1 ($ Million)	Configuration 2 ($ Million)
BCS	55.3	29.5
Bonds and Insurance (2%)	1.1	0.6
Permitting (5% of DCS)	2.8	1.5
Design Engineering and Management (15% of DCS)	8.3	4.4
Construction Engineering and Testing (15% of DCS)	6.7	3.6
Design and Construction Contingencies (40% of DCS)	22.1	11.8
OPCC	**96.3**	**51.4**

At this stage of design, significant uncertainties related to subsurface conditions exist because a subsurface investigation has not been performed. RJH made reasonable assumptions to develop the cost opinion. Uncertainties that could have a significant impact on the OPCC are described below:

- Required Foundation Treatments: We considered that the seepage barrier through alluvium would consist of an earthfill core trench with a double-row grout curtain along the dam centerline. We estimated the depth to bedrock and considered that the grout curtain would extend up to about 80 feet deep throughout the valley floor and about 50 feet deep in the abutments. If bedrock is shallower than estimated, the core trench will not need to be as deep. Also, if the bedrock has a lower permeability than anticipated, a grout curtain may not be required.
- Riprap and Bedding Source: We do not know if the bedrock materials at the site are appropriate for producing riprap and bedding. For the cost opinion, we assumed these materials would be imported from a regional quarry. The cost for these materials would be significantly lower if they are produced on site.

The OPCC is based on professional opinions and will change as design details are developed. Actual costs would be affected by a number of factors beyond current control, such as supply and demand for the types of construction required at the time of bidding, changes in material supplier costs, changes in labor rates, competitiveness of contractors and suppliers, availability of qualified bidding contractors, changes in applicable regulatory requirements, and changes in design standards. Conditions and factors arising as the Project proceeds from development through bidding and construction may result in constructions costs that differ from the estimate provided in this report.

5.2 Economic Benefits

A quantitative benefit-cost analysis has not been performed. This will be performed in the next stage of design if the Project receives funding. For this screening-level study, we identified the following qualitative benefits that are anticipated to result from construction of the Project:

- Increased drought and wildfire resiliency for municipal water supply
- Additional water storage for future population growth
- Increased recreational opportunities and tourism
- Additional water for irrigation
- Support river health of the San Juan River

SECTION 6 - PROPOSED PROJECT

6.1 General

RJH developed a screening-level design for a dam and reservoir at the Dry Gulch site for the purposes of evaluating project feasibility and developing a screening-level cost opinion and evaluation of possible impacts. A discussion of the screening-level design is provided below.

6.2 Existing Conditions

6.2.1 General

The Dry Gulch site (Site) consists of three parcels: 552.73 acres (main Dry Gulch), 68.11 acres next to San Juan River, and 5.49 acres immediately south of the second parcel.. The lower portion of the basin consists of wetlands and grasslands, and upper portions are predominantly scrub-land and forest. Developed features at the site include Park Ditch and gravel roadways; there are no dwellings or structures upstream of the proposed dam. The land at the Site was historically used for cattle ranching because the flat topography and grassland vegetation are favorable for grazing. SJWCD and PAWSD generally own the land at the mouth of Dry Gulch, the dam site, and most of the reservoir site. Other land ownership at the site consists of private property zoned for agriculture/ranching and San Juan National Forest. A property ownership map is provided on Figure 6.1. Additional information on wetlands is presented in Section 8.

Park Ditch begins at the San Juan River approximately 3 miles upstream of the site. The existing ditch is a trapezoidal earthen channel with a capacity of about 60 cfs and a total length of about 12.8 miles, likely constructed in the early 1900s (Hudson, 2021).

6.2.2 Site Geology

Based on published mapping (Steven et al., 1974) and previous project reports (Yeh, 2025), geologic units onsite generally include the following, from oldest to youngest:

- Cretaceous-age (66 million to 145 million years old) Mesaverde Formation (Kmv) exists beneath the proposed dam foundation and generally throughout the southwest portion of the site. This unit is reported to be up to 250 feet thick and consists of interbedded sandstone and shale, with some coal beds reported in the lower formation. (GSA, 2022).

- Cretaceous-age (66 million to 145 million years old) Lewis Shale (Kpcl) formation overlies the Mesaverde Formation and exists in the northeast portion of the site. This unit is reported to be up to 2,700 feet thick and generally consists of shale with some interbedded sandstone beds in the upper layers.
- Tertiary-age (2.6 to 66 million years old) terrace alluvium exists on top of the ridge on the north side of the valley. This deposit is expected to be up to about 50 feet thick and consist of a gravelly alluvium with clay and silt. Much of this deposit has been mined from the property for commercial aggregate production and a limited quantity is expected to remain.
- Quaternary (less than 2.6 million years old) alluvium exists in the valley floor. This unit is expected to be up to about 30 feet thick.
- In places where terrace alluvium and alluvium are not present the bedrock is expected to be covered by up to about 10 to 20 feet of colluvium.

Based data from the NRCS Soil Survey, alluvium and colluvium are expected to be predominantly fine-grained (clayey) soils with at least 50 percent fines, liquid limits of about 30 to 40, and plasticity indices of about 25 to 30. We anticipate that the plasticity and gradation composition of the alluvial and colluvial soils are also representative of the underlying bedrock.

A geologic map showing the distribution of these units is shown on Figure 6.2. Bedrock is expected to dip downward slightly to the northeast.

The following subsurface data is available near the Site:

- Three water wells have reportedly been drilled within about a half mile of the site (Yeh, 2025). We interpret that these wells are within the Mesaverde Formation. The well logs report predominantly shale bedrock and the wells yielded about 3 to 5 gpm.
- Two borings were performed at the site in 1990 (Yeh, 2025). The exact locations of these borings are unknown, but they were reportedly advanced about 600 feet apart with one hole on each side of the valley. The borings generally encountered about 12 to 27 feet of clayey soil overlying shale.

6.2.3 Hydrology

BHI performed inflow hydrology for the proposed dam in general accordance with Colorado Office of the State Engineer Dam Safety (SEO) standards and methods. Basin-specific rainfall depths and distributions were developed for the 2-hour Local Storm (LS), 6-hour LS, 72-hour General Storm (GS) and 72-hour Tropical Storm (TS) PMP events using the Regional Extreme Precipitation Study (REPS) Rainfall Estimation Tools. Hydrologic modeling was performed in the U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) using the Colorado State University-Soil Moisture Accounting (CSU-SMA) method. The CSU-SMA method estimates extreme flood production mechanisms by accounting for infiltration excess runoff, saturation excess runoff, and subsurface lateral flow. The Clark Unit Hydrograph (UH) method was used to estimate rainfall-runoff transformation in HEC-HMS and is generally applicable for undeveloped basins in Colorado.

The rainfall and basin runoff parameters were input into a hydrologic model in HEC-HMS Version 4.13 that included a 3.3-square-mile basin for the Dry Gulch watershed. A simulation run was developed for each of the four PMF storm events, and the runoff results for each storm event are provided in Table 6.1.

TABLE 6.1
BASIN RUNOFF (RESERVOIR INFLOW) RESULTS

PMP Storm Event	Peak Runoff (cfs)	Volume (acre-feet)
2-hr LS	2,859	1,657
6-hr LS	2,269	1,602
72-hr GS	926	1,470
72-hr TS	1,056	2,028

The SEO procedure includes verification of the model's reasonableness by evaluating if the peak flow of the PMF storm events are within the 90-percent confidence interval of the SEO's Regional Peak Flow Envelope Curve, which represents the likely PMF magnitude based on historic and paleoflood data. The peak flow of the 2-hour and 6-hour Local Storm PMFs are within the 90-percent confidence interval of the curve, generally indicating that the inflow hydrology is reasonable and suitable for use in this study. The inflow hydrology memorandum is presented in Appendix B.

6.3 Key Issues Impacting Concept Development

Based on our understanding of Project objectives, constraints, and Site conditions, RJH identified the following key considerations that influenced development of a concept:

- Depth and properties of the alluvium in the valley bottom.
- Consistency and permeability of bedrock in the valley and abutments.

- The need to construct the embankment and slope protection using onsite materials to manage Project costs.
- Gravity inflow from Park Ditch is desirable, if feasible, to avoid constructing a pump station. A pump station is less desirable because of capital and operating costs and on-going maintenance.
- Outlet works facilities will be required to convey both routine and emergency releases.
- Multi-level reservoir withdrawals may be desirable to provide flexibility to manage water quality of regulated releases from the reservoir, but this requirement is unknown at this stage of design. We have assumed a low-level outlet structure is acceptable.
- The outlet works conduit and structures should be founded on bedrock to reduce the likelihood of settlement.
- Park Ditch conveyance will need to be maintained across the site following construction of the dam and reservoir.
- The spillway will be used to control the maximum reservoir pool. The spillway should operate passively (i.e., without the use of gates or valves).
- Erosion of the spillway channel is acceptable during extreme flood events if it does not pose a risk to dam safety.
- Constructing Project facilities on SJWCD property is desirable to the greatest extent practicable.

6.4 Configurations

RJH developed screening-level concepts for the following two reservoir configurations:

- Configuration 1: 11,000 ac-ft reservoir. This is the largest possible reservoir that can be filled using SJWCD's conditional water right on Park Ditch.
- Configuration 2: 4,000 ac-ft reservoir. This is the largest reservoir size that would accommodate gravity inflows from Park Ditch near the right abutment of the dam.

A plan view of both configurations is provided on Figure 6.2. Key dam and reservoir characteristics for each configuration are presented in Table 6.2.

TABLE 6.2
DAM AND RESERVOIR CHARACTERISTICS

Parameter	Configuration 1	Configuration 2
Dam Height (ft)	109	78
Normal Storage Capacity (ac-ft)	11,000	4,000
Maximum Normal Pool Elev.(ft)	7,351	7,320
Dam Crest Elev.(ft)	7,356	7,325

6.5 Project Components

6.5.1 Overview

The primary Project components needed to address these primary issues are illustrated on Figures 6.4 to 6.11 and include:

- Embankment dam
- Outlet works
- Spillway
- Park Ditch diversion facility
- Park Ditch bypass facility

Additional information on primary Project components is described below.

6.5.2 Embankment

6.5.2.1 Design

An earthen embankment dam is a practical type of dam for this Site based on foundation conditions and available onsite borrow materials. Available borrow materials for embankment construction would include clayey soils from within the reservoir area and bedrock material excavated from the spillway channel. For this level of study, we considered that the embankment would consist of homogenous clayey fill and a filter/drainage system consisting of a chimney filter, blanket drain, and toe drain. The upstream slope would be 4.5 horizontal to 1 vertical (H:V), and the downstream slope would be 3H:1V. A 40-foot high, 80-foot-long stability berm along at the downstream toe of the dam using bedrock material excavated from the spillway channel.

We considered that much of the embankment would be founded on alluvium throughout the valley floor. The dam will likely require seepage barriers through the foundation alluvium and bedrock to reduce seepage losses and provide adequate seepage stability. The seepage barrier through alluvium could consist of an earthfill core trench or a soil-bentonite barrier wall. For this level of design, we considered that the seepage barrier through alluvium would consist of an earthfill core trench. Near the dam centerline, the core trench would be excavated through alluvium, and the embankment fill would key into bedrock to intercept potential seepage paths through the foundation alluvium.

We also considered that a double-row grout curtain would be installed along the dam alignment to reduce the hydraulic conductivity of foundation bedrock. The embankment core trench would connect to the top of the grout curtain. The drill holes in each row of the grout curtain would be angled in opposite directions to improve the likelihood of intercepting high-angle fractures. We considered that the grout curtain would extend up to about 80 feet deep throughout the valley floor and about 50 feet deep in the abutments. Foundation treatment techniques need to be re-evaluated after additional subsurface data is collected.

Gravel surfacing would be placed along the embankment crest to improve trafficability and protect the crest. The downstream slope would be covered with topsoil and vegetated with grass to reduce erosion. Upstream slope protection would consist of riprap and riprap bedding that would be imported to the site. A plan, centerline profile, and typical maximum embankment section are shown on Figures 6.4, 6.5, 6.6, 6.8, 6.9, and 6.10. The downstream toe of the dam embankment would be about 350 feet from the property boundary, which exceeds the height of the dam and therefore complies with SEO Rules.

6.5.2.2 Stability Analyses

RJH used GeoStudio Slope/W to perform two-dimensional limit equilibrium stability analyses for one maximum embankment section and evaluated key static loading conditions that are expected to control the embankment slopes. Material properties used during stability analyses are summarized in Table 6.3. These properties were developed based on judgment and our experience with materials similar to the anticipated foundation units and available onsite borrow materials.

TABLE 6.3
SUMMARY OF MATERIAL PROPERTIES FOR STABILITY ANALYSES

	Alluvium	Embankment Fill	Mesaverde Formation	Filter Sand
Moist Unit Weight (pcf)	N/A(1)	120	N/A	130
Saturated Unit Weight (pcf)	115	125	145	135
Drained Friction Angle, Φ' (deg.)	24	26	28(2)	35
Drained Cohesion (psf)	0	0	0	0
Undrained Friction Angle $Φ^R$ (deg.)	14	15	18	N/A
Undrained Cohesion (psf)	600	550	1000	N/A
Residual Strength Friction Angle, Φ' (deg)	N/A	N/A	15	N/A

Notes:
1. N/A means the property is not applicable to the material.
2. Drained friction angle of bedrock corresponds to the fully softened strength.

RJH evaluated the downstream slope stability for steady state seepage conditions from a full reservoir with either fully softened or residual bedrock strength. We evaluated the upstream slope stability for rapid drawdown conditions using the Duncan 3-Stage Method. We considered rapid drawdown from a full reservoir to empty. This is a standard loading condition for evaluating upstream slope stability of embankment dams; however, it is very conservative and might not be achievable because of outlet works hydraulic capacity. Based on these analyses, adequate safety factors would be provided by a 3H:1V downstream slope with a stability berm and a 4.5H:1V upstream slope. Calculated safety factors are summarized in Table 6.4. This evaluation was performed for Configuration 1 and conservatively applied to Configuration 2.

TABLE 6.4
SUMMARY OF STATIC SLOPE STABILITY RESULTS

Slope	Key Loading Condition	Calculated Safety Factor	Minimum Required Safety Factor
3H:1V Downstream Slope with Berm	Steady State Seepage from Normal Pool (Fully softened bedrock strength)	1.5	1.5
3H:1V Downstream Slope with Berm	Steady State Seepage from Normal Pool (Residual bedrock strength)	1.2	1.0
4.5H:1V Upstream Slope	Rapid Drawdown from normal pool to empty	1.3	1.3

6.5.3 Outlet Works

The outlet works would be used to enable releases from the reservoir to the San Juan River for routine operations and for emergency evacuation. This facility would consist of a low-level intake structure at the upstream toe of the dam with a guard gate and a trashrack, a conduit through the dam, a downstream valve vault, and an impact basin near the downstream toe of the dam to dissipate energy from discharges.

RJH considered an outlet works alignment near the exposed rock outcrop at the left abutment to provide a bedrock foundation. The outlet works would be installed at about the grade of the existing stream, and upstream and downstream channels would be excavated to connect the outlet works intake and discharge to the main channel of Dry Gulch. A plan and profile of the outlet works is provided on Figures 6.6 and 6.10.

Routine release requirements are not known yet; therefore, emergency release requirements were used to size the feasibility-level outlet works. For emergency releases, SEO Rule 7.8.2.1 requires that outlet works are sized to release the top five feet of the reservoir in five days and the entire reservoir in a reasonable amount of time (SEO, 2020). The conduit would need to be a 36-inch-diameter pipe for Configuration 1 and 30-inch-diameter pipe for Configuration 2, respectively. The downstream end of the pipe would bifurcate to one or more smaller pipes within a valve vault to provide smaller reservoir discharges for a broader range of operational flows. All flow meters, control valves, and operational controls for the reservoir would be provided within the valve vault.

6.5.4 Spillway

We considered the dam to be classified as an extreme hydrologic hazard because the estimated life loss of a hydrologic failure would very likely exceed 1. The Rules (SEO, 2020) require a dam to safely convey the inflow design flood (IDF) through a spillway. The IDF for an extreme hydrologic hazard dam is the PMF. The controlling storm event is the event that results in the highest reservoir water surface elevation when routed through the spillway. Based on reservoir routing in HEC-HMS, the controlling PMF event and IDF for the dam is the 2-hour Local Storm.

RJH developed a spillway design concept to convey the 2-hour Local Storm PMF event. The concept generally consists of a short approach channel, a concrete control weir to control reservoir outflow into the spillway channel, and a rock-cut spillway channel. The spillway channel would discharge to a natural drainage downstream of the left abutment of the dam, which would eventually convey flows into Dry Gulch. A plan and profile of the spillway concept is provided on Figures 6.7 and 6.11. Spillway discharge flows and channel geometries for both dam configurations are provided in Table 6.5 below.

TABLE 6.5
SPILLWAY FLOW CHARACTERISTICS AND GEOMETRY

Parameter	Configuration 1	Configuration 2
Capacity (cfs)	290	1200
Bottom Width (feet)	20	50
Side Slopes (H:V)	1.5:1	1.5:1
Channel Slope (%)	0.5	0.5
Flow Depth (feet)	2.5	5.5
Flow Velocity (fps)	5	3.5

RJH performed preliminary two-dimensional hydraulic modeling of the spillway channel and downstream drainage to evaluate velocities and erosion potential during the PMF. We expect the native rock comprising the spillway channel will withstand the approximately 5 fps spillway flow velocity. Based on engineering judgement and published literature in Hydraulic Design of Flood Control Channels (USACE, 1994), sedimentary rock can typically withstand velocities up to about 10 fps. Erosion of surficial alluvial material is expected to occur in the downstream drainage and in the valley, but this is not expected to be a dam safety concern. The PMF storm events are unlikely to produce peak flow rates or durations capable of eroding the significant volume of bedrock material between the downstream drainage and the reservoir, and erosion of the spillway during an extreme event is not expected to result in an uncontrolled reservoir release.

6.5.5 Hydraulic Conveyance Facilities

Additional hydraulic facilities would be required to bypass Park Ditch flows and fill the reservoir. Concepts for these hydraulic facilities are provided in the following sections.

6.5.5.1 Park Ditch Bypass Facilities

Park Ditch intersects Dry Gulch and continues downstream but would be disconnected if a dam was constructed across Dry Gulch. Bypass facilities would be constructed to maintain continuity of Park Ditch and deliver water to shareholders downstream of Dry Gulch. As part of the Project, SJWCD would also be required by Water Right Case No. 04CW85 to enter into an operations and maintenance agreement with Park Ditch Company.

The Park Ditch bypass would consist of constructing a gravity pipeline along the downstream slope of the dam embankment. The bypass pipe would be installed in a casing pipe to mitigate dam safety concerns. This concept would generally improve the conveyance efficiency in Park Ditch because about four miles of open ditch in Dry Gulch would be bypassed, reducing seepage and evaporation losses and maintenance requirements.

A concrete intake structure would be located at the bypass inlet along near the right abutment of the dam. An energy dissipation facility would be located at the bypass outlet. RJH performed preliminary hydraulic calculations and identified that a 24-inch diameter bypass pipe is required.

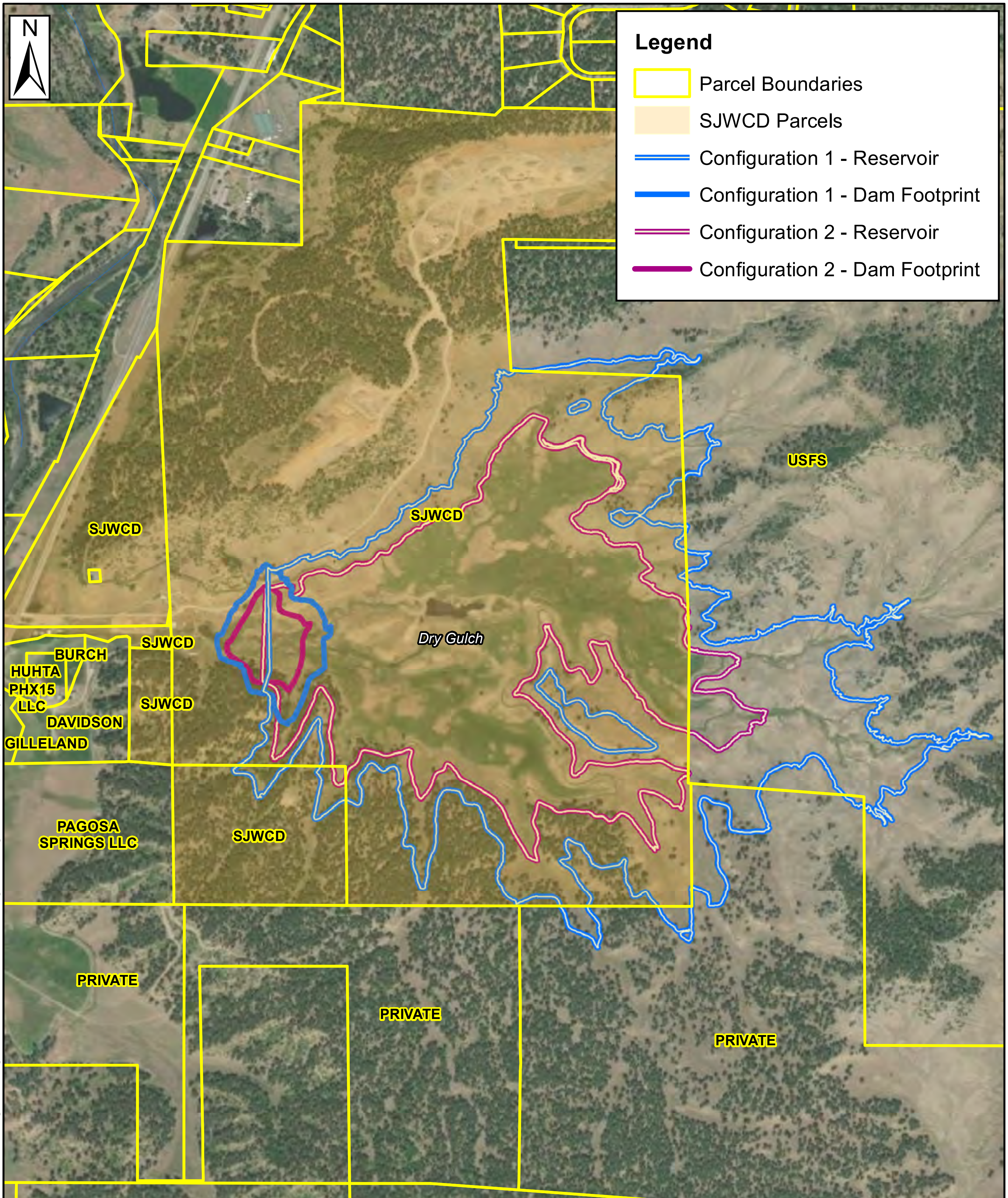
6.5.5.2 Reservoir Filling Facilities

The reservoir would be filled by diverting flow from the San Juan River through the existing Park Ditch diversion structure and irrigation canal. Park Ditch would convey reservoir filling flows (up to 50 cfs) in the ditch to the reservoir site. Flow would be conveyed from Park Ditch into the proposed reservoir in the following ways:

- Configuration 1: A pump station would be constructed near the dam to pump Project flows from Park Ditch over the embankment to fill the reservoir.
- Configuration 2: Park Ditch flows would be routed into the reservoir by gravity through the right abutment of the dam. Flow would be conveyed in a pipe and discharged into the reservoir on a concrete rundown structure.

Additional work is required to evaluate if the reach of Park Ditch upstream of the reservoir requires a) enlargement to facilitate Project diversions or b) improvements to address stability or seepage loss issues. The Project would require a conveyance agreement and coordination with Park Ditch Company.

The water right would allow for a new diversion to be constructed on the San Juan River near its confluence with Dry Gulch. This concept would be evaluated further in future phases of design is likely less desirable than a diversion from Park Ditch because a) it would require a new diversion on the river and b) costs associated for the pump station, diversion, and conveyance pipeline from the river to the reservoir would be more expensive. For these reasons, this option was not considered as part of the screening-level study.



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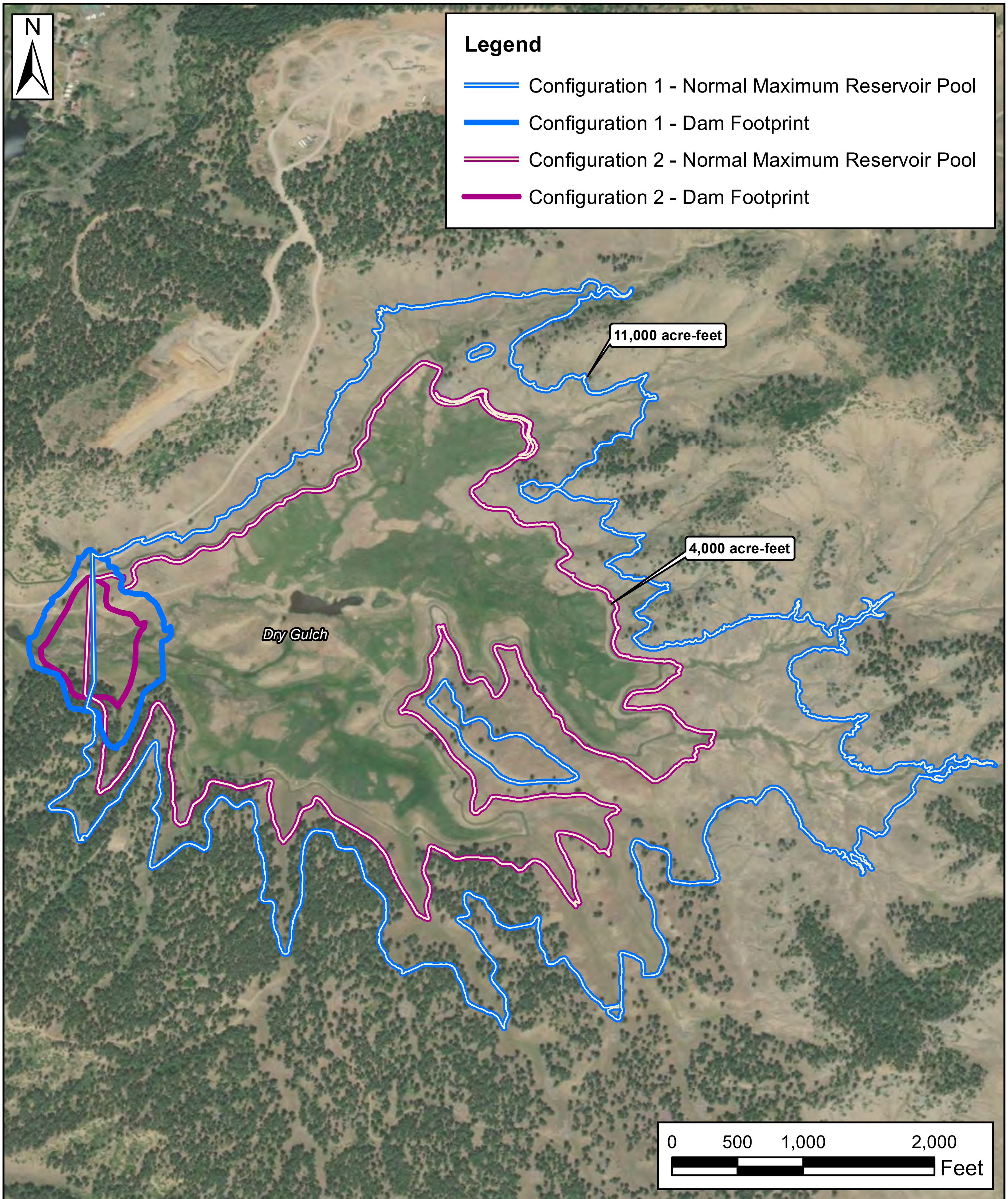
SAN JUAN RESERVOIR HEADWATERS PROJECT	PARCEL MAP	
PROJECT NO. 25127	February 2026	**Figure 6.1**



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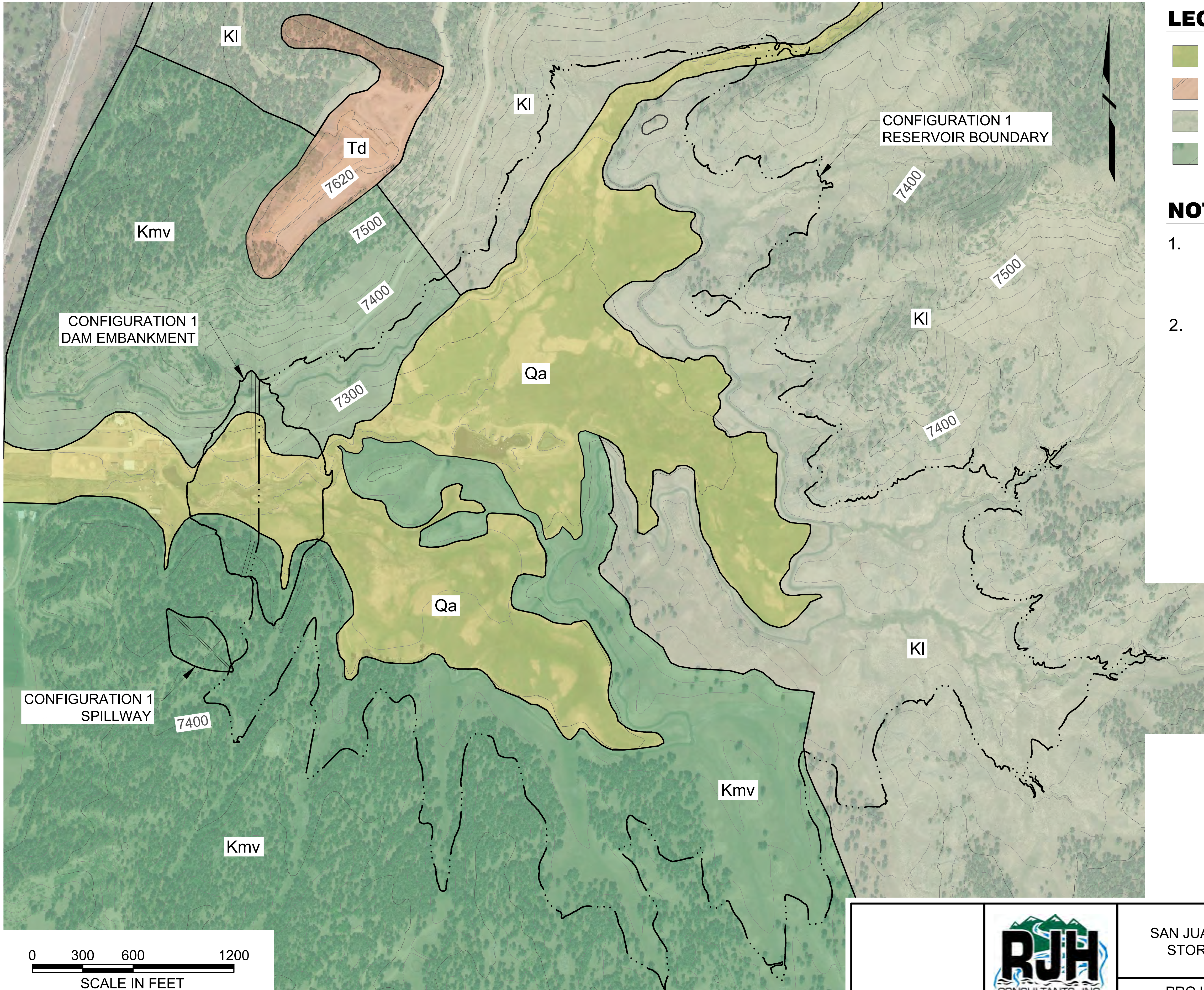
SAN JUAN RESERVOIR HEADWATERS PROJECT

PLAN OF RESERVOIR CONFIGURATIONS

PROJECT NO. 25127

February 2026

Figure 6.2



LEGEND

- QUATERNARY ALLUVIUM (Qa)
- TERTIARY TERRACE DEPOSITS (Td)
- CRETACEOUS LEWIS SHALE (Kl)
- CRETACEOUS MESAVERDE FORMATION (Kmv)

NOTES

1. ALL GEOLOGIC CONTACTS ARE APPROXIMATE AND ARE BASED ON PUBLISHED MAPPING BY (STEVEN ET AL., 1974) AND PREVIOUS PROJECT REPORTS (YEH, 2025).
2. BEDROCK IS INTERPRETED TO BE DIPPING DOWNWARD SLIGHTLY TO THE NORTHEAST.

PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.	SAN JUAN HEADWATERS STORAGE PROJECT	GEOLOGIC MAP	
	PROJECT NO. 25127	February 2026	Figure 6.3

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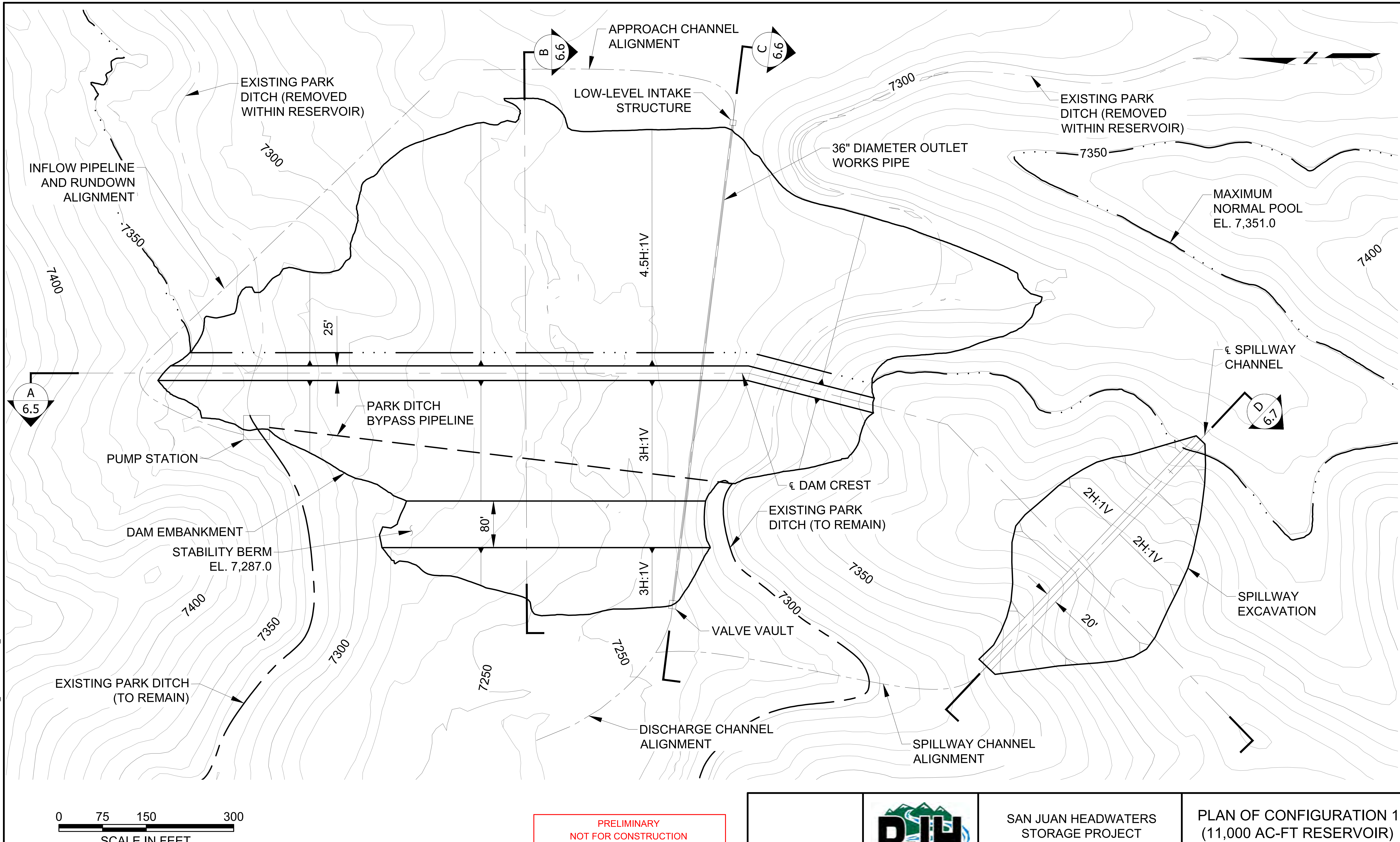

PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.

SAN JUAN HEADWATERS STORAGE PROJECT

PLAN OF CONFIGURATION 1 (11,000 AC-FT RESERVOIR)

PROJECT NO. 25127

February 2026

Figure 6.4

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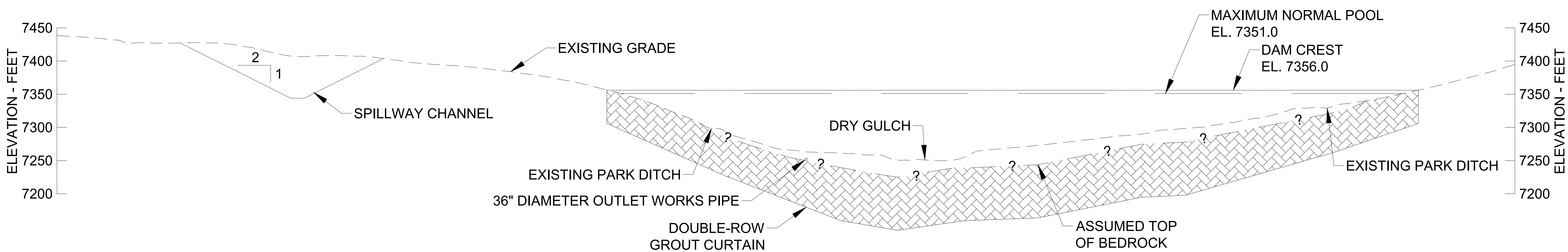

PROFILE A
DAM CREST 6.3

0 75 150 300
SCALE IN FEET

PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.	SAN JUAN HEADWATERS STORAGE PROJECT	CONFIGURATION 1 EMBANKMENT PROFILE (11,000 AC-FT RESERVOIR)	
	PROJECT NO. 25127	February 2026	Figure 6.5

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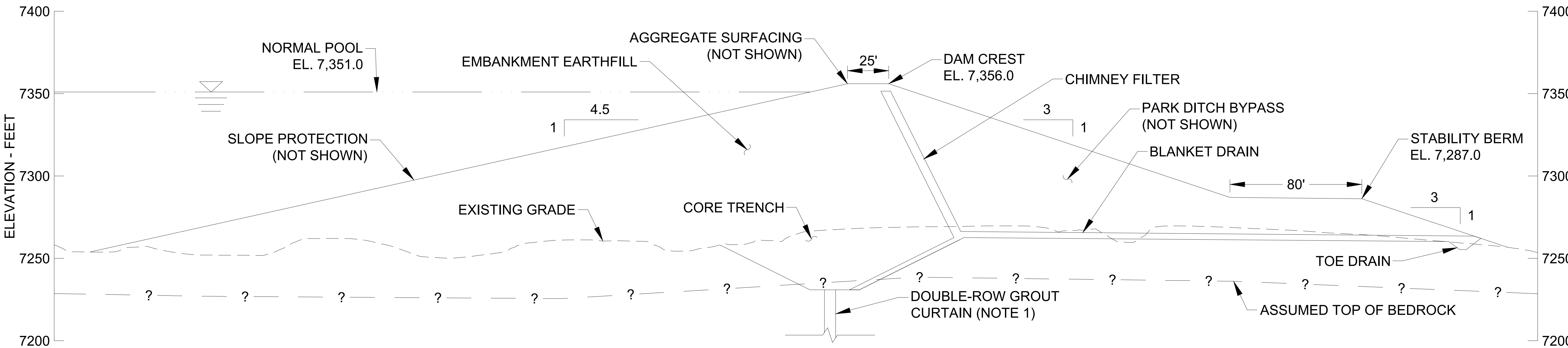
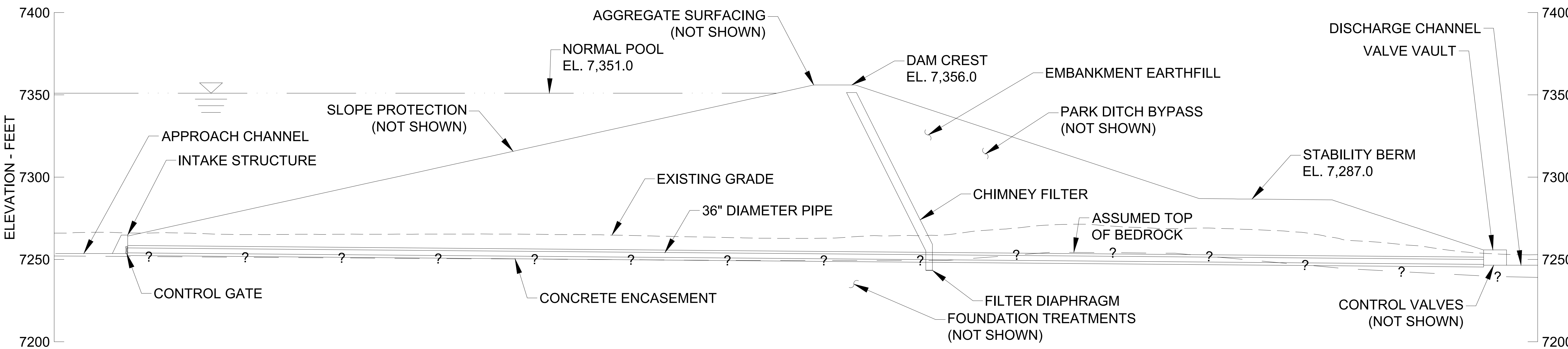


SECTION B
MAXIMUM SECTION 6.3



SECTION C
OUTLET WORKS 6.3

PRELIMINARY
NOT FOR CONSTRUCTION

NOTE:
1. GROUT CURTAIN EXTENDS ABOUT 80 FEET BELOW TOP OF BEDROCK AT MAXIMUM DAM SECTION AND MINIMUM 50 FEET BELOW TOP OF ROCK AT THE ABUTMENTS.

0 30 60 120
SCALE IN FEET

RJH CONSULTANTS, INC.

SAN JUAN HEADWATERS STORAGE PROJECT

CONFIGURATION 1
OUTLET WORKS PROFILE
(11,000 AC-FT RESERVOIR)

PROJECT NO. 25127

February 2026

Figure 6.6

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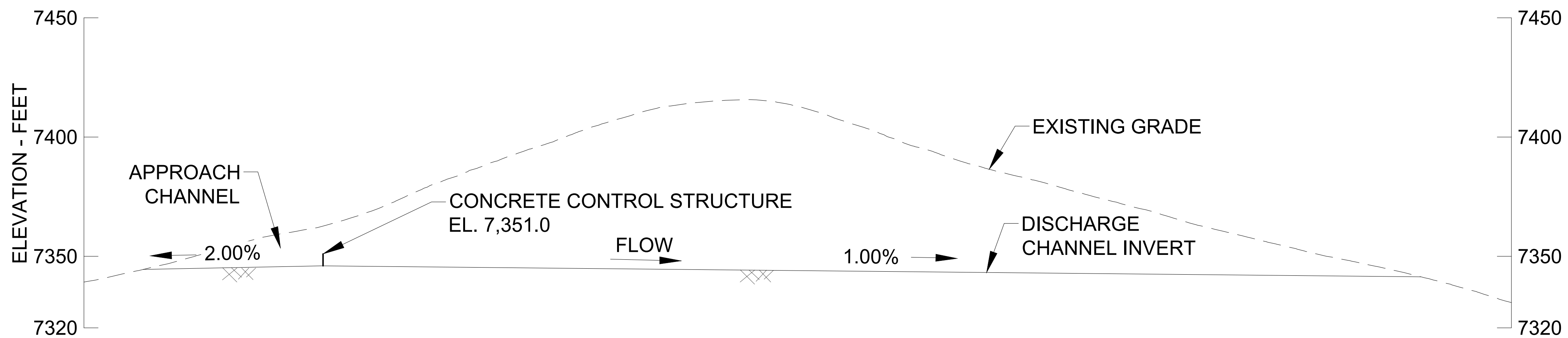


PROFILE D
SPILLWAY 6.3

0 30 60 120
SCALE IN FEET

PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.

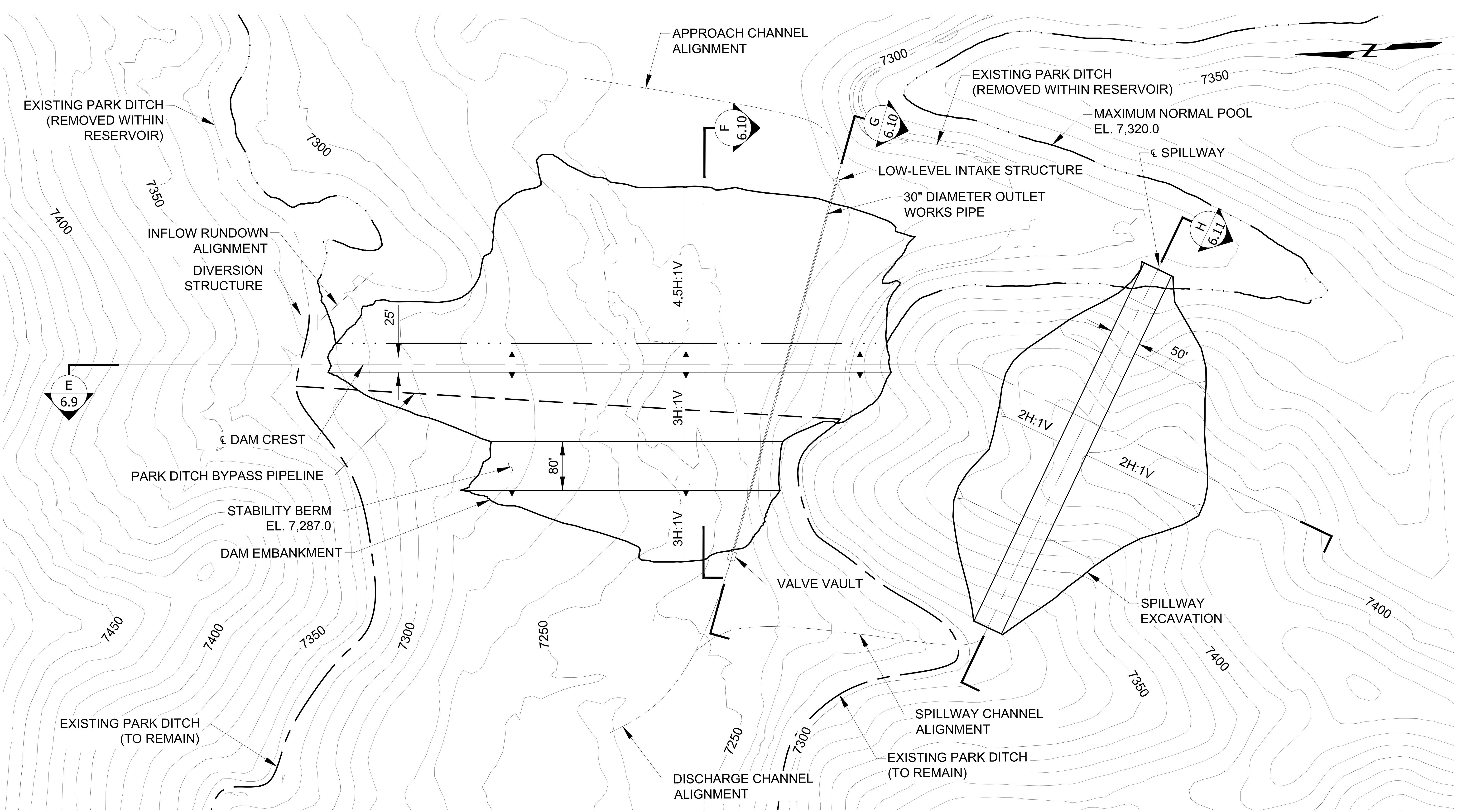
SAN JUAN HEADWATERS STORAGE PROJECT

PROJECT NO. 25127

CONFIGURATION 1
SPILLWAY PROFILE
(11,000 AC-FT RESERVOIR)

February 2026

Figure 6.7



0 75 150 300
SCALE IN FEET

PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.

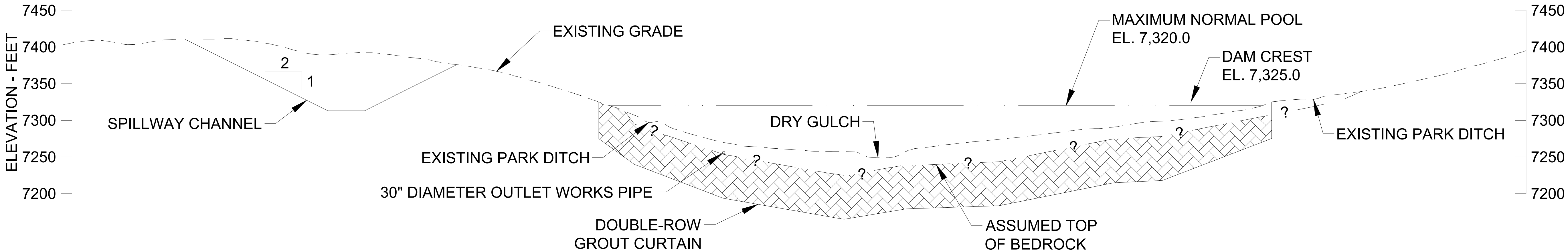
SAN JUAN HEADWATERS STORAGE PROJECT

PROJECT NO. 25127

PLAN OF CONFIGURATION 2 (4,000 AC-FT RESERVOIR)

February 2026

Figure 6.8

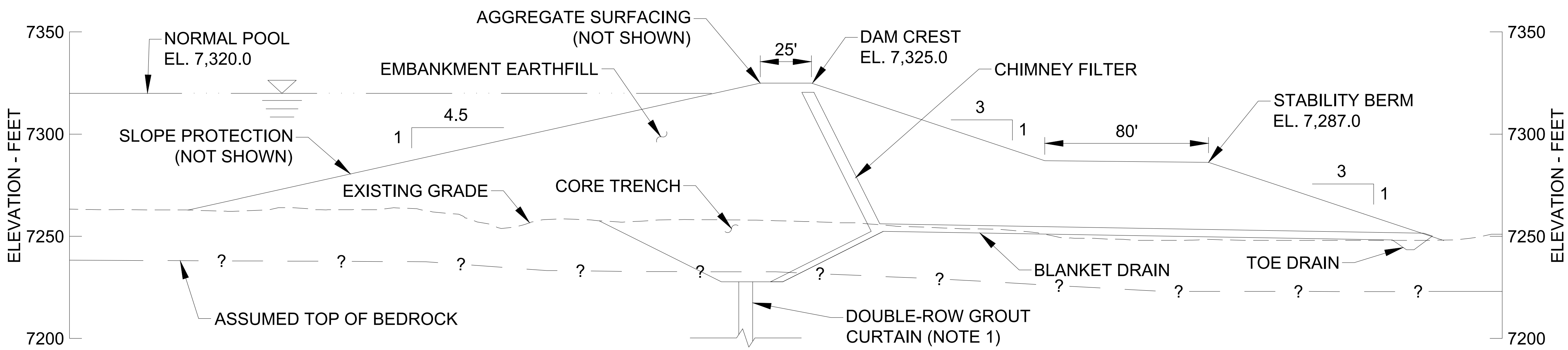


PROFILE E
DAM CREST 6.7

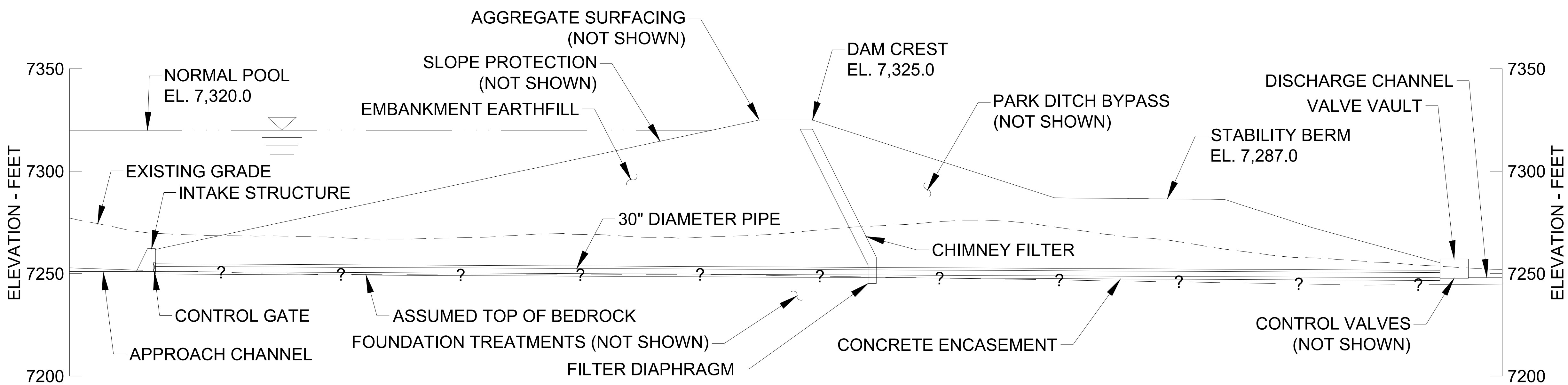
0 75 150 300
SCALE IN FEET

PRELIMINARY
NOT FOR CONSTRUCTION

	RJH CONSULTANTS, INC.	SAN JUAN HEADWATERS STORAGE PROJECT	CONFIGURATION 2 EMBANKMENT PROFILE (4,000 AC-FT RESERVOIR)
		PROJECT NO. 25127	February 2026 Figure 6.9



SECTION F
MAXIMUM SECTION 6.7



SECTION G
OUTLET WORKS 6.7

PRELIMINARY
NOT FOR CONSTRUCTION

NOTE:

1. GROUT CURTAIN EXTENDS ABOUT 60 FEET BELOW TOP OF BEDROCK AT MAXIMUM DAM SECTION AND MINIMUM 50 FEET BELOW TOP OF ROCK AT THE ABUTMENTS.

0 30 60 120
SCALE IN FEET

RJH CONSULTANTS, INC.

SAN JUAN HEADWATERS STORAGE PROJECT

PROJECT NO. 25127

CONFIGURATION 2
EMBANKMENT SECTIONS
(4,000 AC-FT RESERVOIR)

February 2026 | Figure 6.10

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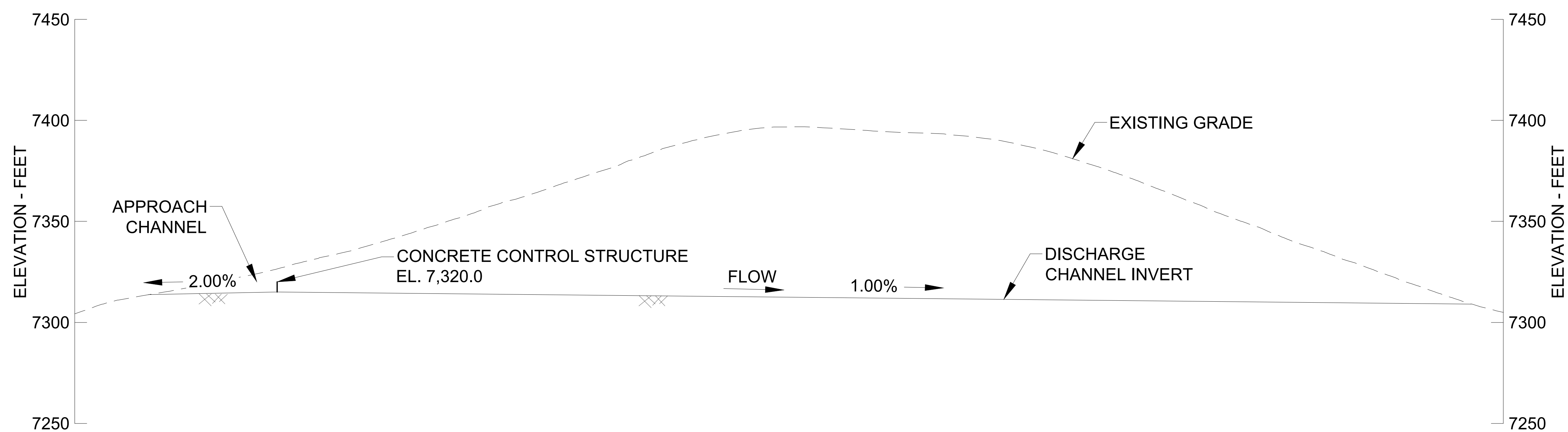

PROFILE
SPILLWAY
H
6.7

0 30 60 120
SCALE IN FEET

PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.	SAN JUAN HEADWATERS STORAGE PROJECT	CONFIGURATION 2 SPILLWAY PROFILE (4,000 AC-FT RESERVOIR)	
	PROJECT NO. 25127	February 2026	Figure 6.11

SECTION 7 - RISK AND UNCERTAINTY

RJH has identified several considerations that introduce risk and uncertainty to the Project, which are described as follows.

Water Rights and Supply:

- Changing climate conditions and precipitation patterns will impact the water supply in the upper San Juan River. The magnitude of this change is difficult to predict but recent trends generally show an increased likelihood of prolonged drought. Extrapolation of historical water supply supports the viability of this Project (see Section 2.3), but the uncertainty of future climate conditions introduces risk to the Project.
- Others have upstream conditional water rights that are senior to the CWCB instream flow right (not including the Project water right). The Project must bypass the CWCB instream flow right, so annual shortages and reduced diversions would impact the Project if the upstream conditional water rights were developed.
- The conditional water rights for the Project will expire if SJWCD cannot meet CWCB's due diligence requirements by demonstrating an intent to use the water right.

Water Demand:

- Population growth in Pagosa Springs area may remain steady or increase but are not projected to decrease, impacting the demand for municipal water, recreation, and conservation.
- Minimum environmental releases and sediment flushing flows to meet environmental permit requirements are currently unknown and flows to address these needs could impact the Project.

Technical:

- Additional subsurface geologic and geotechnical investigation may indicate that the Dry Gulch Reservoir site requires significantly more below-grade work than anticipated, which could dramatically increase Project costs.
- Historical documentation of Park Ditch has indicated that the first three miles of the ditch upstream of the Project is generally unstable and susceptible to landslides. The viability of expanding Park Ditch and using an open channel to reliably convey water to the reservoir is currently unknown and would require geotechnical evaluation.

- Spillway and outlet works alignments could change based on the location of competent bedrock identified in future subsurface geologic and geotechnical investigation.

Permitting:

- Environmental permitting regulations may change during Project development and substantially alter Project feasibility, cost, or schedule.

Legal and Property:

- The grant funding from CWCB used to purchase the property requires that the planning period for the project be completed by 2035.
- The land in Dry Gulch is jointly owned by PAWSD and SJWCD. Advancement of the project will require cooperation from PAWSD.
- The private property owner for the parcel along the spillway alignment may decide not to sell or grant an easement.
- The U.S. Forest Service (USFS) may not accept water storage on their property.

Stakeholders and Public Outreach:

- Lack of funding has limited public outreach efforts to date. The Project could be difficult to implement without sufficient public support. Currently, there are various groups in the community that both support and oppose the project.

Economics:

- SJWCD does not have sufficient funds to cover the next phases of planning, permitting, and design for a project of this magnitude, which is consistent with other local rural entities in Colorado. Other funding sources would be required to advance the Project.

SECTION 8 - ENVIRONMENTAL ANALYSIS

8.1 General

ERO performed a site visit and desktop environmental resources study to identify the following:

- Potential waters and wetlands, threatened and endangered (T&E) habitat, and cultural resources at the site.
- Environmental and cultural studies and permits that would likely be needed to construct the Project.

This study pertains only to the proposed reservoir footprint and did not consider additional disturbance areas that may be associated with the project including, but not limited to, temporary construction areas, staging areas, new access roads, relocation of Park Ditch, dam features, other pump or pipeline features, and borrow areas. The environmental resources study memorandum is presented in Appendix C and summarized below.

8.2 Methods

On November 11, 2025, ERO staff assessed the project area for potential environmental issues. In addition to the 2025 site visit, ERO reviewed publicly available data, online maps and inventories, topographic maps, and aerial photographs, and reports from previous cultural surveys in the project area to identify environmental resources. This records review included water resources (including wetlands), threatened and endangered species, USFS sensitive species, wildlife habitat, raptors and migratory birds, archaeological and historical resources, and other potentially sensitive or listed species with the potential to occur in the project area.

8.3 Results

8.3.1 Water Resources

8.3.1.1 Streams and Open Waters

The USGS Jackson Mountain, Colorado topographic quadrangle map and the NWI show multiple unnamed intermittent drainages with eventual connections to the San Juan River and one ditch (Park Ditch) in Dry Gulch in the project area (USGS, 2022; USFWS, 2025). During the 2025 site visit, these features did not have flowing water; however, the drainage features with associated wetlands were observed in the project area as described in more detail below.

8.3.1.2 Wetlands

Wetlands in the project area are categorized as riverine, freshwater emergent wetlands, and freshwater ponds (Cowardin et al., 1979). Table 8.1 summarizes each of the potential WOTUS features and includes the Cowardin classification for each potential WOTUS in the proposed project alternatives.

TABLE 8.1
STREAM, OPEN WATER, AND WETLAND SIZE AND CLASSIFICATION IN THE PROJECT AREA

Water/Wetland	Configuration 1 Wetlands/Water Size (acres)	Configuration 2 Wetlands/Water Size (acres)	Cowardin Classification
Park Ditch (riverine)	12.16	7.27	R4SBC, R4SBCx, R5UBH
Freshwater emergent wetland	53.92	53.75	PEM1B, PEM1C
Freshwater pond	1.16	1.16	PABFh
Total Wetlands and Open Water Areas	67.24	62.18	-

8.3.2 Endangered Species Act Compliance

During the 2025 site visit, ERO assessed the project area for potential habitat for threatened, endangered, proposed, and candidate (T&E) species listed under the Endangered Species Act (ESA) of 1973, as amended (16 United States Code 1531 et seq.). Adverse effects on a federally listed T&E species or its habitat require consultation with the USFWS under Section 7 or 10 of the ESA. The USFWS IPaC resource list for the project area identifies several T&E species with potential habitat in the project area or with potential to be affected by the project. Federally listed T&E species were analyzed based on the location and available habitat in the project area, not by alternative.

There is potential habitat for monarch butterfly and silverspot in the project area; however, further surveys are needed to identify if host plant species are present that could result in the presence of the monarch butterfly or silverspot and, therefore, potential impacts on the species if the project were to occur. If host species are observed during surveys, further consultation with the USFWS would be required and a biological assessment (BA) would be required.

For Colorado pikeminnow and razorback sucker, populations are known from downstream below the Navajo Reservoir Dam in the San Juan River. Depletions from diversions for the proposed reservoir may result in reduced water availability or could result in adverse impacts, but further analysis of diversion amounts and anticipated impacts downstream would need to be described in the BA. Consultation with the USFWS would be necessary to determine effects.

8.3.3 U.S. Forest Service Sensitive Species

ERO identified USFS Region 2 sensitive wildlife species with potential to occur on San Juan National Forest lands in the project area that could be affected by the proposed project. USFS sensitive species were not analyzed by alternative but based on habitat availability in the project area. Over 30 species were identified where some form of suitable habitat was identified in the project area.

8.3.4 Other Wildlife, Raptors, and Migratory Birds

In 2021, Colorado Parks and Wildlife (CPW) released a High Priority Habitat (HPH) table that identifies species and habitats, and recommendations to avoid and minimize impacts on wildlife from land use development (CPW, 2023). Data from CPW map databases available on CODEX (CNHP, 2025) were reviewed, and HPH in the project area includes elk migration corridor, elk winter concentration area, and mule deer migration corridor. These HPH habitats overlap both configurations. ERO recommends discussing the project with CPW early in the process to identify impacts on elk and mule deer and potential mitigation measures to reduce or offset impacts.

Additionally, raptor species and bald and golden eagles that are protected under the Bald and Golden Eagle Protection Act have the potential to occur in the project area, such as red-tailed hawk (Buteo jamaicensis), bald eagle, golden eagle (Aquila chrysaetos), ferruginous hawk, American peregrine falcon, northern harrier, American goshawk, and osprey (Pandion haliaetus). Surveys should be completed to identify any active nests are present, and they will need to be avoided during construction or other proposed project activities, and avoidance measures should be followed as outlined by CPW recommendations (CPW, 2020) and any other input from the USFS or U.S. Bureau of Reclamation (Reclamation).

8.3.5 Cultural Resources

ERO reviewed available data on known and potential cultural resources in the project area. The file search with Compass showed that no previous inventories have been conducted in the project area and no sites have been documented; however, La Plata Archaeological Consultants (LPAC) surveyed 1,257 acres from 2007 to 2009 at the request of Pagosa Area Water and Sanitation District and Harris Engineering. A report was prepared and submitted to San Juan Water Conservancy District in 2017 (Fuller, 2017). The report does not appear to have been submitted to the State Historic Preservation Office (SHPO); no site state numbers were assigned and there is no record of the project on Compass.

LPAC documented 50 sites during the 2007-2009 survey. A total of 30 sites are within one or both proposed reservoir footprints. A total of 15 resources are within the smaller reservoir footprint (Configuration 1). These sites are primarily prehistoric artifact scatters (n=12), with 2 multicomponent sites with both precontact and historic components and 1 historic artifact scatter. Many of these sites had diagnostic artifacts indicative of an Archaic Period association. Two sites were recommended eligible and six sites were recommended needs data (undetermined). The remaining seven sites are officially not eligible (n=1) or recommended not eligible.

The remaining 15 sites from the LPAC 2007-2009 survey are located outside of the smaller reservoir but within the boundaries of the larger reservoir footprint (Configuration 2) and are all precontact artifact scatters. Two of these sites were recommended eligible and nine sites were recommended needs data (undetermined). The remaining four sites were recommended not eligible.

In addition to the OAHP file search, ERO conducted a review of historical maps, historic aerials, Colorado Division of Water Resource records, and General Land Office (GLO) records to assess the potential for unknown historical resources, such as roads, ditches, and buildings, in the project area. No additional resources were observed in the records reviewed.

Because these survey results were never finalized, SHPO consultation is incomplete, and the survey is more than 15 years old, a new cultural resource survey would be required and SHPO consultation would need to be completed.

8.4 Expected Permitting Needs

Overall, adverse impacts could be possible for T&E species, USFS sensitive species, and cultural resources, and consultation with the associated agency is recommended to identify mitigation requirements. The following are the anticipated surveys, documentation, and consultation needs; however, additional information and planning may identify the need for further survey, reporting, or permitting requirements.

- Preparation of Standard Form (SF) 299 for the USFS to apply for a special-use permit (SUP).
- Preparation of the appropriate NEPA document (Categorical Exclusion, Environmental Assessment, or Environmental Impact Statement) as determined by the lead agency to satisfy NEPA compliance. Once written and reviewed by all cooperating agencies, a finding of no significant impact (FONSI) would be issued by the lead agency to allow the project to proceed.
- Natural resource surveys and reports to support the SUP, Reclamation, environmental permitting, and ESA Section 7 consultation process:
    - General habitat assessment survey and necessary species-specific surveys.
    - Biological Assessment for submittal to the USFWS.
    - Biological Evaluation for submittal to the USFS.
    - Discussion with CPW on HPH species and potential mitigation.
- Wetland surveys and reporting for compliance with Section 404 of the CWA:
    - Wetland delineation. The wetland delineation report and associated forms would be submitted to the Army Corps of Engineers (Corps) to begin consultation.
    - A Preconstruction Notification form (PCN) for submittal to the Corps.
    - Consultation with the Army Corps of Engineers (Corps) will determine if any documented wetlands are jurisdictional and whether a Nationwide or Individual Permit would be required.
- Cultural Resource surveys and reporting for NHPA compliance:
    - A Class III cultural resource survey that complies with the Colorado State Historic Preservation office (SHPO) and agency requirements.
    - Results would be compiled in a report that meets SHPO and agency standards, and site and isolated find forms would be completed.
- Phase I Environmental Site Assessment may also be required by agencies for NEPA compliance.

SECTION 9 - LEGAL AND INSTITUTIONAL REQUIREMENTS

9.1 Water Rights Issues

SJWCD owns water rights sufficient to fill and store 11,000 acre-feet of water for all contemplated Project uses, with priorities dating to 1967 and 2004 as detailed in Section 2.2.2. In addition, there remains water available for appropriation in the San Juan River, so additional water rights could be obtained for the Project if necessary.

9.2 Legal and Institutional Requirements

This off-stream raw water storage project has water rights which allow for an initial fill and a refill each year as described in detail in Section 2.2.2. The adjudicated fill rate is limited to 50 cfs from the sources described and subject to terms and conditions intended to protect instream flows in the San Juan River.

9.3 Multi-Jurisdictional and Interagency Agreements

Depending on the selected reservoir configuration, there may be a requirement to coordinate with the USFS for an inundation permit or a possible land swap agreement. In addition, if the larger storage option is selected (Configuration 1), there will be a negotiation with a private landowner for storage for inundation. Representatives of SJWCD have previously had discussions with both the USFS and private land owner, but definitive arrangements have not been reached with either.

9.4 Permitting Procedures

Permits that are anticipated to be required to advance the Project are described in Sections 3.5 and 8.4. We plan to implement the following strategies to accelerate the permitting process:

- Develop a permitting matrix: At the start of the Project, we would identify federal, state, and local permits and approvals that are required to advance the Project, including how they are interconnected. Federal reviews such as NEPA and Clean Water Act Section 404 will likely drive the critical path, but they will be influenced by state dam safety, wildlife consultations, historic preservation reviews, and county land-use approvals. We would develop a permitting matrix and schedule early in the Project, which would facilitate discussions with agencies and help identify data collection needs and key issues.

- Early engagement of agencies: We would coordinate with the U.S. Army Corps of Engineers, Colorado Parks and Wildlife, the State Engineer's Office, and other key agencies would early in the Project. Early coordination would help clarify agency roles and align expectations around study methodologies, modeling assumptions, and impact thresholds. We would also maintain regular, structured check-ins throughout permitting - rather than waiting for formal comment letters - to allow critical issues to be resolved quickly, preventing delays caused by multiple rounds of revisions.
- Perform early, targeted data collection: Early, high-quality, and defensible data collection shortens review timelines by reducing uncertainty, limiting requests for supplemental studies, and strengthening the record against potential challenges. We would work with regulators to identify agency-accepted methodologies and coordinate data collection plans prior to performing the field work.
- Reduce impacts through design and mitigation: We would work to reduce impacts to the greatest extent possible through the design process. This will involve clear documentation showing how impacts were reduced or avoided through design decisions. We will consider "right-sizing" the Project by changing the normal pool elevation several feet if environmental permitting impacts can be reduced and will consider ways design features such as multi-level outlets, environmental bypass flows, or sediment management features can reduce downstream impacts.

9.5 Unresolved Issues

The Project land is owned jointly by PAWSD and SJWCD. CWCB provided funding for the purchase, including a grant to SJWCD and loan to PAWSD. PAWSD, SJWCD, and CWCB are parties to an agreement that set out certain conditions relating to repayment of the loan, including a planning period during which PAWSD is restricted from selling the Project Property. The planning period ends in 2036.

There is a pending dispute between SJWCD and PAWSD regarding future water supply and demand, which influences PAWSD view of the feasibility of the Project and its willingness to continue to hold the land where the Project is to be built. The districts have agreed to address this dispute with professional mediation which is scheduled for early March 2026. If the dispute is not resolved, then there is a risk that the land and conditional water rights could be lost.

SECTION 10 - NON-FEDERAL FUNDING

10.1 Non-Federal Funding Sources

10.1.1 General

SJWCD is funded through a mill levy that provides approximately $100,000 per year. Their funding is low compared to other water conservation and utility districts. Increasing the mill levy would require a vote by district residents; the additional revenue could contribute to project funds but would not likely be sufficient to plan permit, design, or construct the project. This limited funding emphasizes the need to work with Federal, State, and private partners to find additional, significant funding to meet the water needs of the region.

If Federal funding were received and the Project was advanced, the project could be marketed to potential stakeholders. The following sections include potential partners that may have an interest in funding the Project and contribute to the non-Federal cost share.

10.1.2 Colorado Water Conservation Board

CWCB operates the Colorado Water Plan Grant Program, which generally includes two grant cycles per year and allocates funds for storage and supply projects. In 2026, CWCB expects to have about $38 million in total funds to award in this program across several qualifying project categories. Other grant opportunities available through CWCB that are potentially applicable to this project include Water Supply Reserve Fund Grants and Project Bills Grants. CWCB also provides low-interest loans for the design and construction of municipal water projects through the Water Project Loan Program (CWCB, 2025).

SJWCD has a working relationship with CWCB and has received financial support from them in the past, including to purchase the Dry Gulch Reservoir site, because CWCB supported the project. CWCB has an incentive to construct the project to increase their instream environmental water right in the San Juan River.

10.1.3 Private Development

If the Project design is advanced, SJWCD plans to engage developers in discussions regarding a private-public partnership. This collaborative financing and management model could help cover a significant portion of capital costs. We anticipate this would include controlled real estate development around the reservoir with careful regulation to maintain public access for dam safety operations and to protect water quality in the reservoir from developed areas.

SJWCD would retain ownership of the dam and water, and either sell or lease land to the developer. Based on projected growth of the Pagosa Springs area and strong tourism, we anticipate this concept would generate significant interest from the development community. The site has exceptional mountain views and is relatively flat, which would both be attractive to developers.

SECTION 11 - SUMMARY AND CONCLUSIONS

RJH offers the following summary conclusions based on this screening level storage evaluation:

1. SJWCD was formed in 1987, in accordance with the Water Conservancy Act, with a decree to conserve, maximize, and utilize the water resources of the San Juan River and its tributaries.
2. Water storage in the District is limited, and future population growth, climate change impacts, lack of redundancy, and variable demand are expected to result in water scarcity, adversely impacting the economy and residents.
3. Constructing a new reservoir would serve SJWCD's mission and purpose and assist with meeting current and future water needs, provide water to restore a portion of the recreation season, and create redundancy and reliability in the municipal water system to safeguard against impacts resulting from wildfire and drought.
4. PAWSD is the municipal water supplier for Pagosa Springs. Most of their supply is from direct diversions on Four Mile Creek and the San Juan River. We understand that PAWSD does not currently have plans to build a new water storage reservoir. PAWSD maintains a water storage system of about 4,000 ac-ft, but not all of this is dedicated to water supply.
5. The existing PAWSD water storage reservoirs all receive direct runoff from the Martinez Creek watershed and are vulnerable to a single wildfire event in this basin. A new reservoir at the Dry Gulch site would be located on a relatively small drainage basin outside of the Martinez Creek watershed, which would improve wildfire resiliency.
6. SJWCD and PAWSD purchased the Dry Gulch site property with the intent of constructing a new reservoir at the site.
7. SJWCD maintains conditional water rights (1967 and 2004) that would accommodate a reservoir at the Dry Gulch site with an annual fill volume of 11,000 acre-feet.
8. SJWCD's conditional water rights will expire if the Project is not advanced.
9. WWG performed a water supply, demand, and shortage analysis on the upper San Juan River Basin to inform this Project and estimated that in 2050, the average annual water shortage in the district would range from 4,100 to 73,000 ac-feet.
10. WWG identified that a 10,000-acre-foot reservoir would be able meet the projected mid-range 2050 municipal demands every year during the evaluated period (29 years) and could meet all other mid-range demands (environmental, agricultural, recreation) in 19 of 29 years.

11. The preferred alternative for this Project is a reservoir at Dry Gulch site because it is the only alternative that meets the purpose and need, meets the formulation criteria, and can store 11,000 ac-ft. The Hood site is a less efficient site and can only store a maximum of 8,100 ac-ft at significantly higher costs.
12. A reservoir at the Dry Gulch site would involve constructing the following components: embankment dam, outlet works, spillway, Park Ditch diversion facility, and Park Ditch bypass facility. These facilities appear to be technically viable; however, additional data, analysis, and coordination are needed to better define the components.
13. SJWCD is funded through a mill levy that provides approximately $100,000 per year, which is not sufficient to design or construct the project. This limited funding emphasizes the need to work with Federal, State, and private partners to find additional, significant funding to meet the water needs of the region.
14. Potential ways to obtain non-federal funding include CWCB grants and a public-private partnership to develop the site around the reservoir.

SECTION 12 - NEXT STEPS

If the Project receives funding from Reclamation, we anticipate the following Project components would subsequently be advanced concurrently:

Public Outreach

This task would involve engaging potential customers in the Pagosa Springs area and marketing the Project to potential stakeholders. At the onset of this phase, we would develop a detailed outreach package. These techniques are expected to include a combination of educational and informative activities, surveys, public meetings, user-friendly materials, branding, and various input and communication methods that can be easily used and shared both online and in-person. We would also develop branded materials to build trust and recognition of the Project and create a study-specific website. Several public events would likely be held to educate the stakeholders and public and to solicit input for future decision making.

Water Modeling

We would perform water resources modeling to better refine existing estimates of demands, inflows, storage volumes, evaporation losses, releases, and reliability under different conditions (average years, drought years, and climate-change scenarios). This modeling would show how often the reservoir would fill, how much water it could reliably supply, how frequently shortages might still occur, and support selection of an appropriate reservoir size. A key part of this study would be evaluating how the proposed reservoir would operate alongside existing water rights, downstream obligations, and environmental flow requirements.

Economic Analysis

This task would involve economic forecasting and modeling to better assess the overall financial viability of the Project. This would likely involve performing a benefit-cost analysis and a financial feasibility assessment. A benefit-cost analysis would compare the full range of long-term costs—such as construction, permitting, operation, and maintenance—against expected economic benefits from improved water reliability, drought resilience, fire protection, agricultural support, and recreation. Related evaluations such as life-cycle cost analysis and risk/sensitivity analysis would help ensure that long-term maintenance, climate variability, and cost overruns are realistically being considered. This task would also consider how various funding sources and approaches could generate sufficient revenue to advance the project.

Feasibility Design

A feasibility-level design would be developed to an approximately 10-percent design stage. This would be used to confirm the technical viability of the Project; better define the size, location, and configuration of key Project facilities; improve Project cost opinions; defining land acquisition needs; and provide a basis for environmental permitting assessments. We anticipate the feasibility-level design would include:

- Identifying key design criteria including operational, maintenance, stakeholder, regulatory, and aesthetic criteria.
- Performing a geotechnical investigation program to evaluate subsurface conditions and potential on-site borrow materials.
- Developing feasibility-level configurations for the embankment dam, outlet works, spillway, and water conveyance facilities.
- Developing feasibility-level cost opinions.

Permitting

We would conduct pre-application coordination with key regulatory agencies, specifically USFS, USFWS, USACE, CPW, and SHPO. This step would assist with identifying which permits will likely be required, NEPA requirements, and level of environmental review (Categorical Exclusion, Environmental Assessment, or Environmental Impact Statement, etc.). We would also perform field surveys including wetland delineations, habitat surveys, and cultural surveys.

Funding Assistance

This task would involve coordination with potential funding partners and applying for additional grants. We would also perform site development studies to better assess the potential revenue that could be generated by developing the site.

SECTION 13 - REFERENCES

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APPENDIX A

SAN JUAN WATER SUPPLY AND DEMAND ANALYSIS MEMORANDUM

Memorandum

To:	Al Pfister
From:	Brenna Mefford and Erin Wilson
Date:	7/29/2022
Re:	San Juan Water Supply and Demand Analysis

Background

The San Juan Water Conservancy District (District) contracted with Wilson Water Group (WWG) to complete an analysis of current and future water supply and demand through 2050, building on the West Fork Alternatives Study in 2020. This analysis supports both the District's 2021 Strategic Plan and the District's restructured San Juan River Headwaters Project Agreement.

2021 Strategic Plan

As stated in the District's 2021 Strategic Plan, the District's primary focus has been water storage. The District's 2021 Strategic Plan laid out objectives and goals for the District and the first objective is "…meet the agricultural, municipal, environmental and recreational water needs of the SJWCD community." Under this objective the District has goals to determine how to meet the communities water needs, either through storage or from alternative measures.

To meet these goals, the District needs to understand current demand and a potential range of future demands for the aforementioned community needs. The District's boundary includes both the town of Pagosa Springs and rural areas of Archuleta County. Like many Colorado mountain towns, the town of Pagosa Springs and surrounding areas have seen population growth. Along with the growth, the San Juan region has been experiencing what hydrologists and planners call the "millennial drought" that began around 2000. While the West Fork Alternatives Study in 2020 looked at supply and demand, the District was interested in updating the supply and demand to incorporate recent dryer years, an increase in population growth during the pandemic, and recent environmental and recreation studies.

SJRHP Restructured Agreement

The District's main project has been the San Juan River Headwaters Projects (SJRHP), also known as the Dry Gulch Reservoir Project. The District owns conditional water rights for Dry Gulch Reservoir. In 2006, the Pagosa Area Water and Sanitation District (PAWSD) became a formal partner with the District on the SJRHP. PAWSD and the District purchased the property for the project using money from a grant and a loan from the Colorado Water Conservation Board (CWCB). After purchasing the property, the PAWSD board decided to suspend the Project due to community concerns regarding need and cost. This led to a restructuring effort in 2016, in which the recognized lead entity for the project changed from PAWSD to SJWCD. The restructuring agreement affected the loan and allowed for a 20-year planning period with an option for an additional 20 years. Under the restructured agreement, the District is obligated to:

- Lead the long-term management of the project
- Promote the project and develop additional stakeholders
- Pursue efforts to acquire additional land necessary for the project with written approval from the CWCB and PAWSD.
- Take the lead on future water court proceedings in relation to the Project water rights

The restructured agreement also imposed consequences on the District and PAWSD, and their rate payers if the project is not constructed or if the property is sold during the planning period. The District, PAWSD, and CWCB all have obligations and interest in the SJRHP. An updated water supply and demand analysis, with potential reservoir sizing, is a step to support planning for the Project pursuant to the restructured SJRHP agreement.

The overall goal of this water supply and demand analysis is to provide a range of future demands and potential shortages to municipal; agricultural; and environmental and recreational uses and to propose potential solutions, including potential reservoir sizes, for meeting potential water supply shortages in the future. The demands shown in this memorandum cover a range of future possibilities, based on publicly available data. The District will need to work with CWCB, PAWSD, and the San Juan Watershed Enhancement Partnership (WEP), as well as other stakeholders, to determine more detailed demands prior to water rights diligence or infrastructure design.

Municipal and Industrial Water Supply and Demand

Pagosa Area Water and Sanitation District (PAWSD) is the largest municipal water provider in the San Juan basin and serves the town of Pagosa Springs and the surrounding area. Most of PAWSD's service area overlaps with the District's service area as shown in Figure 1.

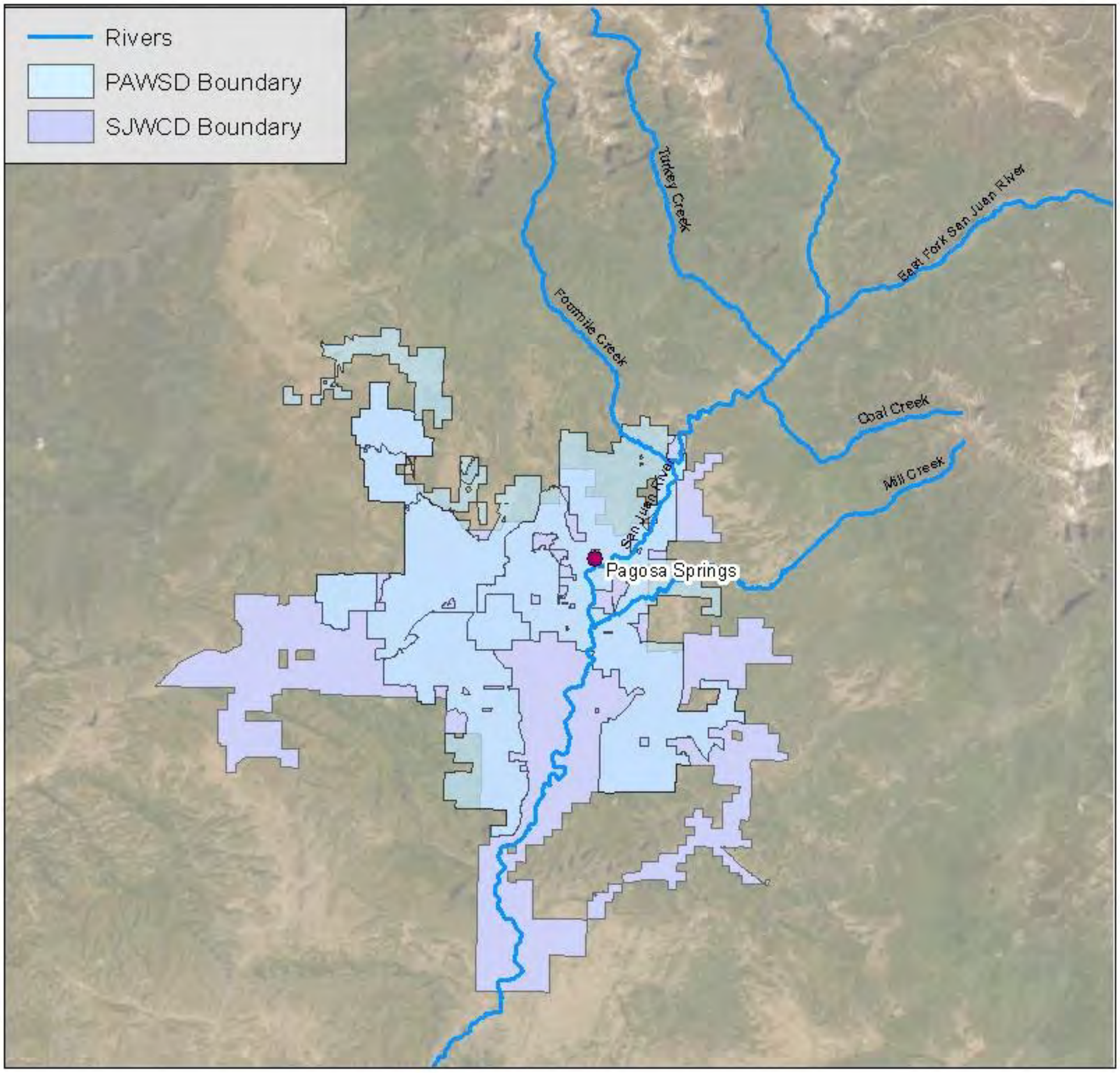

Figure 1. San Juan Water Conservancy District and Pagosa Area Water and Sanitation District Boundaries

The town of Pagosa Springs owns water rights that are used to irrigate parks near the San Juan River. Archuleta County uses some of PAWSD water for road maintenance, and the use is included in PAWSD's total water use. Two large subdivisions use water outside of the town of Pagosa Spring: San Juan River Village and Aspen Springs. The San Juan River Village Water District uses well rights to provide water to roughly 170 taps , while the homes in Aspen Springs rely on water trucked from PAWSD fill stations. Both subdivisions consist of some full-time residents, but mainly second homes and short-term rental houses.

To help develop estimates of current and future water demand, WWG reached out to James Dickhoff with town of Pagosa Springs, Justin Ramsey with PAWSD, Pam Flowers with Archuleta

County, and Cynthia Purcell with San Juan River Village Metro District, to discuss increases in population and potential future trends. WWG also discussed associated current and future water needs. Below summarizes the discussions:

- Over the past two years, Archuleta County has seen an increase in applications for building permits compared to previous years. However, due to the rising cost of building materials, some of the permits have been cancelled.
- Over the past two years, PAWSD has seen an increase in the number of requests for taps.
- The number of developers reaching out to the town of Pagosa has increased in the past two years, and new developments have been planned. Developments include townhomes, condos, single-family homes, and possible RV "subdivisions".
- Due to the rising cost of housing in Colorado, the town of Pagosa is looking to build workforce housing to ensure that employees for the main tourism draws (skiing, rafting, hot springs, etc.) have access to affordable housing. Many locals and workers have been priced out of the competitive housing market and cannot afford to live where they work.
- During the pandemic shutdown, many second homeowners in Pagosa Springs were able to move permanently to Pagosa Springs and work remotely.
- As a result of the pandemic shutdown, more of the workforce are able to work remotely and are moving to Colorado mountain towns, including Pagosa Springs.
- A new HGTV show, Root Design, is likely to put a national spotlight on Pagosa Springs. While the effects of this show are unknown, it is expected that it will increase tourism as well as local population.
- Colorado's recent increase in wildfires have municipalities, including PAWSD, worried about how a large fire could affect their water intakes. A large wildfire around Pagosa Springs has the potential to cause PAWSD to shut down their water intakes on affected water ways to avoid the inflow of soot and debris caused by a fire. A fire in this area could continue to affect the town after the fire is extinguished, due to erosion and runoff during rain events in following years.
- The two largest subdivisions outside of the town of Pagosa Springs (San Juan River Village Metro District and Aspen Springs Metro District) are getting closer to the full build out. According to the San Juan River Village Metro District, over 74 percent of the taps have been purchased. There are not currently other proposed large subdivisions outside of the town of Pagosa; however, if the other two are fully developed, other large subdivisions could be proposed/developed. Note that WWG was not able to connect with anyone at the Aspen Springs subdivision but was able to talk with PAWSD about how Aspen Springs operates.

To determine current and future demand, WWG utilized publicly available data from PAWSD's 2020 Drought Management Plan and 2021 data provided by PAWSD. As directed in the scope of work for this project, WWG worked with PAWSD to understand municipal demand and build on information learned from the West Fork Forks Alternative Study; therefore, it was important to use published demand data from the district versus revising or estimating new values. The

Drought Management Plan noted that PAWSD estimates water demand based on their raw water and potable water produced. PAWSD's average water demand for raw and potable water produced from 2008 to 2017 was 2,246 acre-feet.

The West Forks Alternatives study, completed in 2020, used the 2008 to 2017 average demand. Based on discussions with PAWSD, and as noted in Append D of their 2020 Drought Management Plan, water demand on average has increased recently due to an increase in population and development. PAWSD's average water demand from 2017 to 2021 was 2,536 acre-feet. As shown in PAWSD's 2020 Drought Management Plan, water produced varies from year to year based on weather and consumer consumption and it is best to look at averages or trends rather than comparing one year to the next. As such, WWG utilized PAWSD's average water demand for raw and potable water produced from 2017 to 2021, using a similar approach as PAWSD in their Drought Management Plan to estimating demand.

WWG also talked to the San Juan River Village Metro District about water use. The district currently utilizes two gallery wells and is in the process of constructing a third gallery well. The district does not expect to need more wells to meet total build-out demand. The total demand from the metro district is currently around 14 ac-ft per year, and they believe there three wells will be sufficient to meet their build-out demand.

To estimate future population growth, WWG looked at population growth estimates from the demographer's office, PAWSD, the Growing Water Smart Workgroup, and the Technical Update to the Colorado Water Plan (Technical Update). These sources provide different estimates of population growth. The demographer's office estimated lower growth, while the Technical Update and the Growing Water Smart Workgroup both provided a range of low to high estimates. WWG reached out to representatives from the town of Pagosa, PAWSD, and Archuleta County and presented the different estimates from each source. Working with the three entities, WWG developed three population growth scenarios based on their local knowledge and the sourced estimates as follows:

- Low: 1.7 % growth – This value is based on the 2019 Growing Water Smart Workgroups Average population growth for Archuleta County from 2020 to 2050.
- Medium: 2.6% Growth - This value is based on the 2019 Growing Water Smart Workgroups High population growth for Archuleta County from 2020 to 2050.
- High: 5% For ten years, then 2% through 2050 – This value is based on conversations with the town of Pagosa, PAWSD, and Archuleta County. Since the beginning of the pandemic, the area around Pagosa Springs has seen growth estimated to be around 5% per year. The town expects this growth to continue for the foreseeable future; but is likely not sustainable to 2050. Therefore, this scenario represents growth decreasing after 10 years.

These three growth scenarios provide the District with a range of municipal demands for planning purposes. As was experienced during the pandemic shutdown, growth can change based on factors difficult to plan for, therefore a range of municipal water demands versus a single forecasted population estimate is a reasonable approach. Note that current demand includes demands for all water uses sectors: residential, irrigation, commercial, and water lost due to leaks. To be conservative, WWG assumed that all water use sectors would grow at the same rate. Table 1 shows the current and projected population and demand estimates for each of the three scenarios. Note that the current population (10,025) is based on the Colorado Demographer estimate for Archuleta County for 2020 and reduced by 25 percent to represent PAWSD's service area.

Table 1. Current and 2050 Population Estimates, GPCD and Demand for Municipal Water in the PAWSD Service Area.

	Current (2020)	2050 Projections		
		Low (1.7%)	Medium (2.6%)	High (5% for ten years, 2% after)
Population	10,025	16,623	21,652	24,979
GPCD	226	226	226	226
Demand	2,536 AF	4,208 AF	5,481 AF	6,323 AF

As shown in Table 1, the population PAWSD serves could increase by between 6,500 to 14,900, resulting in an increase in demand for water from PAWSD. GPCD was held constant for this analysis and includes water use for the sectors outlined above, consistent with the GPCD rate calculated in PAWSD's 2008 Water Conservation Plan. GPCD is lower if only residential water use is included; however other water use sectors often increase along with residential population. GPCD estimates were not specified in PAWSD's 2020 Drought Management Plan. PAWSD will likely continue implementing water conservation practices that could impact GPCD; however, WWG did not predict what conservation practices may be implemented, or the impact of those practices.

Currently there are no industrial users that are self-supplied in Archuleta County. As noted above, there are industrial water users that are supplied by PAWSD, and their demands are included in PAWSD's demands. PAWSD does not currently provide data for different types of water users. The estimates shown above were not confirmed by PAWSD and are provided only for the Districts use in understanding potential future municipal demand.

Based on the 2020 Drought Management Plan and conversations with PAWSD staff, PAWSD estimates their existing supplies can meet current demands through a 2-year drought without use restrictions. PAWSD currently plans to meet future demand by using planned upgrades to water treatment plants, continuing to fix leaks in its system, and constructing additional pump stations/pipelines that could help increase water production. In addition, per the restructured agreement with CWCB and SJWCD, PAWSD must plan for future water demands to be met first with SJRHP water and consider SJRHP as the preferred option for long-term water planning.

Agricultural Water Supply and Demand

Significant future demands for agricultural water in the San Juan basin would depend on an increase in current irrigated acreage. The State of Colorado's irrigated acreage assessments, updated on an approximate 5-year basis, shows that irrigated acreage has decreased by 13 percent since 1990 in Water District 29 of the San Juan basin. The recent Technical Update also projected no increase in irrigated acreage through 2050. However, in below average hydrologic years, there are late irrigation season water supply limitations that could benefit from water stored during the runoff period.

WWG used the Colorado Decision Support System (CDSS) consumptive use model to estimate the potential crop demand of current irrigated acreage and actual crop consumptive use based on irrigation diversions recorded by the Division of Water Resources over the past 30 years. Even though irrigation shortages are primarily due to physical and legal water limitations, some shortages may be due to irrigation practices, such as limiting irrigation to allow for grazing. For this analysis, it was conservatively assumed that irrigation shortages were due to water supply limitations. Figure 2 shows annual irrigation shortages within the District for the last 30 years.

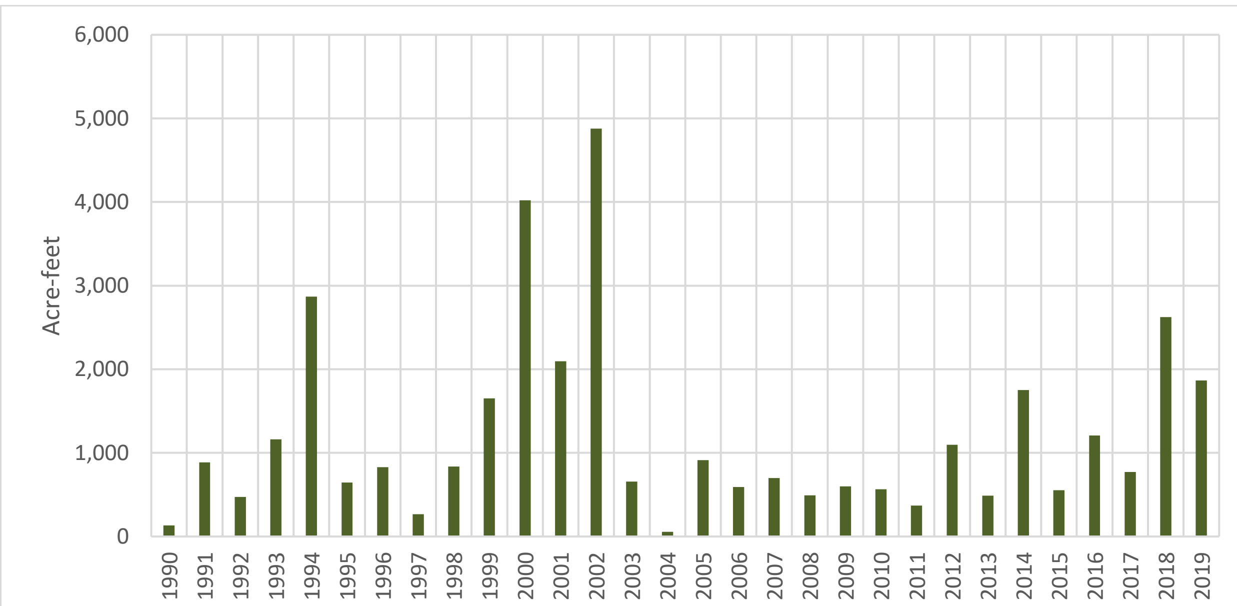

Figure 2. Irrigation Shortages in the District Boundary 1990 through 2019

As shown in Figure 2, annual irrigation shortages ranged from around 50 acre-feet in 2004 to almost 5,000 acre-feet in 2002, with an annual average shortage of 1,200 acre-feet over the period 1990 through 2019. As expected, higher shortages occur in dry years such as 2002, 2018, and 2019. Access to storage could help agricultural producers in the District reduce irrigation shortages during drought years. The estimated shortages were used as a potential demand on future District storage. Note that the irrigation rights are senior to conditional water rights in the basin; therefore, the development of conditional water rights will not increase potential agricultural demand of District storage.

Environmental and Recreational Water Supply and Demand

Similar to the West Fork Water Rights Alternative Study, WWG determined how often the instream flow through the town of Pagosa Springs is met and how often the environmental flow bypass stipulations imposed on the District's Dry Gulch conditional water rights in Case No. 04CW85 would have been met based on recent hydrology. In addition, WWG reviewed environmental and recreational needs identified in the San Juan Watershed Enhancement Partnership (WEP) Phase II Report on Non-Consumptive Needs Assessment (WEP Phase II Report). The WEP Phase II Report was completed in June of 2021 and provided flow thresholds for boating, angling, and sediment transport that WWG used to estimate environmental and recreational demands. There are a wide range of flow demands for the identified environmental and recreational needs; therefore, the demands and shortages were analyzed individually.

CWCB Instream Flow Demands

The CWCB instream flow reach on the mainstem of the San Juan River begins at the confluence of the East and West Forks of the San Juan River and extends to the town of Pagosa Springs. The instream flow water right is 50 cfs from March 1 to August 31 and 30 cfs from September 1 to February 29, fora total annual demand of roughly 29,000 AF. The San Juan at Pagosa Springs streamflow gage (USGS ID 09342500) was used to determine how often the mainstem instream flow rights is satisfied. Figure 3 shows the daily instream flow shortages over the last 30 years. The CWCB instream flow right is a junior water right in the basin, with a 1980 appropriation date. Unlike the shortages to senior agricultural uses, as shown in Figure 3, the need for District storage to meet the environmental demands would increase if upstream conditional water rights were developed. Based on the current Division of Water Resources water rights information, there are 66 conditional water rights summing to just under 50 cfs (not including the Dry Gulch diversion water right) that are senior to the instream flow water right. Most of the water rights are decreed for less than 1 cfs.

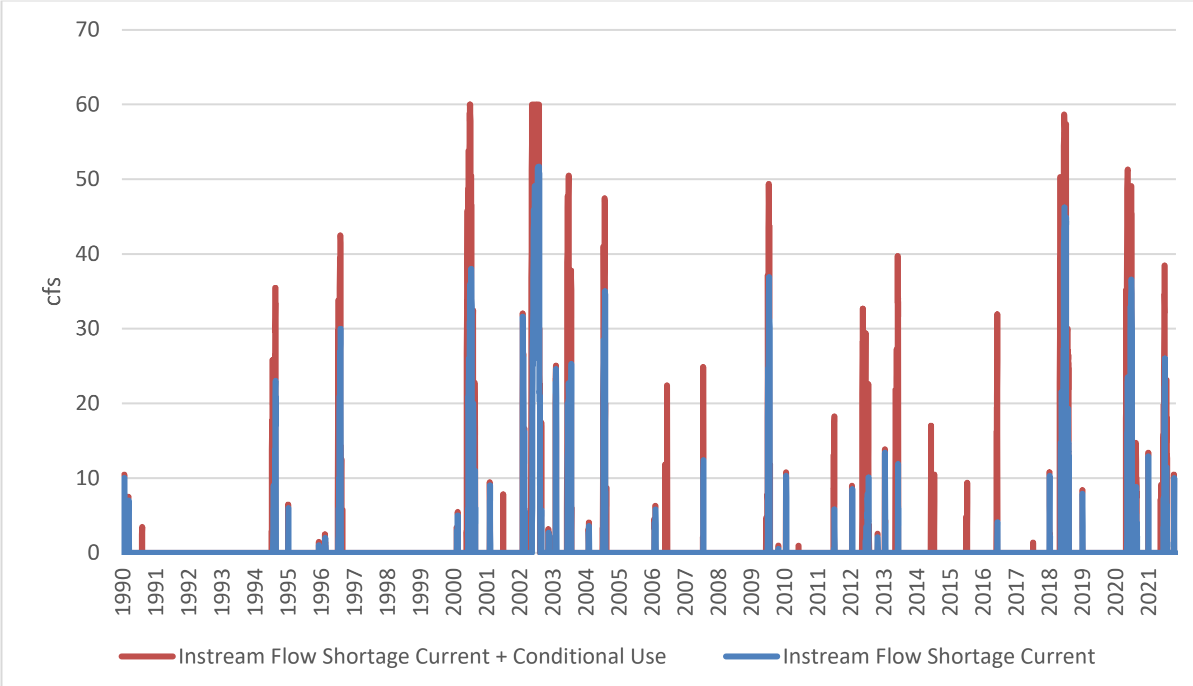

Figure 3. Daily San Juan River Instream Flow Shortages 1990 through 2020

As shown in Figure 3, in most years the current instream flow right is satisfied. Instream flow shortages generally occur in July and August only in dryer years with limited late season precipitation. This coincides with the period that municipal and agricultural demands are greatest and the typical high season for tourists in Pagosa Springs that enjoy recreation on the San Juan River. Annual shortages range from 0 acre-feet in most years to 4,368 acre-feet in 2002 (6,746 acre-feet if upstream conditional rights were developed).

Dry Gulch Stipulated Bypass Requirements

Environmental flow bypass stipulations were added as a requirement for development of the Dry Gulch water rights during the 2004 diligence proceedings. These stipulated flows are double the current instream flow right on the mainstem of the San Juan River (100 cfs from March 1 to August 31 and 60 cfs from September 1 to February 29), providing a total annual demand of roughly 58,000 AF. Backup documentation on the basis for these flows could not be found, however these stipulated flows may be justified and necessary to meet environmental needs, therefore could be protected under a new instream flow filing or water acquisition. Colorado Parks and Wildlife (CPW) and CWCB would need to perform an analysis to determine if the flows are necessary to preserve or improve the natural environment to a reasonable degree. Figure 4 shows the daily shortages on the mainstem San Juan River if the stipulated flow rates were justified. As shown, the need for District storage to meet these flow shortages would increase if upstream conditional water rights were developed.

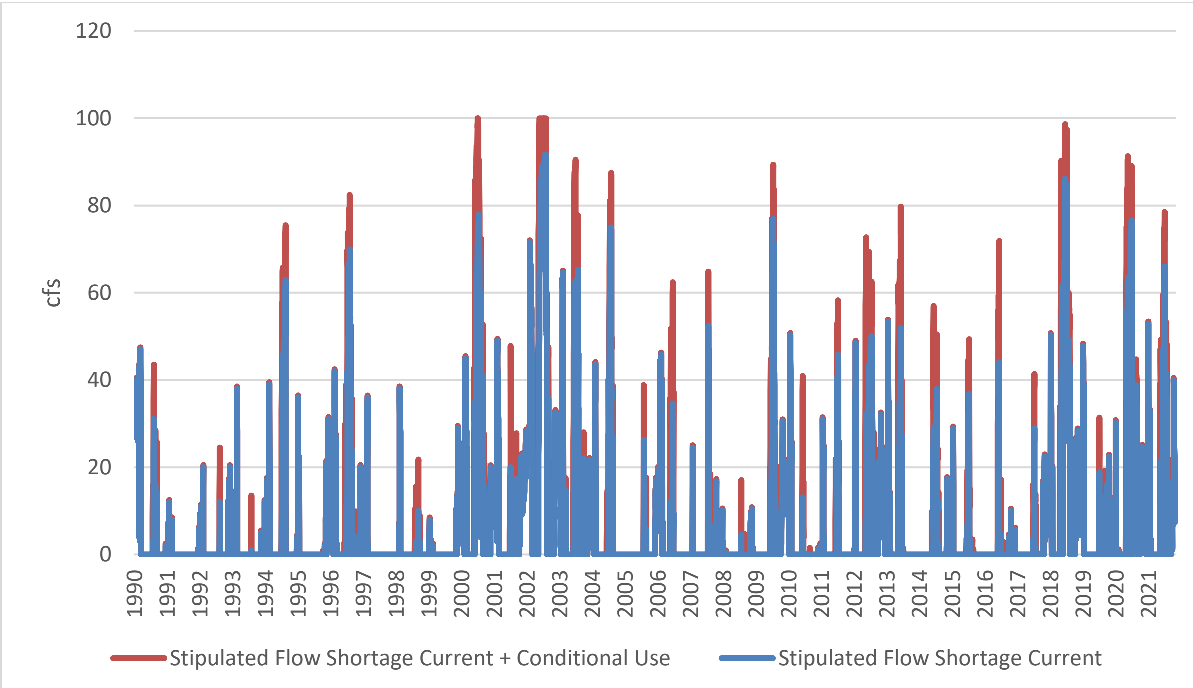

Figure 4. Daily San Juan River Environmental Stipulated Flow Shortages 1990 through 2020

The environmental stipulated flows result in increased shortages compared to the current instream flow demands in late summer and winter months in both hydrologically dry and hot years. Annual shortages range from 0 acre-feet in many years to 21,482 acre-feet in 2002 (24,679 acre-feet if upstream conditional rights were developed). The average annual shortage over the 30-year analysis period is 3,327 acre-feet.

Recreational Flows

The WEP Phase II Report documented user preference flows for recreational angling and whitewater rafting on the San Juan River. According to the report, the San Juan basin offers exceptional fishing and whitewater opportunities that bring in tourists to the area. The town of Pagosa Springs relies on tourism as a source of revenue and therefore it is important to understand the flow preferences and how they are met. The WEP Phase II Report documented user preference flow ranges (minimum tolerable, lower acceptable, lower optimal, upper optimal, upper acceptable) for different types of angling including wade fishing, bank-fishing, and float fishing. They also documented user preference flows for and different types of whitewater recreation, including rafting, kayaking, tubing, and standup paddle boarding. WWG utilized the lower acceptable flows to investigate how often they are or are not met for rafting, tubing, wade-fishing and float fishing. Note that the other angling and whitewater activities listed in the WEP Phase II Report had flows the fell within the activities/flows WWG analyzed. Below is a summary of the flows for each activity from the WEP Phase II Report and the assumptions WWG made for the analysis.

- Wade Fishing

  - WEP Phase II Report, Lower Acceptable: 100 cfs
  - Assumed fishing could occur from March 1 to November 31. The WEP Phase II Report did document some winter fishing, however it was minimal.
- Float Fishing
  - WEP Phase II Report, Lower Acceptable: 300 cfs
  - Assumed fishing could occur from March 1 to November 31. The WEP Phase II report did document some winter fishing, however it was minimal.
- Tubing
  - WEP Phase II Report, Lower Acceptable: 30 cfs
  - Assumed Tubing could only occur from June through August. Tubing cannot occur till after the runoff, the air temperature needs to be warm enough, and there needs to be enough water to not get caught on the rocks on the bottom of the river.
- Rafting
  - WEP Phase II Report, Lower Acceptable: 250 cfs
  - Assumed Rafting could only occur from May through August. This assumption was based on information in the WEP Phase II Report and on rafting outfitters' websites. Note that in many years rafting currently cannot occur past June in the "Town Run" area due to low water conditions.

Table 2 documents the annual demand for each activity and the minimum, maximum and average shortages that have occurred from 1990 through 2021 at the San Juan River at Pagosa Springs stream gage. Figure 5 shows the annual shortage for each activity from 1990 through 2021

Table 2. Annual Demand and Maximum, Minimum, and Average Shortages for Recreational Angling and Whitewater Activities at the San Juan River at Pagosa Springs Stream Gage.

Activity Type	Annual Demand (AF)	Shortage (AF)		
		Minimum	Maximum	Average Annual
Wade Fishing	54,548	0	24,143	4,611
Float Fishing	163,645	9,351	126,483	54,468
Tubing	5,475	0	1,908	72
Rafting	60,995	0	46,099	11,751

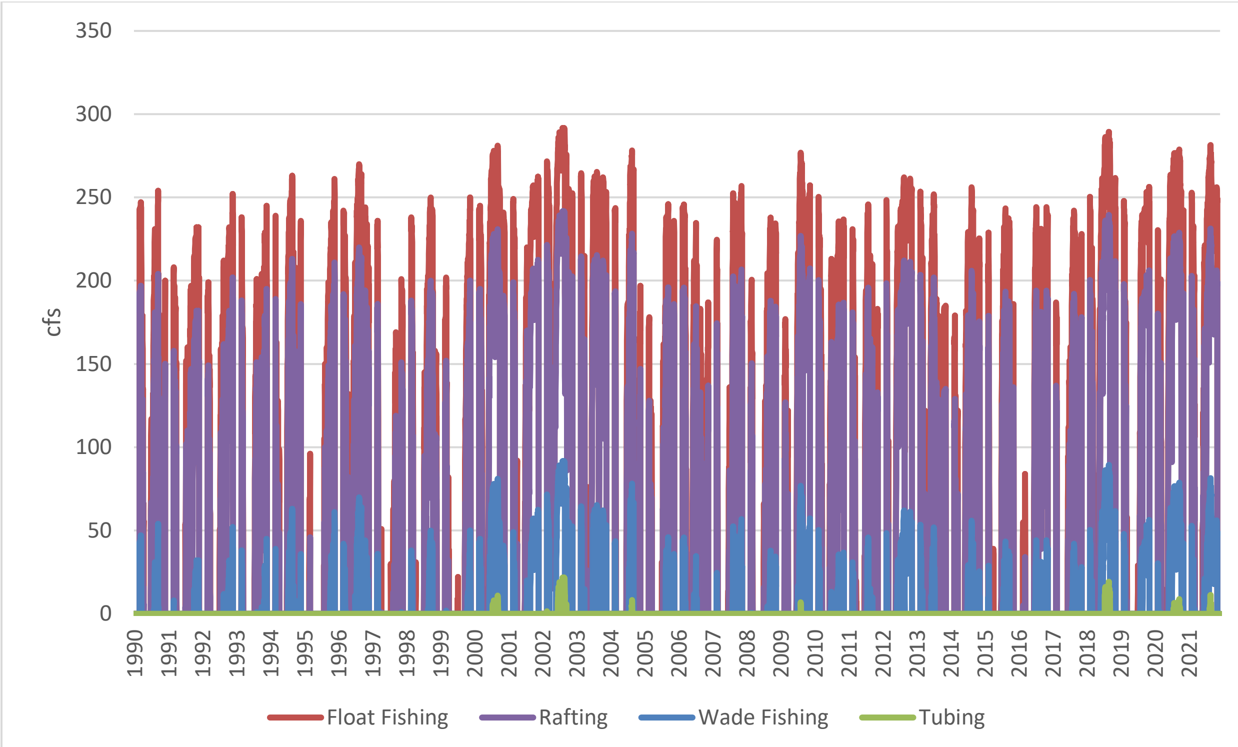

Figure 5. Daily San Juan River Recreational Flow Shortages 1990 through 2021

Float fishing has the highest demand and the highest shortages of the recreational activities in the WEP Phase II Report and tubing has the lowest demand and lowest shortages. The WEP Phase II Report noted that, even though the report utilized a focus group of local experts to develop the flow thresholds, whether a flow is suitable for fishing or floating is considered a matter of opinion and is dependent on skill level, knowledge, and other factors. Nevertheless, numbers from the report were used for this analysis.

Sediment Transport Target Flows

The WEP Phase II Report also documented optimum sediment transport characteristics for sites on the mainstem San Juan River. Aquatic habitats and nearshore ecosystems rely on sediment transport to provide nutrients and to create and/or maintain aquatic habitats. Too much sedimentation can be detrimental to habitats and severely alter a river, while too little sediment transport can lead to nutrient depletion. Table 9 in the WEP Phase II report provides flow management targets for transport thresholds and peak flow (effective discharge) events. The report states that transport flows should occur, on average, for 30 or more days each year and the peak flow events should occur for three-days at a frequency of roughly every two years. Table 3 shows the targeted flows for the San Juan River at Pagosa Springs.

Table 3. WEP Phase II Report Recommended Flow Targets for Sediment Transport

Location	Phase II Transport Threshold (cfs for minimum of 30 days/year)	Peak Flow - Effective Discharge (cfs for 3 days every 2 years)
San Juan River in Pagosa Springs	1,225	2,410

WWG identified how often the transport threshold and peak flow targets were met historically and how often a shortage occurred. Figure 6 shows the number of days each year that the transport threshold flow was met. Figure 7 shows daily streamflow from 1990 through 2021 and the peak flow effective discharge. Typically, when the peak flow reaches the target threshold it occurs for three days or more.

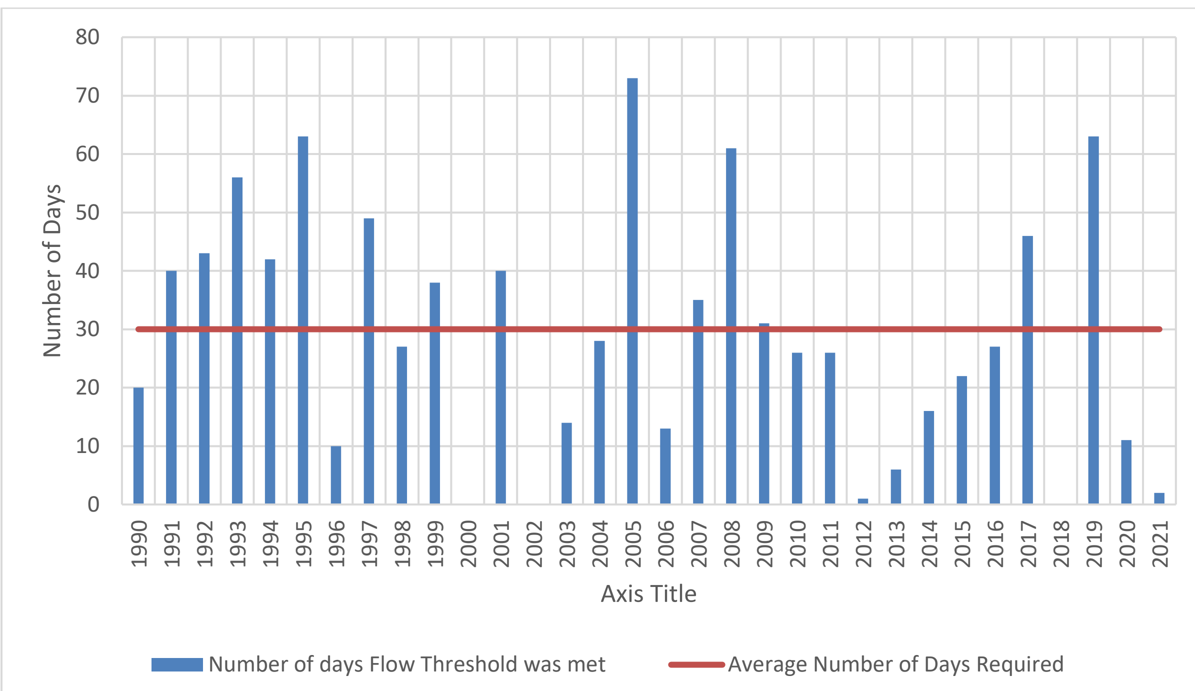

Figure 6. Number of Days Each Year that the WEP Phase II Transport Flow Threshold was Met 1990 through 2021

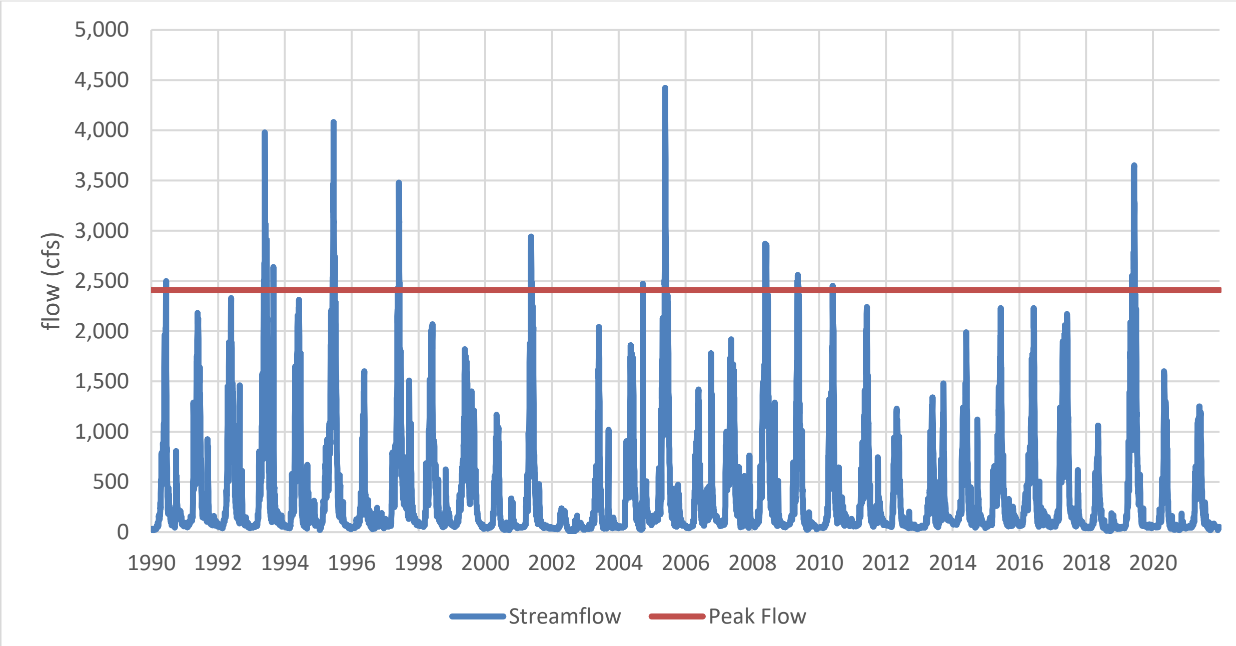

Figure 7. Daily Streamflow at the San Juan at Pagosa Springs and the Peak Flow (Effective Discharge) Target Flow 1990 through 2021

Both the transport flow and peak flow targets were met more frequently in the 1990s, corresponding to wetter hydrologic years. From 2010 through 2021, the flow targets have been met less frequently, corresponding to the recent "millennial drought". Table 4 shows the average annual shortages for both the transport flow threshold and the peak flow effective discharge target flow from 1990 to 2021.

Table 4. Phase II Transport Flow Threshold and Effective Discharge Annual Demand and Average Annual Shortage at the San Juan at Pagosa Springs Stream gage.

Flow Type	Annual Demand (AF)	Average Annual Shortage (AF)
Phase II Transport Flow Threshold	72,893	7,927
Peak Flow Effective Discharge*	14,340	910

*Note that the Peak Flow Effective Discharge only needs to be met roughly every two years.

Due to the wide range of flow needs from the WEP Phase II Report, WWG developed three scenarios to investigate environmental and recreational flow needs.

- Minimum – The minimum environmental and recreational demands are based on release to assure the mainstem instream flow at the San Juan River at Pagosa Springs stream gage is always met. This demand also would meet the demand for the lower acceptable range for tubing. This demand does not meet the lower acceptable demands for wade fishing, float fishing, or rafting. It also does not meet the Dry Gulch stipulated environmental flows or the sediment transport flows.

- Mid-Range – The middle environmental and recreational demand is based on meeting the Dry Gulch stipulated environmental flows and meeting the lower acceptable range for wade fishing from March to November. By meeting the lower acceptable range for wade fishing, it also meets the lower acceptable range for tubing and the instream flows.
- Maximum – The maximum environmental and recreational demand is based on meeting the maximum demand for all categories for each month. For December through February, the maximum demand is the stipulated environmental flows. In March, April, and July through November, the maximum demand is the lower acceptable flow for float fishing (300 cfs). The May and June maximum demand is the sediment transport demands (1,225 cfs for 30 days), assumed to be from May 16 to June 14.

Figure 8 shows the daily shortage of each of the three environmental and recreational demands, based on the streamflow at the San Juan River at Pagosa Springs stream gage. Table 5 summarizes the average annual shortages for the three demands.

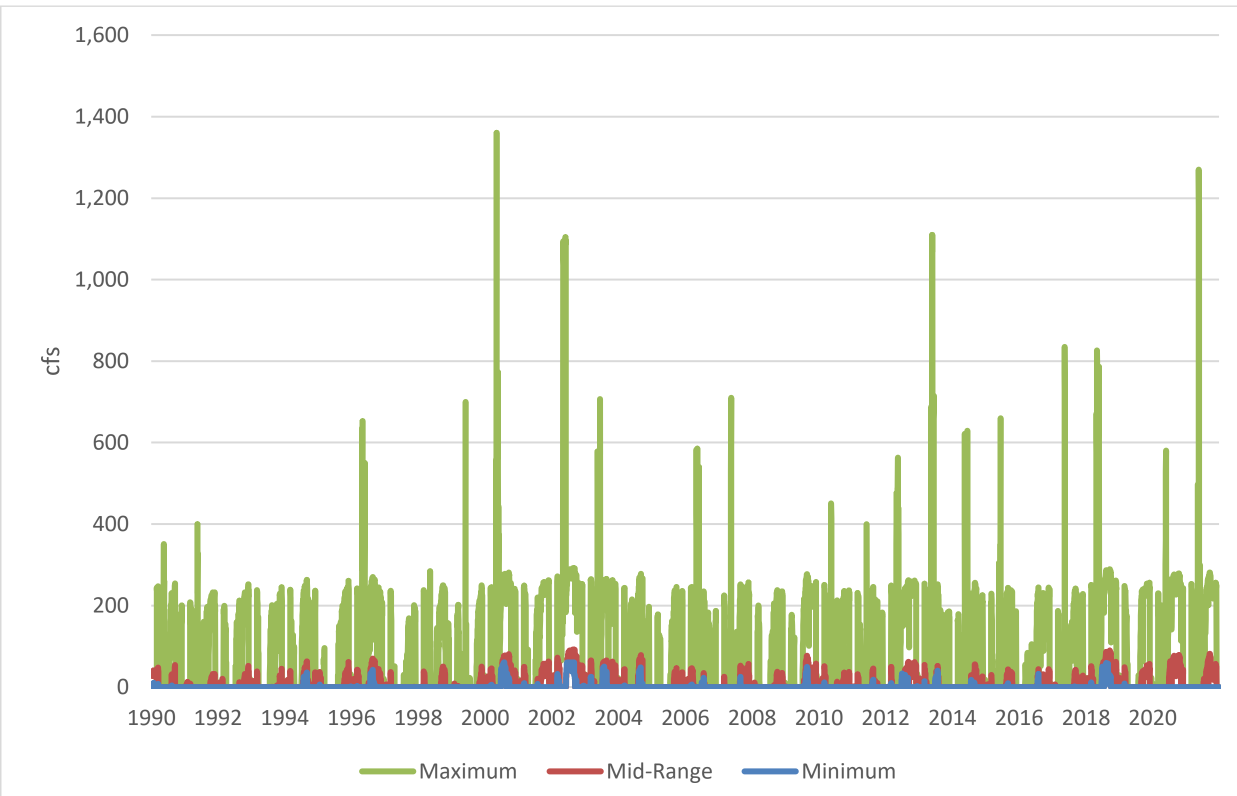

Figure 8. Range of Environmental and Recreational Shortages 1990 to 2021

Table 5. Average Annual Shortages for the Three Environmental and Recreational Demands

	Minimum	Mid-Range	Maximum
Average Annual Shortages	1,288	6,298	68,571

The shortages shown in Figure 8 and Table 5 range from 0 acre-feet to 185,705 acre-feet (2002) under the three scenarios.

Total Demands and Shortages

The estimated municipal, agricultural, and environmental and recreational demand above were combined to determine a projected range of 2050 demands. The range is presented based on Low, Medium, and High demands as follows:

- Low Demand – Low municipal growth, minimum environmental and recreational demands, and historical agricultural shortages.
- Mid-range Demand – Medium municipal growth, mid-range environmental and recreational demands, and historical agricultural shortages.
- High Demand – High municipal growth, high environmental and recreational demands, and historical agricultural shortages.

Figures 9, 10 and 11 show the estimated 2050 shortages for Low, Mid-range, and High demands and how they fluctuate based on historical climate and streamflow conditions. Note that because irrigation shortages were only available through 2019, the figures report shortages based on the hydrologic period 1990 through 2019.

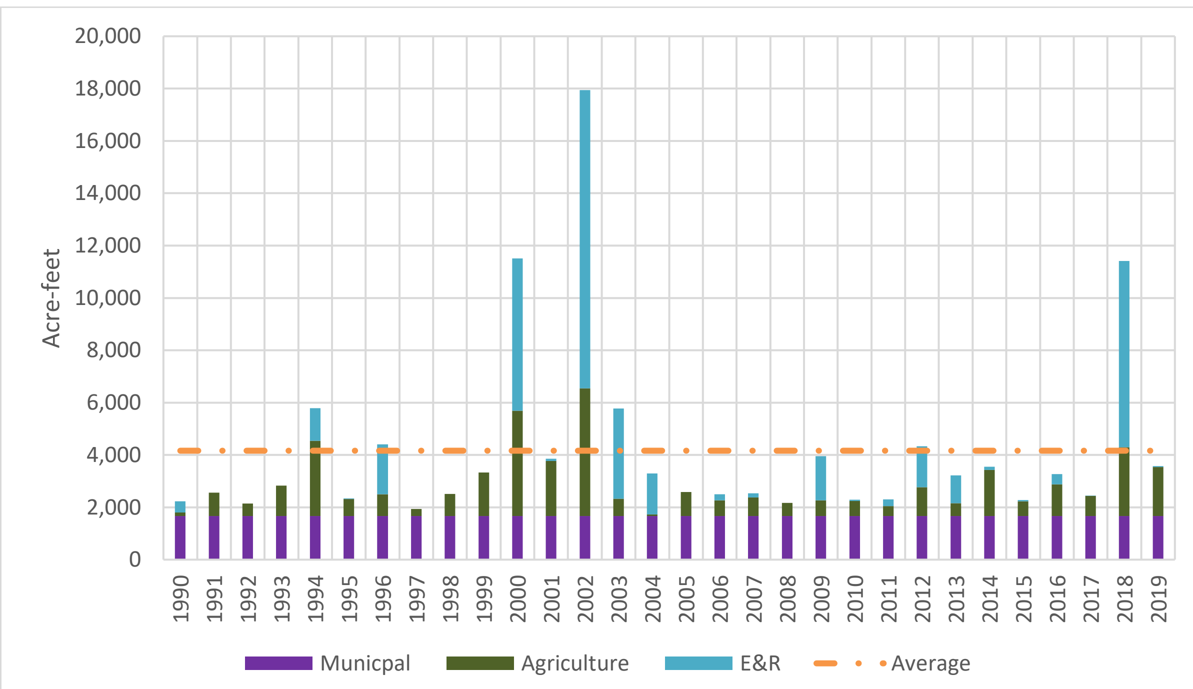

Figure 9. Low Demand Annual 2050 Projected Shortages

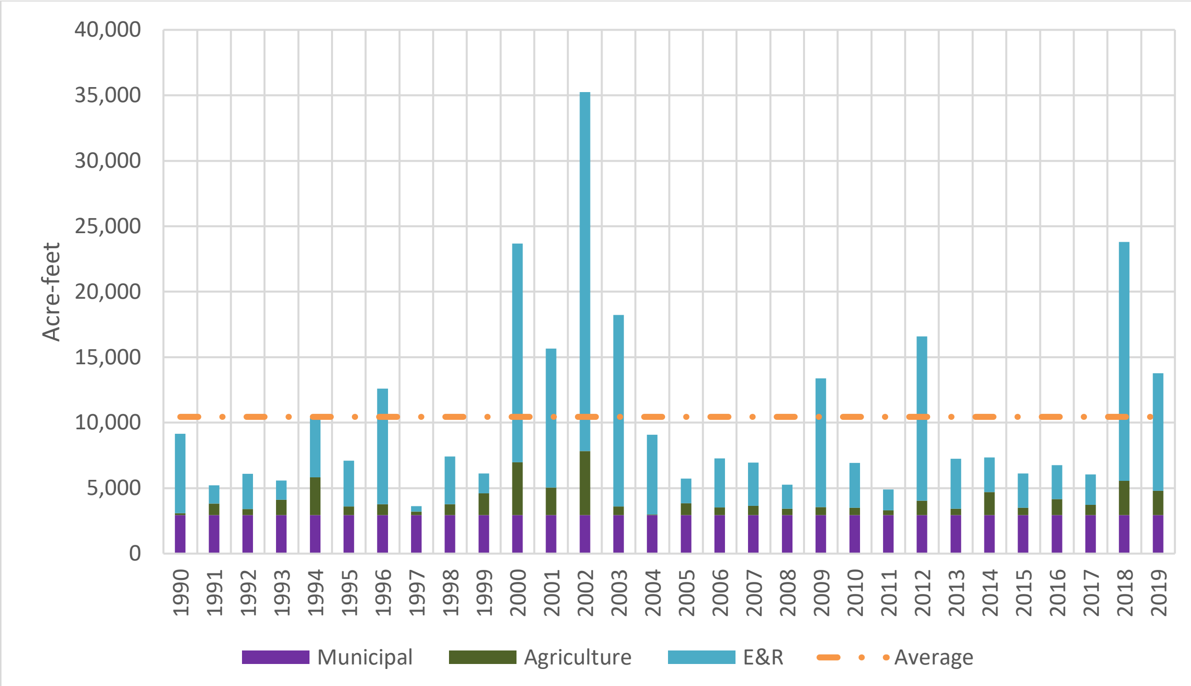

Figure 10. Mid-Range Demand Annual 2050 Projected Shortages

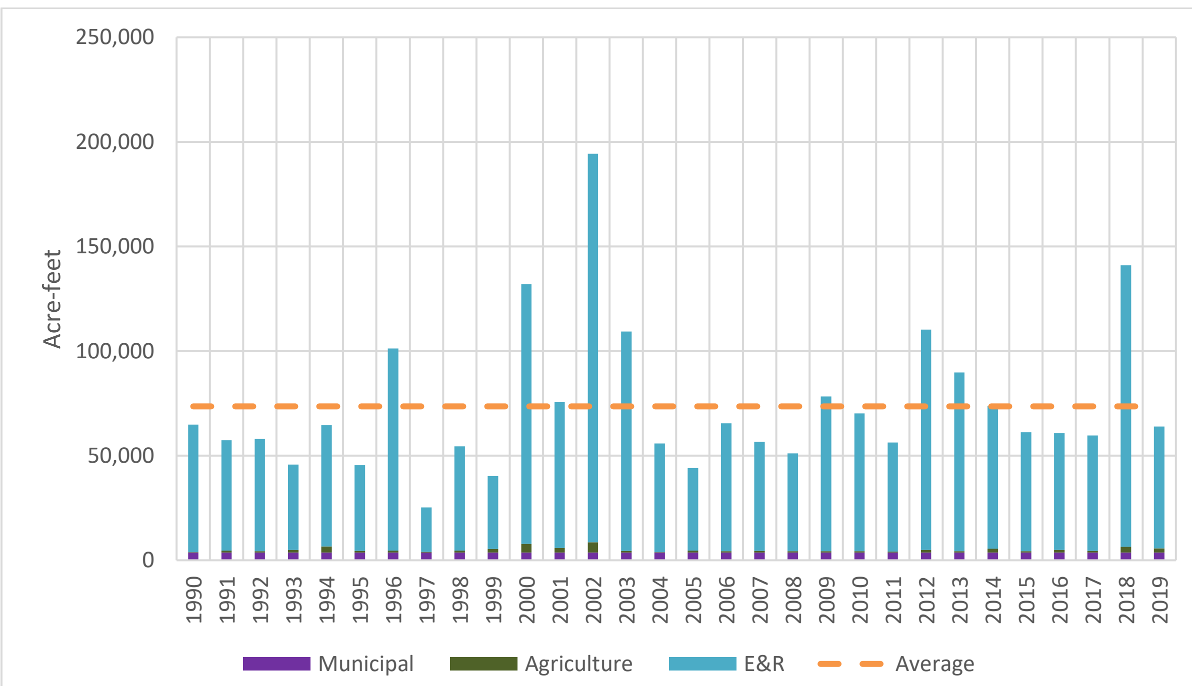

Figure 11. High Demand Annual 2050 Projected Shortages

Figures 9, 10 and 11 show an average annual future shortage that ranges from around 4,100 acre-feet to 73,000 acre-feet. The Upper San Juan basin could potentially meet potential shortages through a combination of new storage, expanding and/or improving existing reservoirs, improving the watershed health, temporary fallowing, or other alternatives. As noted above, the District is obligated by the restructured agreement with CWCB to continue investigating the SJRHP, and PAWSD is obligated to plan for future water demands to be first met with water from the SJRHP. Therefore, consideration of the SJRHP to meet projected shortages as included in the scope of this effort. The size of a reservoir depends both on the demand level and District's goals for meeting shortages. For example, the reservoir could be sized to meet the average of all shortages (average yield), to meet municipal shortages in all years (municipal yield), or to meet all shortages even in the driest years (firm yield).

Potential Reservoir Sizes

The limiting factors in reservoir sizing are the legally and physically available water to fill the reservoir, the 50 cfs filling constraint, and the demands driving reservoir releases. WWG did a water availability analysis to determine the potential range of reservoir sizes that would be needed to meet the range of projected shortages shown above. The water availability analysis assumed that water could be diverted into a reservoir at a maximum of 50 cfs based on the Dry Gulch Reservoir water right and that the Dry Gulch environmental flow stipulations had to be met when the reservoir was filling. The reservoir was assumed to be full at the start of the modeling period. The goals of the reservoir analysis were to meet municipal demands all years and to meet other shortages except in dry years. Table 6 provides the potential reservoir sizes based on the Low and Mid-Range Demand projected shortages. Note that because the annual High Demand shortages are greater than water available for filling (limited by 50 cfs), the reservoir inflow cannot keep up with the reservoir releases; therefore, a reservoir cannot meet the High demand shortages regardless of size.

Table 6. Potential Reservoir Sizes Based on the Projected Low and Mid-Range Annual 2050 Demand Shortages to Meet Municipal Shortages in all Years

	Low	**Mid-Range**
Potential Reservoir Size	1,600	10,000

Figures 12 and 13 show the projected reservoir daily content for the potential Low and Mid-Range Demand reservoir sizes.

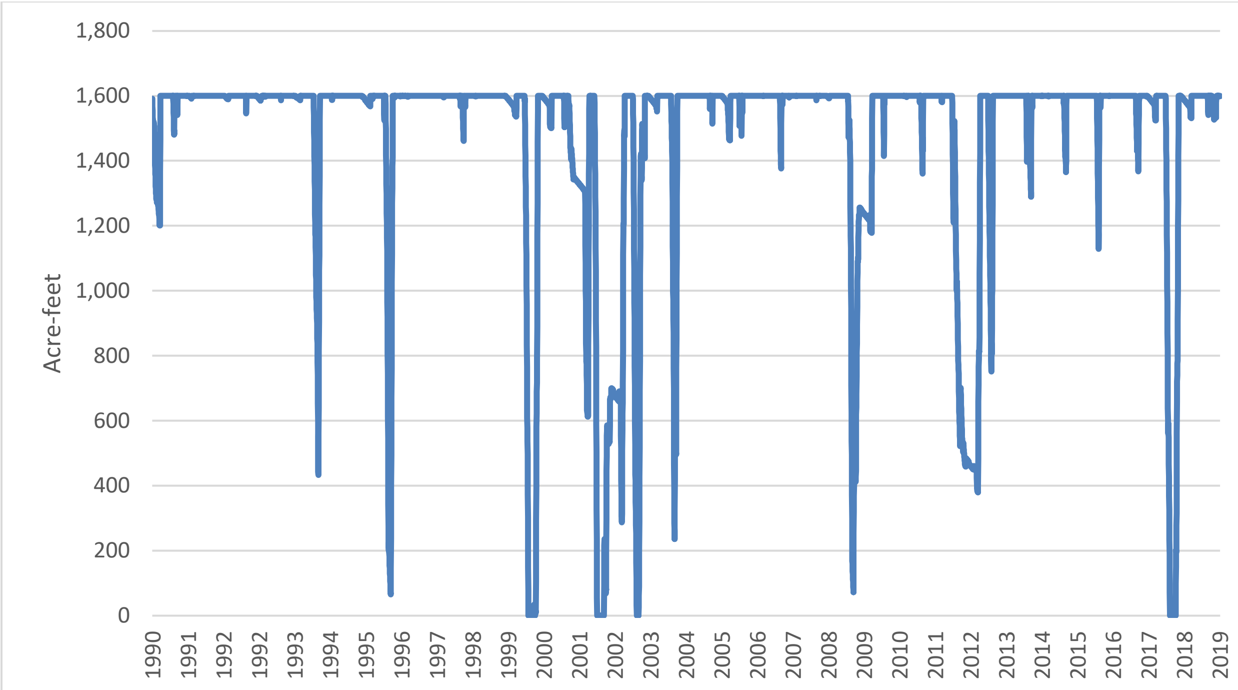

Figure 12. Reservoir Capacity over the Model Period for the Reservoir Meeting Low Demand Municipal Shortages (1,600 ac-ft)

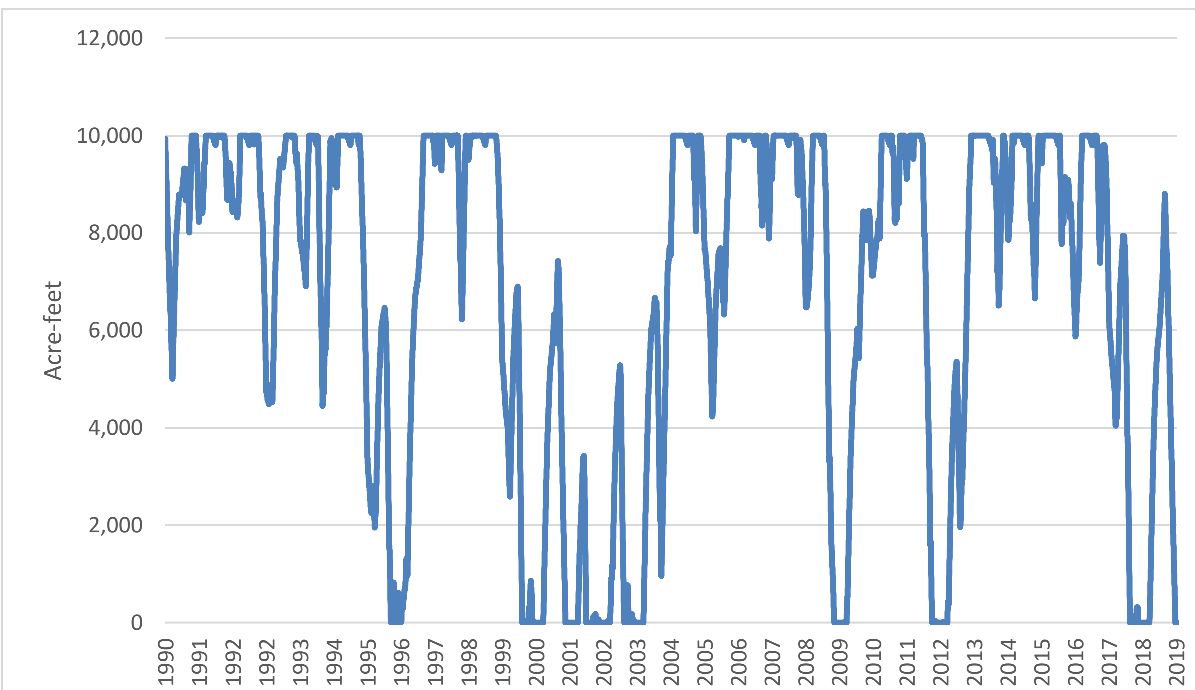

Figure 13. Reservoir Capacity over the Model Period for the Reservoir Meeting Mid-Range Demand Municipal Shortages (10,000 ac-ft)

Figure 12 shows that a low demand reservoir could meet low Demand shortages (instream flow, irrigation shortages, and municipal demands) except in significantly below average years (4 years out of 30 years). The mid-range reservoir (Figure 13) could meet municipal demand shortages in every year; but cannot meet shortages to all demands in below average years (11 years out of 30 years). If the District moves forward with reservoir options, there needs to be more discussion and coordination to determine the critical demands that should be met from reservoir storage.

Alternative Measures to Meet Projected Demands

A reservoir is the historically most common option to meet additional demands; however, there are other potential opportunities to improve streamflow to meet additional demand. Healthy ecosystems provide some natural water storage, and recent research has focused on ways to increase natural water storage. Improved natural water storage theoretically improves baseflows later in the summer after peak runoff. Brissette (2017) considered the effects of stream restoration as a tool to increase storage and baseflow discharge. The results from this study showed increased alluvial aquifer recharge and underflow in the restore reach, versus continued alluvial aquifer drainage in the degraded reach. Increased alluvial aquifer recharge could improve late season flows.

Another study (Goeking et al., 2020) considered the effects of forest health on water yield. Goeking et al. found that the hypothesis that forest cover loss results in more water due to decreased evapotranspiration may not be completely true as some studies have shown that forest disturbance can actually decrease snowpack and streamflow. The analysis suggests that healthier forests could lead to increased water yield.

Westbrook et. al (2006) looked at beaver ponds in small mountain streams and how they benefit the streamflow by keeping the water table elevation higher and reducing the rate at which the water table declines. This could have the effect of keeping late season stream flows higher.

Note that there has not been extensive research into these natural methods for maintaining higher streamflow, and information from the studies are often site-specific. Therefore, it is unclear how much additional streamflow would occur or be maintained within the District if there was increased effort at stream restoration, improved forest health, or introduction and protection of existing beaver habitats. However, researchers agree that these options would improve overall stream health.

Another potential option to meet shortages is through temporary voluntary agricultural fallowing. Temporary fallowing could benefit streamflow and meet other demands during drought years. For example, based on Colorado's publicly available San Juan StateCU model, the average annual crop consumptive use from 2000 through 2019 in Water District 29 was 1.05 acre-feet per acre. There is just over 5,000 irrigated acres in Water District 29 above Pagosa Springs based on Colorado's irrigated acreage assessment. If 25 percent of the acreage was temporarily fallowed, this could result in approximately 1,300 ac-ft of conserved consumptive use the year of fallowing that could be used to meet other demands. However, this fallowing may not be a permanent or reliable water source to meet future demands and depends on either a statewide or local program providing compensation to producers and producers who are willing to participate.

Currently, a multi-year field research project near Kremmling, Colorado is investigating the effects of temporary fallowing of perennial grass fields on both streamflow and producer hay yield in the year of fallowing and subsequent years. This study supplements several fallowing investigations performed by Dr. Joe Brummer and Dr. Perry Cabot with Colorado State University over the past 10 to 15 years. Those studies include fallowing of grass fields near Steamboat Springs, Kremmling, Gunnison, Montrose, Cimarron, and Orchard Mesa.

The combined studies indicate that some high-productive grass hay fields were able to recover from fallowing by the next year; however, many fields, especially low-productive fields, did not return to full crop yield for up to three years. Dr. Cabot, who is leading the Kremmling project research team, believes that recovery of the fallowed fields could be site specific and dependent on the type of grass and the soil profile. Understanding how temporary fallowing affects the following year yield is important for farmers and ranchers to weigh the risks when participating in a temporary fallowing program. Note that the investigation is still on-going and a final report for the Kremmling project is not yet available. However, Dr. Cabot did indicate that if the District is interested in considering fallowing as an option to meet demands in dryer years, site specific field conditions and soil information is critical to understanding both potential consumptive use savings, and potential extended year impacts to crop yield.

WWG recommends that the District continue to monitor results of research in these areas, as they may provide alternatives to reservoir storage to help the District meet demands in the future.

Future Water Needs from the Technical Update to the Water Plan

The Colorado Water Plan considered five water supply and demand scenarios for projected year-2050 that incorporated population change, agricultural water needs, potential conservation measures, social values, and climate conditions. The five scenarios are the basis of the analyses and modeling completed for the Technical Update to the Water Plan. The results from the Technical Update are included in this analysis as another potential scenario for 2050 water use in the District boundary. This analysis includes results from three of the five scenarios that bracket the Technical Update demand and supply potential futures:

1. Business as Usual
2. Cooperative Growth
3. Adaptive Innovation

Figure 12 graphically shows and compares the scenarios and key drivers.

Figure 14. Graphical Explanation Selected Colorado Water Plan scenarios

Technical Update Municipal Demands

Municipal water use demands were estimated from the Technical Update documentation by using the population and GPCD estimates for Archuleta County. Archuleta County population was reduced by 25 percent because PAWSD serves approximately 75 percent of Archuleta County. The reduced population and the GPCD were used to estimate current and 2050 demands in the PAWSD service area. Table 6 shows the population, GPCD, and demand estimates for the PAWSD service area for current (year 2015 for the Technical Update analysis) and 2050 conditions for the three scenarios.

Table 7. Technical Update 2015 and 2050 estimates for Population, GPCD, and Municipal Demand in the PAWSD Service Area

	Current (2015)	Business As Usual	Cooperative Growth	Hot Growth
Population	9,313	19,928	18,857	28,711
GPCD	220	197	189	216
Demand (AFY)	2,295	4,398	3,992	6,947

As shown, the Technical Update demand for 2015 is slightly lower than the current (2022) municipal demand estimate discussed above, reflecting increased municipal use from 2015 to 2022. The GPCD number used in the Technical Update is slightly lower than PAWSD's estimates shown in Table 1 (220 compared to 226). The Hot Growth scenario population is greater than the 2050 population estimates shown in Table 1; while the Business As Usual and Cooperative Growth scenarios are within the range of the population projects used by WWG.

Technical Update Agricultural Demands

The Technical Update agricultural water demands include a regional assessment of irrigated acreage lost due to urbanization; all scenarios assumed that 3,800 acres removed for the southwest region. The Technical Update documentation did not report how much of that acreage was due to urbanization around Pagosa Springs. However, based on Pagosa Springs current population compared to other towns in the southwest region it was estimated that roughly 20 percent (760 acres) could be removed around Pagosa Springs. The Technical Update also assumed that in Cooperative Growth and Hot Growth scenarios, crop demands increased due to warming climate. Table 7 shows the estimated agricultural demand and shortages from the Technical Update within the District. Cooperative Growth crop demands increased by 38 percent and Hot Growth crop demands increased by 47 percent; however, due to projected decreases in runoff, shortages increased from Business as Usual by a factor of 3.2 and 3.6 respectively.

Table 8. Technical Update Agricultural Demands and Shortages within the District

	Business As Usual	**Cooperative Growth**	**Hot Growth**
Total Demand	15,000	20,800	22,100
Total Shortage	1,120	3,600	4,100

Technical Update Environmental Demands

The Technical Update did not estimate environmental and recreational demand or supply outside of decreed instream flows; whereas WWG incorporated WEP Phase II Report environmental demands into the historical hydrology-based analysis above. WWG estimated the shortages to the instream flow based on the streamflow estimates at the San Juan River at Pagosa Springs stream gage from the Technical Update documentation. Note that the Technical Update streamflow is on a monthly time step, whereas WWG's analysis was done on a daily time step for environmental and recreational demands.

Table 9. Instream Flow Average Annual Demand and Shortages based on Streamflow from the Technical Update

Instream	**Demand (AF)**	**Shortages (AF)**		
		Business As Usual	Cooperative Growth	Hot Growth
Mainstem San Juan River	29,018	114	825	1,457

Total Demands and Shortages

Based on the information in the Technical Update, WWG developed projected 2050 annual demands from the three scenarios. Figures 16 to 18 show the Technical Updates estimated the projected 2050 annual demand shortages for municipal, agriculture and environmental and recreation for the three different scenarios.

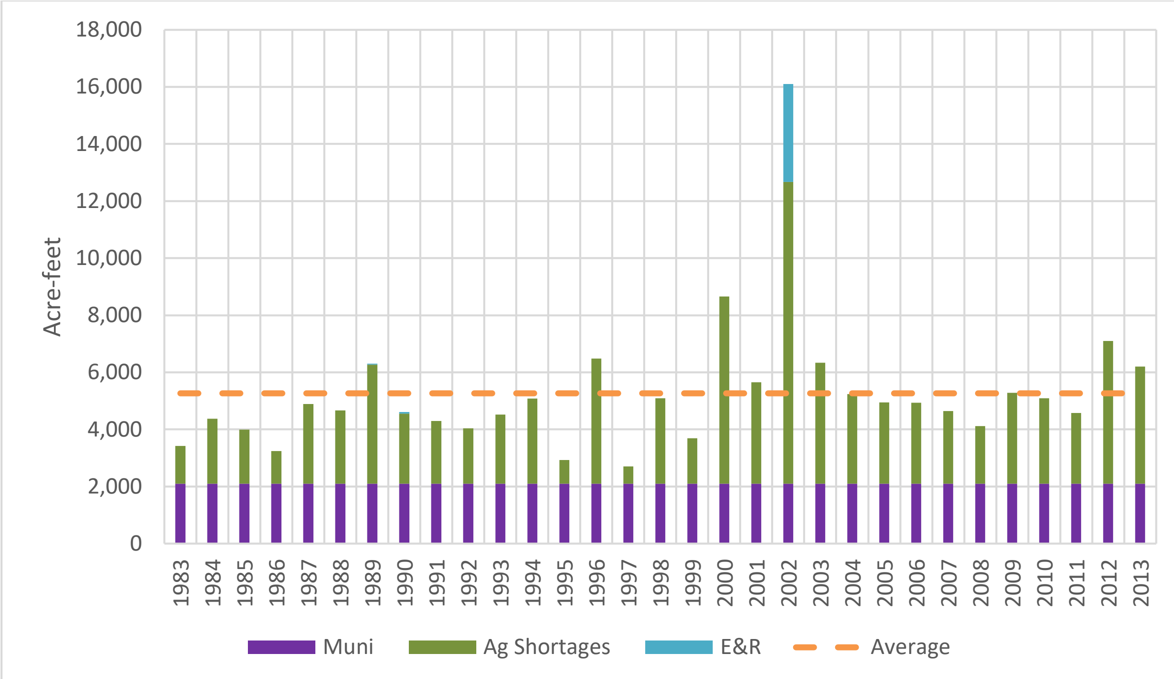

Figure 15. 2050 projected Annual Shortages for Business-as-Usual Scenario

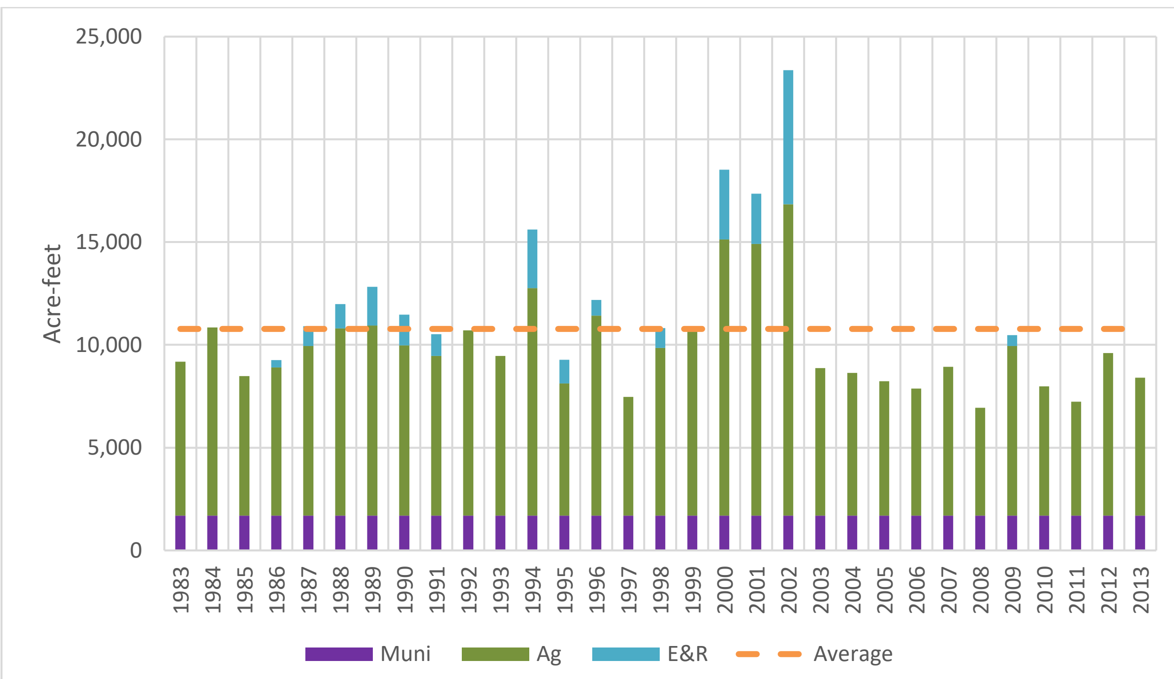

Figure 16. 2050 projected Annual Shortages for Cooperative Growth Scenario

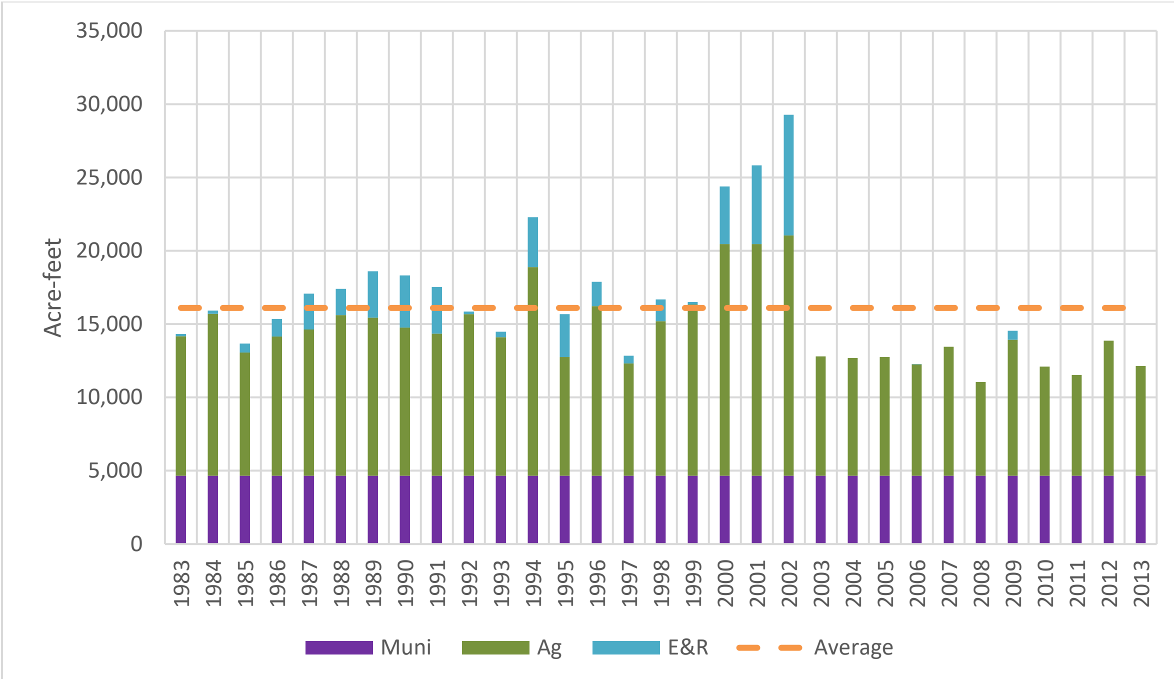

Figure 17. 2050 projected Annual Shortages for Hot Growth

The average annual demands shown in Figures 16 through 18 range from around 5,200 (Business-As-Usual) to 16,100 ac-ft (Hot Growth). The Technical Update was completed on a monthly time-step and did not consider the full range of environmental and recreational shortages included in the WEP Phase II Study. Therefore, reservoir sizing was not considered for the Technical Update Scenarios.

Summary

The following summarizes observations from the San Juan demand and water availability analysis.

- Municipal demands could more than double if the pace of population growth in PAWSD's area continues at current rates.
- Under historical climate conditions, agricultural demands are not expected to increase and may actually decrease due to urbanization.
- The WEP Phase II report provided target flows for environmental and recreational needs, which provide a wide range of demands. Meeting all the environmental and recreational target flows in the WEP Phase II Report, even with new storage, is not feasible as water available for storage during runoff would be significantly limited by the target flows.
- The range of target flows reported in the WEP Phase II Report could allow the District to work with the town of Pagosa Springs to identify environmental and recreational flow targets that would benefit both tourism and the environment.
- Reservoir sizing is dependent on the demands determined to be critical by the District. For example, a 3,000 acre-feet reservoir would meet all future municipal demand shortages (Low, Mid-Range, and High). A 10,000 acre-feet reservoir would meet future

municipal and mid-range agricultural and environmental demands in all years except very dry years. There is no feasible reservoir to meet the full High Demand shortages.
- The two largest concerns affecting current and future water uses are earlier runoff and the potential for a catastrophic fire. Having storage to help capture earlier runoff could continue to be important in the future and additional storage could provide redundancy and help mitigate the effects of a fire.
- Other alternatives including stream restoration, fallowing, and forest health have the potential to improve streamflow and the District should continue to monitor on-going projects to see how the results could be applicable in the Upper San Juan basin.
- The Technical Update results show that the selected climate change scenarios, along with growth in and around Pagosa Springs, result in larger potential consumptive demands and associated shortages.

References

Brissette, Christine M. (2017) Stream restoration effects on hydraulic exchange, storage and alluvial aquifer discharge, Graduate Student Theses, Dissertations, and Professional Papers. 109992. https://scholarworks.umt.edu/etd/10992

Goeking, S. A., Tarboton, D. G. (2020) Forests and Water Yield: A Synthesis of Disturbance Effects on Streamflow and Snowpack in Western Coniferous Forests, *Journal of Forestry*, Volume 118, Issue 2, Pages 172–192, https://doi.org/10.1093/jofore/fvz069

Personal Communication, James Dickhoff, Community Development Director, Town of Pagosa Springs

Personal Communication, Justin Ramsey, General Manager, Pagosa Springs Water and Sanitation District

Personal Communication, Pam Flowers, Community Development Director, Archuleta County

Personal Communication, Dr. Perry Cabot, Research Scientist, Colorado State University Agricultural Extension

Westbrook, C. J., Cooper, D. J., and Baker, B. W. (2006), Beaver dams and overbank floods influence groundwater–surface water interactions of a Rocky Mountain riparian area*, Water Resource*. Res., 42, W06404, doi:10.1029/2005WR004560.

Appendix B

Inflow Hydrology Memorandum

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MEMORANDUM

DATE: 12/15/2025

TO: Eric Hahn, RJH Consultants, Inc.
Robert Huzjak, RJH Consultants, Inc.

FROM: Rifka Wine, PE, CFM
Kevin Gilbert, EI

SUBJECT: **San Juan Water Conservancy District Headwaters Dam Inflow Hydrology**

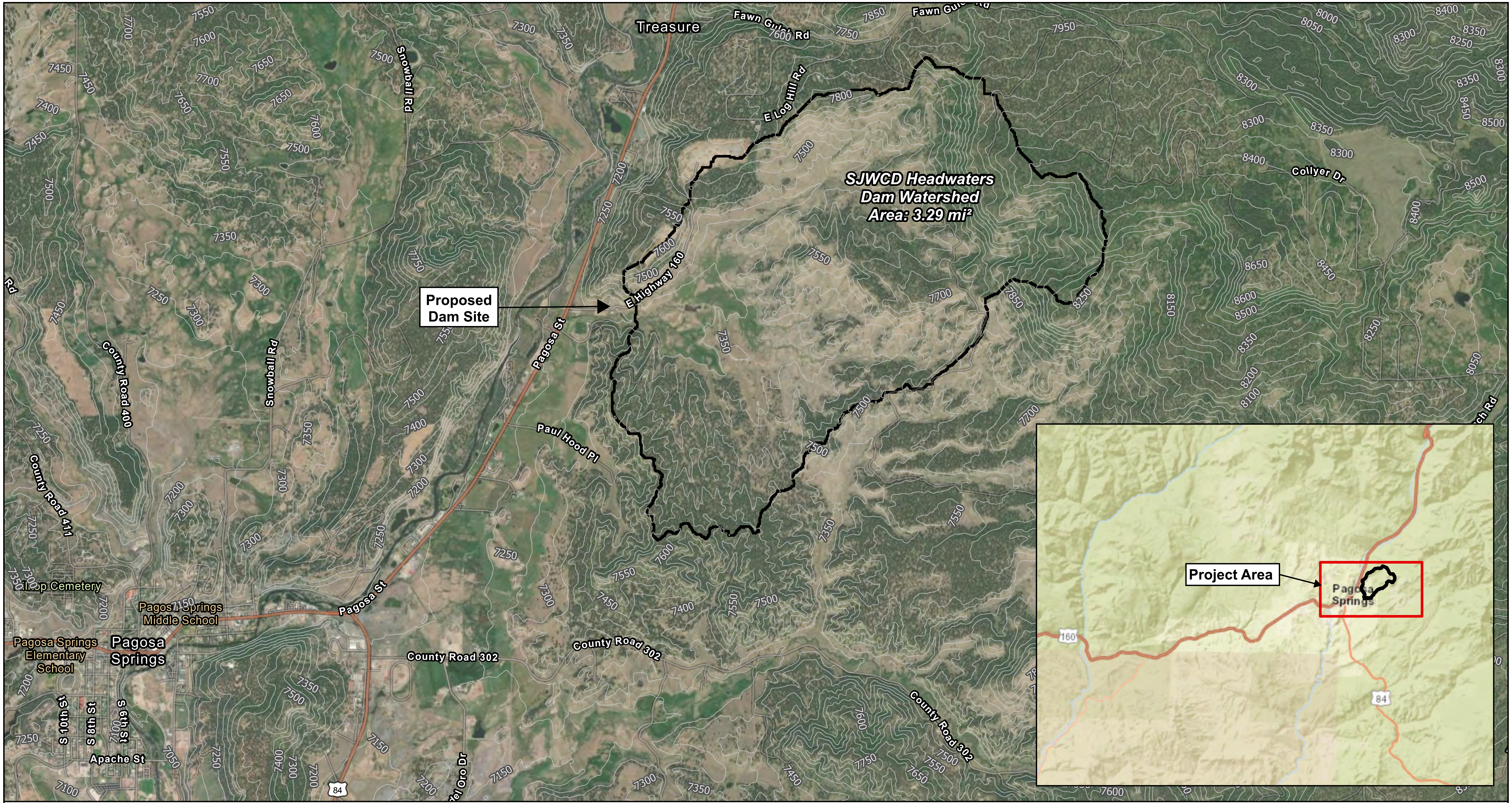
INTRODUCTION

The San Juan Water Conservancy District (SJWCD), established in 1987, commissioned an alternatives analysis in 1989 to evaluate potential reservoir sites for meeting future water demands. In 2007, SJWCD and the Pagosa Area Water & Sanitation District (PAWSD) jointly purchased land in the Dry Gulch area near Highway 160 east of Pagosa Springs for the proposed San Juan Headwaters Project. The project includes developing an 11,000-acre-foot reservoir, and SJWCD has contracted with RJH Consultants, Inc. (RJH) to conduct a project feasibility study.

Bohannan Huston, Inc. (BHI), has teamed with RJH to determine the inflow hydrology to support the study and eventual funding application through the United States Bureau of Reclamation Small Storage Program Grant (SSG). This memorandum summarizes the hydrologic analysis for the watershed, conducted in accordance with guidance from Colorado Dam Safety (CDS), administered by the Colorado Department of Natural Resources (DNR), Division of Water Resources, Office of the State Engineer.

HYDROLOGIC ANALYSIS

CDS provides several guidance documents for hydrologic and hydraulic analysis of dams, and although this feasibility study will not be submitted for official review, the 11,000 acre-ft dam will be jurisdictional, and future design will be subject to approval from CDS. **Figure 1** shows the watershed and its geographic setting near Pagosa Springs.



Watershed Boundary

50' Contour

N

0 1,250 2,500 5,000 Feet

1 in. = 2,500 ft.

SJWCD Headwaters
Project Dam Inflow Hydrology

Figure 1
Vicinity Map

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Author: mcrooks

December 2025

Regional Extreme Precipitation Study

Referencing CDS's *Guidelines for Hydrological Modeling and Flood Analysis* (*Hydrologic Guidelines)* (2022), the first step in the analysis is the Hydrologic Dam Failure Consequence Estimation. Due to the size of the proposed reservoir and location of Pagosa Springs downstream, loss of life in the event of dam failure can be assumed, and a presumptive Extreme Hydrologic Hazard Classification can be made. According to Rule 7.2 of the *Rules and Regulations for Dam Safety and Dam Construction* (*Rules)* (effective January 1, 2020), it is required that the Inflow Design Flood (IDF) shall be sized to safely route a flood generated by the Critical Rainfall that occurs during the Probable Maximum Precipitation (PMP).

To determine the PMP, CDS provides the *Guidelines for the Use of Regional Extreme Precipitation Study (REPS) Rainfall Estimation Tools* (2024), which instructs the process to use the online REPS PMP Web Tool. A preliminary watershed, delineated from StreamStats, was uploaded to the website to gather precipitation data. The REPS PMP Web Tool then determines Temporal Distributions for four different storm types and durations: the 2-hour local storm (LS), the 6-hour LS, the 72-hour General Storm (GS), and the 72-hour Tropical Storm (TS). This precipitation data is included in **Attachment A**.

Rainfall-Runoff Modeling

Hydrologic modeling was performed in the U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) using the Colorado State University-Soil Moisture Accounting (CSU-SMA) method. This method can accurately reproduce extreme flood production mechanisms by accounting for infiltration excess runoff, saturation excess runoff, and subsurface lateral flow. It also employs the use of the Clark Unit Hydrograph (UH) method in HEC-HMS for rainfall-runoff transformation, which is applicable for undeveloped basins in Colorado such as this project's watershed.

Input Data

Before calculating the various CSU-SMA parameters, input data needed to be downloaded from a multitude of sources. Terrain data was downloaded from The National Map at a 10-meter resolution, recommended by the *Hydrologic Guidelines* (CDS, 2022). Landsat red and infrared band images were downloaded from the United State Geological Survey (USGS), dated September 2011. Lastly, soil property raster data sets were provided by the CO DNR, originally sourced from the Natural Resources Conservation Service (NRCS). These rasters included percent clay, percent sand, percent organic matter, and depth to restrictive layer.

CSU-SMA Parameter Calculations

The Fractional Vegetative Cover (Fg) was calculated by first determining the Normalized Difference Vegetation Index (NDVI) based on Section 5.1 of the *Hydrologic Guidelines* (CDS, 2022) and then designating location-specific numerical estimates for forested vegetation and bare soil locations.

Next, the terrain data was added to the HEC-HMS model, and a refined drainage basin was delineated from the approximate location of the proposed embankment. According to the scope of the project, the subbasins were merged into one, simplified basin from which Clark-UH parameters such as longest flow path could be directly extracted from HEC-HMS.

Following the delineation of the watershed, the basin specific soil and vegetation properties were determined. CDS provides a CSU-SMA python ArcToolbox that runs a script that clips those properties to the basin area and calculates additional SMA parameters. **Table 1** below summarizes the results of these calculations, and additional information is included in **Attachment B**.

Table 1 – Hydrologic Parameters

	Parameter	Value
SMA Loss	Soil (%)	60.17
	GW1 (%)	0
	GW2 (%)	0
	Max Infiltration (in/hr)	0.34
	Impervious (%)	0.05
	Soil Storage (in)	2.82
	Tension Storage(in)	1.89
	Soil Percolation (in/hr)	0.02
	GW 1 Storage (in)	0.31
	GW1 Percolation (in/hr)	0.10
	GW1 Coefficient (hr)	16.69
	GW2 Storage (in)	0
	GW2 Percolation (in/hr)	0
	GW2 Coefficient (hr)	0
Clark UH	Time of Concentration, Tc (hr)	1.39
	Storage Coefficient, R (hr)	5.56

HEC-HMS Modeling

In addition to the calculated parameters above, additional recommended parameters are provided by CDS in Table 6 of the *Hydrologic Guidelines* (2022). These include various calculation methods within HEC-HMS and set values such as annual evapotranspiration. Precipitation data, determined from the REPS step, was entered into precipitation gages and meteorological models for each storm type to determine the controlling storm. The HEC-HMS model results are included as **Attachment C** and summarized below in **Table 2**. As shown, the 2-hour local storm produces the largest peak discharge and would result in the most conservatively sized emergency spillway.

Table 2 – HEC-HMS Model Results

PMP Storm	Peak Discharge (cfs)	Volume (ac-ft)
2-hr LS	2,859	1,657
6-hr LS	2,269	1,602
72-hr GS	926	1,470
72-hr TS	1,056	2,028

Reasonableness and Confidence

CDS presents two concepts when reviewing the results of hydrologic models: reasonableness and confidence. Reasonableness refers to the consistency of modeled flood-frequency outputs of flood peaks and volumes with site-specific or regional flood-frequency statistics for hydrologically similar watersheds. Confidence is built through the reasonableness checks process and can also be increased through model calibration by altering set parameters such as the Clark UH storage coefficient parameter (R). However, model calibration is not in the scope of the project during the feasibility study. Various pathways for calibration to build confidence have been documented by BHI and can be explored in the future to build confidence. They include:

- Adjusting the Fg raster to correlate with the seasonality of the storm
- Manipulating the $NDVI_0$ and $NDVI_{inf}$ variables
- Manipulating the R value to effect a different GW1 Coefficient
- Running a second set of models using the Muskingum-Cunge transform
- Running smaller AEP events to compare against available data

The reasonableness check employed in this phase was a comparison of the modeled results to the Regional Peak Flow Envelope Curve & USGS Colorado Flood Database. CDS provides a peak flow envelope curve spreadsheet specific to each REPS storm transposition zone, with this project falling in Zone 10. Plotting the HEC-HMS results on this curve shows that the two LS events are very near the CDS Envelope, but the GS and TS are lower than the 90% confidence bounds (See **Figure 2**).

CONCLUSIONS

The reasonableness check against the peak flow envelope curve confirms that the 2-hour LS is reasonable, but this can be stated with little confidence due to the lack of model calibration. Local Storms are typically the controlling storm for this region and since they provide the highest peak flows, they can be used to conservatively size the emergency spillway for the feasibility study. The emergency spillway for the SJWCD Headwaters Dam should convey the entirety of the 2,859 cfs of discharge from the 2-hour LS, although the Normal and Residual freeboard requirements cannot be determined until the preliminary reservoir geometry is provided.

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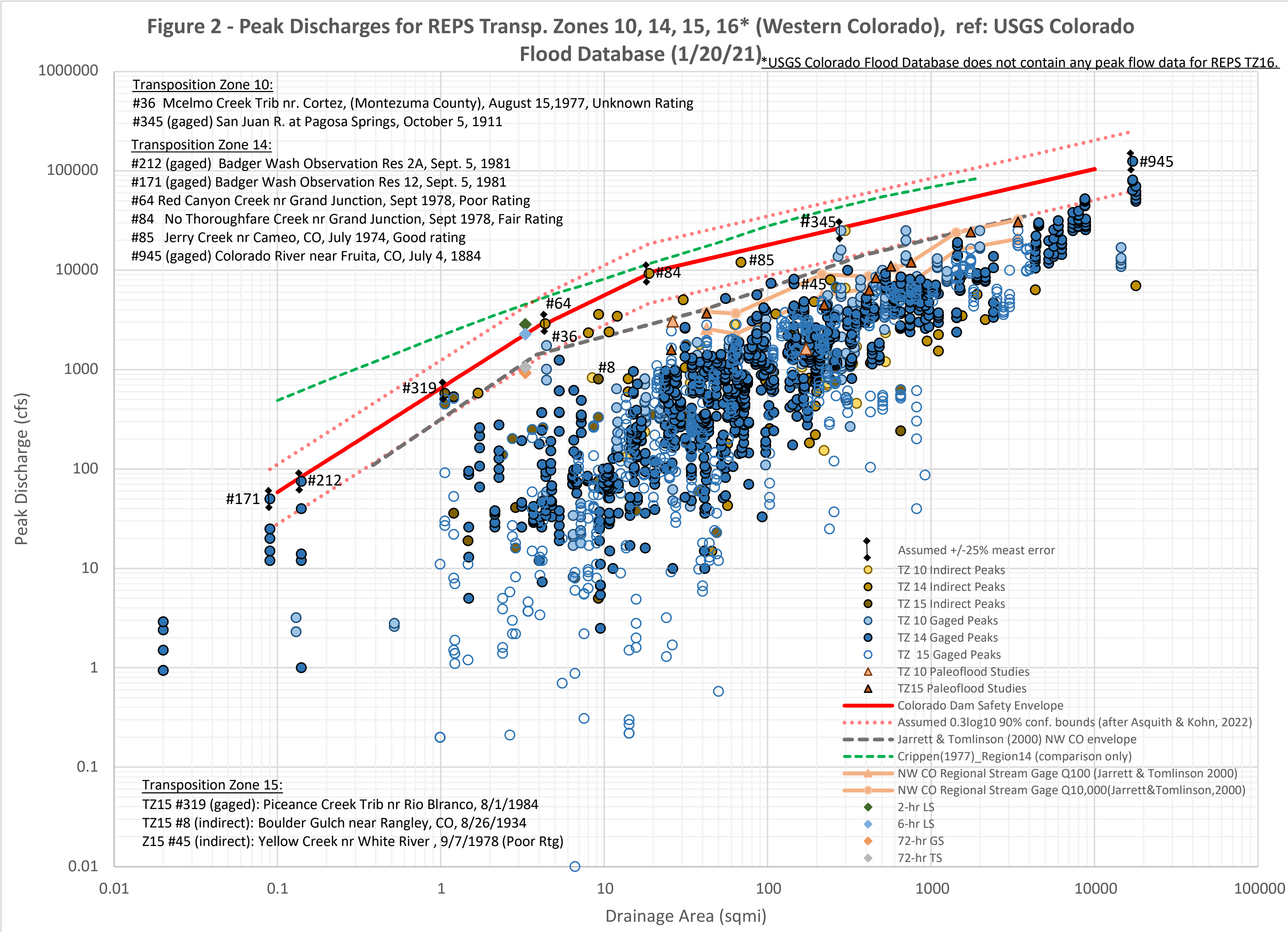


Figure 2 - Peak Discharges for REPS Transp. Zones 10, 14, 15, 16* (Western Colorado), ref: USGS Colorado Flood Database (1/20/21)
*USGS Colorado Flood Database does not contain any peak flow data for REPS TZ16.
Transposition Zone 10:
#36 Mcelmo Creek Trib nr. Cortez, (Montezuma County), August 15,1977, Unknown Rating
#345 (gaged) San Juan R. at Pagosa Springs, October 5, 1911
Transposition Zone 14:
#212 (gaged) Badger Wash Observation Res 2A, Sept. 5, 1981
#171 (gaged) Badger Wash Observation Res 12, Sept. 5, 1981
#64 Red Canyon Creek nr Grand Junction, Sept 1978, Poor Rating
#84 No Thoroughfare Creek nr Grand Junction, Sept 1978, Fair Rating
#85 Jerry Creek nr Cameo, CO, July 1974, Good rating
#945 (gaged) Colorado River near Fruita, CO, July 4, 1884
Transposition Zone 15:
TZ15 #319 (gaged): Piceance Creek Trib nr Rio Blranco, 8/1/1984
TZ15 #8 (indirect): Boulder Gulch near Rangley, CO, 8/26/1934
Z15 #45 (indirect): Yellow Creek nr White River , 9/7/1978 (Poor Rtg)
Peak Discharge (cfs)
Drainage Area (sqmi)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.01
0.1
1
10
100
1000
10000
100000
#945
#345
#85
#84
#45
#64
#36
#8
#319
#212
#171
Assumed +/-25% meast error
TZ 10 Indirect Peaks
TZ 14 Indirect Peaks
TZ 15 Indirect Peaks
TZ 10 Gaged Peaks
TZ 14 Gaged Peaks
TZ 15 Gaged Peaks
TZ 10 Paleoflood Studies
TZ15 Paleoflood Studies
Colorado Dam Safety Envelope
Assumed 0.3log10 90% conf. bounds (after Asquith & Kohn, 2022)
Jarrett & Tomlinson (2000) NW CO envelope
Crippen(1977)_Region14 (comparison only)
NW CO Regional Stream Gage Q100 (Jarrett & Tomlinson 2000)
NW CO Regional Stream Gage Q10,000(Jarrett&Tomlinson,2000)
2-hr LS
6-hr LS
72-hr GS
72-hr TS

REFERENCES

Colorado Dam Safety Branch. (Revised 2022). *Guidelines for Hydrologic Modeling and Flood Analysis.* https://dnrweblink.state.co.us/dwr/ElectronicFile.aspx?docid=3895759&dbid=0

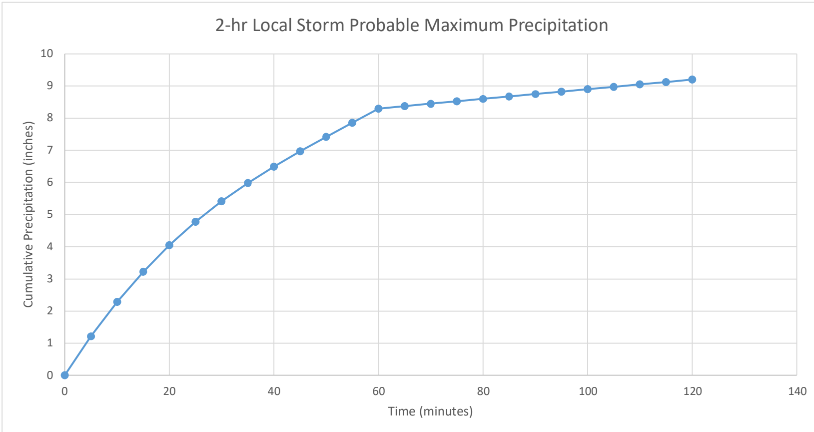
Colorado Dam Safety Branch. (Revised 2024). *Use of Regional Extreme Precipitation Study (REPS) Rainfall Estimation Tools*. https://dnrweblink.state.co.us/dwr/ElectronicFile.aspx?docid=3566813&dbid=0

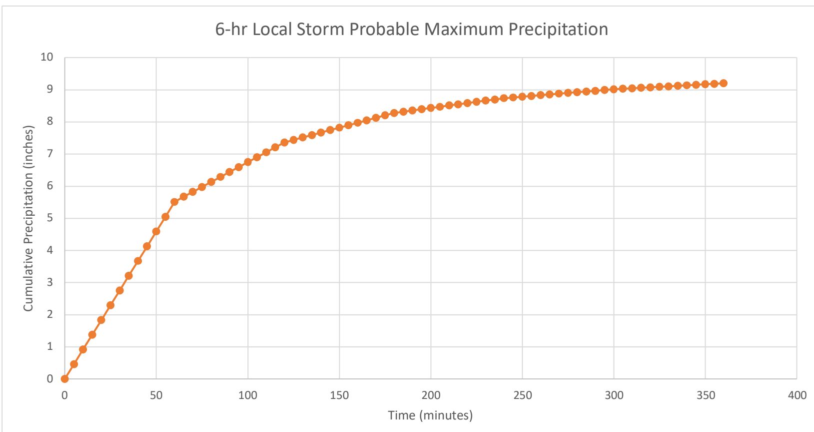
Colorado Department of Natural Resources. Division of Water Resources. (2020). *Rules and Regulations for Dam Safety and Dam Construction*. Code of Colorado Regulations, Rule 2 CCR 402-1. https://dnrweblink.state.co.us/dwr/ElectronicFile.aspx?docid=3552784&dbid=0

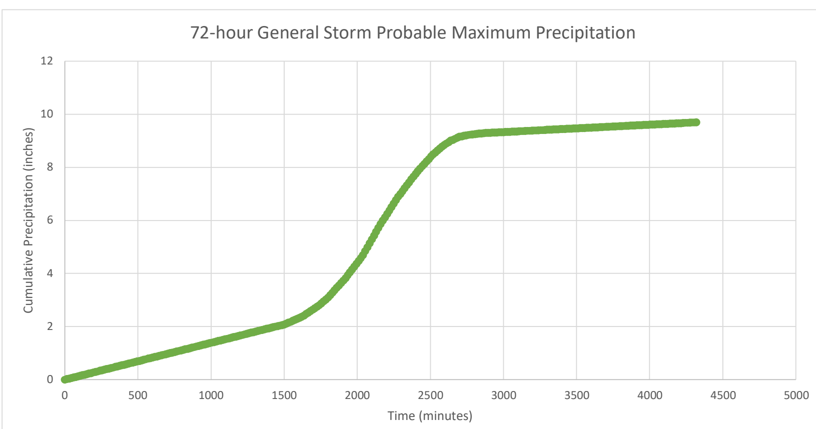
ATTACHMENT A – REPS TEMPORAL DATA

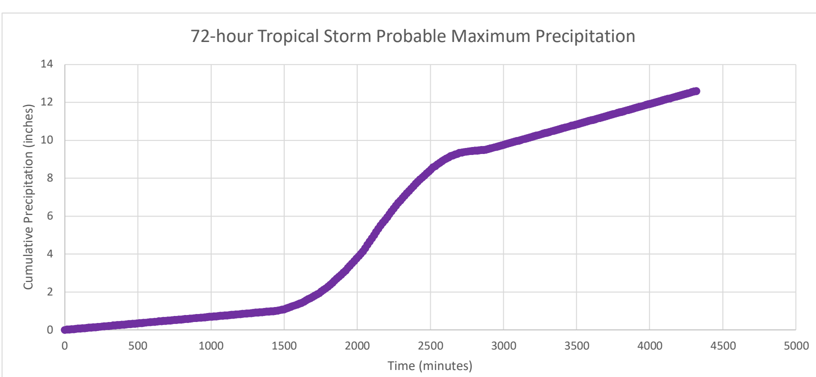
BASIN AVERAGE PMP

STORM_TYPE	PMP_01	PMP_02	PMP_03	PMP_04	PMP_05	PMP_06	PMP_12	PMP_24	PMP_48	PMP_72
Local	8.3	9.2	9.2	9.2	9.2	9.2	9.2	9.2		
General	2.5					6.1	6.9	7.3	9.3	9.7
Tropical	3.7					5.7	7.5	8.5	9.5	12.6


2-hr Local Storm Probable Maximum Precipitation
Cumulative Precipitation (inches)
Time (minutes)
0 1 2 3 4 5 6 7 8 9 10
0 20 40 60 80 100 120 140


6-hr Local Storm Probable Maximum Precipitation
Cumulative Precipitation (inches)
Time (minutes)
0 1 2 3 4 5 6 7 8 9 10
0 50 100 150 200 250 300 350 400


72-hour General Storm Probable Maximum Precipitation
Cumulative Precipitation (inches)
Time (minutes)
0 2 4 6 8 10 12
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000


72-hour Tropical Storm Probable Maximum Precipitation
Cumulative Precipitation (inches)
Time (minutes)
0 2 4 6 8 10 12 14
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000

ATTACHMENT B – HYDROLOGIC PARAMETERS

CSU-SMA Model Parameter Summary Table (ref: Table 6, DSB Guidelines for Hydrological Modeling and Flood Analysis)

Dam: SJWCD Headwaters
Date: 11/13/2025
By: KLG

Method	Parameter (units)	Parameter estimation method	Basin 1	
Meteorological Model				
Precipitation Specified Hyetograph	Specified Hyetograph	See REPS Guidance document for creating REPS design storms and entering as HEC-HMS Time Series -> Precipitation gages	Hyetopgraph from REPS	
Annual Evapotranspiration	Rate (in/day) (NOTE: include subbasins=yes)	Use uniform 2-2.5 mm/day (0.079 - 0.098 in/day), per CSU research (ref: Sujana Timilsina)	0.098	
Basin Model				
Simple Canopy	Initial Storage (%)	parsimony	0	
	Max Storage (in)	Use uniform 4.3 mm (0.169 inch), avg of NFS & SFS from Cache La Poudre site	0.169	
	Uptake Method		Simple	
SMA Loss	Soil (%)	For design storms, base AMC on seasonality of storm type. In general for extreme storms in CO, use field capacity (i.e. limit of gravity drainage)	60.17324704	
	GW1 (%)	Parsimony	0	
	GW2 (%)	Parsimony	0	
	Max Infiltration (in/hr)	Green & Ampt infiltration rate using ½ Ksat and delta = 75mm (~3 in)	0.343259735	
	Impervious (%)	Uniform, based on CSU calibrations/verifications	5%	5% as recommended starting place for mountain undeveloped basins. Use other methods where appropriate (ex. developed basins) and calibrate %impervious as needed per Sections 9 & 10 below
	Soil Storage (in)	Allocate 85-95% of total soil water storage to soil storage, per CSU recommendation	2.817833775	
	Tension Storage(in)	Soil water storage between field capacity and wilting point	1.892913015	
	Soil Percolation (in/hr)	Use 1/4* Ksat, calculated by Saxton & Rawls pedotransfer functions	0.021576561	
	GW 1 Storage (in)	Allocate 5-15% of total soil storage to GW1 layer, per CSU recommendation	0.313092655	
	GW1 Percolation (in/hr)	Uniform try 2.5mm/hr (0.1 in/hr), based on CSU calibrations/verifications	0.1	0.02 to 0.1 in/hr Calibrate as needed per Sections 9 & 10 below, affects losses from system
	GW1 Coefficient (hr)	Use 3 x Clark UH storage coefficient (i.e., 3xR), see Clark UH; based on CSU calibration/verification	16.69059434	
	GW2 Storage (in)	Parsimony	0	
	GW2 Percolation (in/hr)	Parsimony	0	
	GW2 Coefficent (hr)	parsimony	0	
Clark Unit Hydrograph Transform	Method	See Guidelines Section 5.6 or Section 9	Standard	
	Time of Concentration, Tc (hr)	Use Tc from Sabol (2008) HBRPEG (pg. 7) for Rocky Mountain, Great Plains & Colorado Plateau (NOTE: other Tc equations are provided for Urban and Agricultural basins, to be used as appropriate for basin-of-interest)	1.390882862	
	Storage Coefficient, R (hr)	Calculate R using R/(Tc+R)=0.6 to 0.8 for mountain basins, where 0.6 will provide less hillslope storage and 0.8 will provide more. Use lower ratio for basins with less hillslope storage (Wang and Dawdy, 2012)	5.563531448	
	Time-area Method	Use default	Default	
Linear Reservoir Baseflow	Reservoirs (#)		1	
	Initial Type		Discharge	
	GW1 Initial (cfs)		0	
	GW1 Fraction		(Blank)	
	GW Coefficient	Use 3 x Clark UH storage coefficient (i.e., 3xR), see above for Clark UH. Based on CSU calibration/verification	16.69059434	
	GW1 Steps		1	
Muskingum-Cunge Reach Routing			**Reach-1**	
	Length (ft)		17,952	
	Slope (ft/ft)		0.06218	
	Initial Type		Discharge= inflow	
	Mannings n	Use acceptable reference	0.03	Generally 0.03 – 0.07 for mountain streams
	Index Method		Flow	
	Index Flow (cfs)	Use Q-2yr (50% AEP) estimate from StreamStats or other bankfull flow estimate	69.1	\\A-ABQ-FS2B\ABQ-Projects\20260294\SW\Calculations\Misc Calcs\Headwaters Dam streamstats report.pdf
	Shape	Trapazoid or 8-point, etc., depending on channel and available data	Trapazoid	

	Output Raster	Mean
Max Infiltration	HMS_maxinfil	0.34326
Soil Percolation	HMS_soilperc	0.021577
Soil Storage	HMS_ss	2.817834
GW1 Storage	HMS_GW1st	0.313093
Tension Storage	HMS_tens	1.892913
Initial Soil Moisture	HMS_InSM	60.17325

Notes

Since there is only one basin in the watershed, the Mean for each calculated raster from the Python tool was used

Source Rasters: P:\20260294\GIS\Data\Current\Output

Clark UH parameters

Date 11/11/2025

by: K. Gilbert

Basin: SJWCD Headwaters Dam

	Basin Area (SQMI)	Longest Flowpath Length (MI)	Longest Flowpath Slope (FT/FT)	Longest Flowpath Slope (FT/MI)	Centroidal Flowpath Length (MI)	Centroidal Flowpath Slope (FT/FT)	Tc (HOURS)	R/(Tc+R) Ratio	R (HOURS)	GW1 Coefficient (HOURS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Subbasin-1	3.296	3.40006	0.06218	**328.3104**	2.1216	0.02646	**1.390883**	0.8	**5.563531**	**16.6905943**

Notes

(1) Direct from HEC-HMS

(2) Direct from HEC-HMS

(3) Direct from HEC-HMS

(4) (3)*5280 ft/mile

(5) Direct from HEC-HMS

(6) Direct from HEC-HMS

(7) Sabol (2008) Clark UH formula for Rocky Mtn, GP & Colo Plateau: Tc = 2.4*A^0.1*L^0.25*Lca^0.25*S^-0.2 (A [sqmi], L & Lca [mi], S [ft/mi])

(8) Guidance on R/(Tc+R) ratio: Mountains>7500 ft elev, use 0.6-0.8; Plains & Canyons <7500 ft, use 0.2-0.25

(9) R = (Ratio/(1-Ratio))*Tc

(10) GW1 = 3*R

ATTACHMENT C – HEC-HMS MODEL RESULTS

Project: 20260294_SJWCD_Headwaters_D
Simulation Run: PMP 2-hr LS
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 24:00

HMS Version: 4.11
Executed: 25 November 2025, 21:40

Global Parameter Summary - Subbasin

Location

Element Name	Longitude Degrees	Latitude Degrees
Subbasin - 1	-106.95	37.29

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	3.3

Downstream

Element Name	Downstream
Subbasin - 1	Sink - 1

Loss Rate: Soil Moisture Account

Element Name	Percent Impervious Area	Initial Soil Storage Percent	Initial Gw1 Storage Percent	Initial Gw2 Storage Percent	Soil Maximum Infiltration	Soil Storage Capacity	Soil Tension Capacity	Soil Maximum Percolation	Groundwater 1 Storage Capacity	Groundwater 1 Routing Coefficient	Groundwater 1 Maximum Percolation	Groundwate 2 Storage Capacity
Subbasin - 1	5	60.17	0	0	0.34	2.82	1.89	0.02	0.31	16.69	0.1	0

Canopy: Simple

Element Name	Allow Simultaneous Precip Et	Plant Uptake Method	Initial Canopy Storage Percent	Canopy Storage Capacity	Crop Coefficient
Subbasin - 1	No	Simple	0	0.17	1

Transform: Clark

Element Name	Clark Method	Time of Concentration	Storage Coefficient	Time Area Method
Subbasin - 1	Specified	1.39	5.56	Default

Baseflow: Linear Reservoir

Element Name	Number Reservoirs	Routing Coefficient	Initial Baseflow
Subbasin - 1			
Layer 1	1	16.69	0

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	3.3	2858.45	01Jan2000, 02:08	9.43

Sink - 1	3.3	2858.45	01Jan2000, 02:08	9.43

Subbasin: Subbasin-1

Area (MI2) : 3.3
Latitude Degrees : 37.29
Longitude Degrees : -106.95
Downstream : Sink - 1

Loss Rate: Soil Moisture Account

Percent Impervious Area	5
Initial Soil Storage Percent	60.17
Initial Gw1 Storage Percent	0
Initial Gw2 Storage Percent	0
Soil Maximum Infiltration	0.34
Soil Storage Capacity	2.82
Soil Tension Capacity	1.89
Soil Maximum Percolation	0.02
Groundwater 1 Storage Capacity	0.31
Groundwater 1 Routing Coefficient	16.69
Groundwater 1 Maximum Percolation	0.1
Groundwater 2 Storage Capacity	0
Groundwater 2 Routing Coefficient	0
Groundwater 2 Maximum Percolation	0

Canopy: Simple

Allow Simultaneous Precip Et	No
Plant Uptake Method	Simple
Initial Canopy Storage Percent	0
Canopy Storage Capacity	0.17
Crop Coefficient	1

Transform: Clark

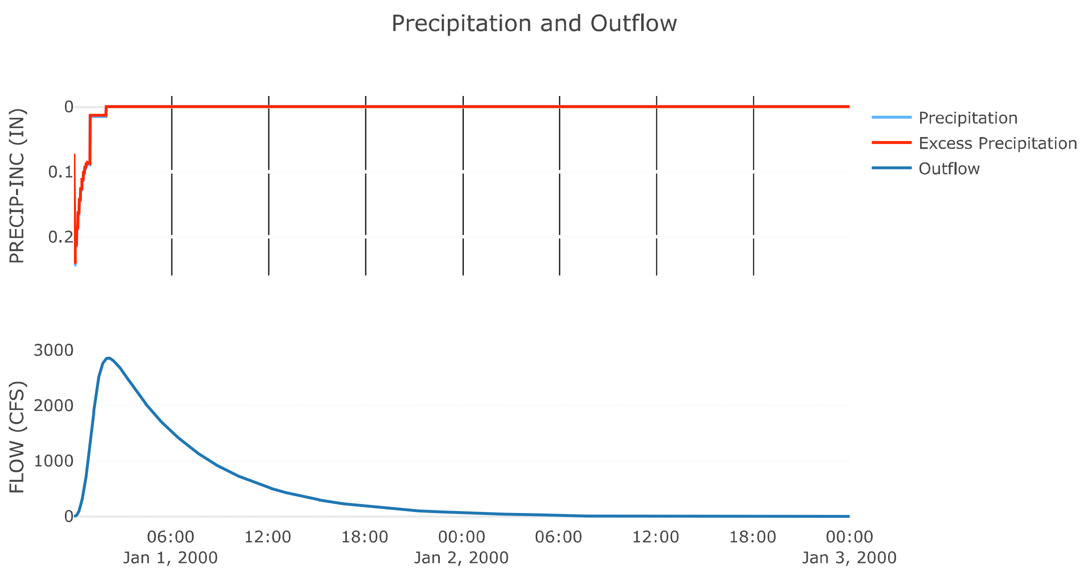
Clark Method	Specified
Time of Concentration	1.39
Storage Coefficient	5.56
Time Area Method	Default

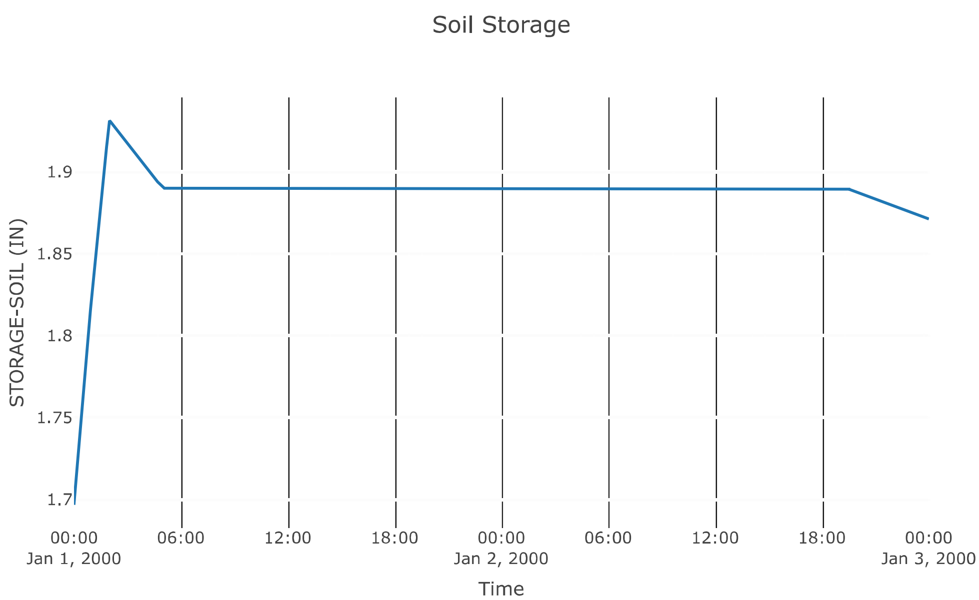
Baseflow: Linear Reservoir

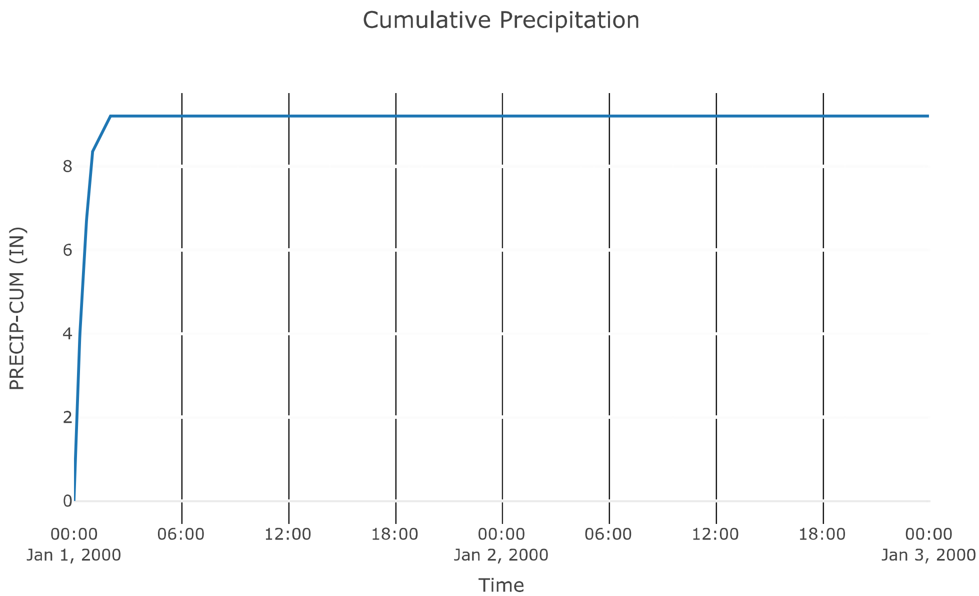
Baseflow Layer List	1	GW - 1 Number Reservoirs	1
		GW - 1 Routing Coefficient	16.69
		GW - 1 Initial Baseflow	0

Results: Subbasin-1

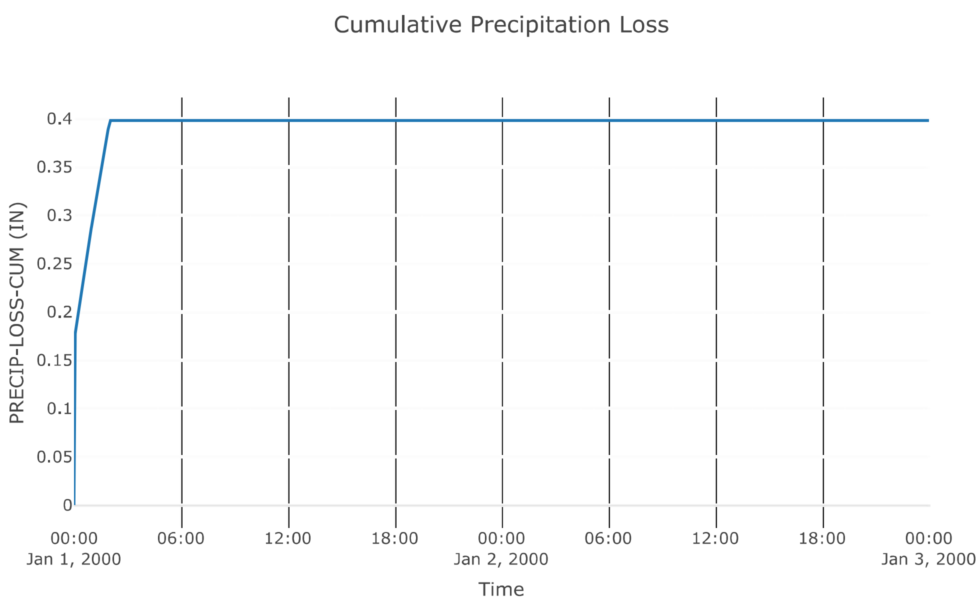
Peak Discharge (CFS)	2858.45
Time of Peak Discharge	01Jan2000, 02:08
Volume (IN)	9.43
Precipitation Volume (AC - FT)	1617.76
Loss Volume (AC - FT)	69.96
Excess Volume (AC - FT)	1547.8
Direct Runoff Volume (AC - FT)	1547.8
Baseflow Volume (AC - FT)	1.16





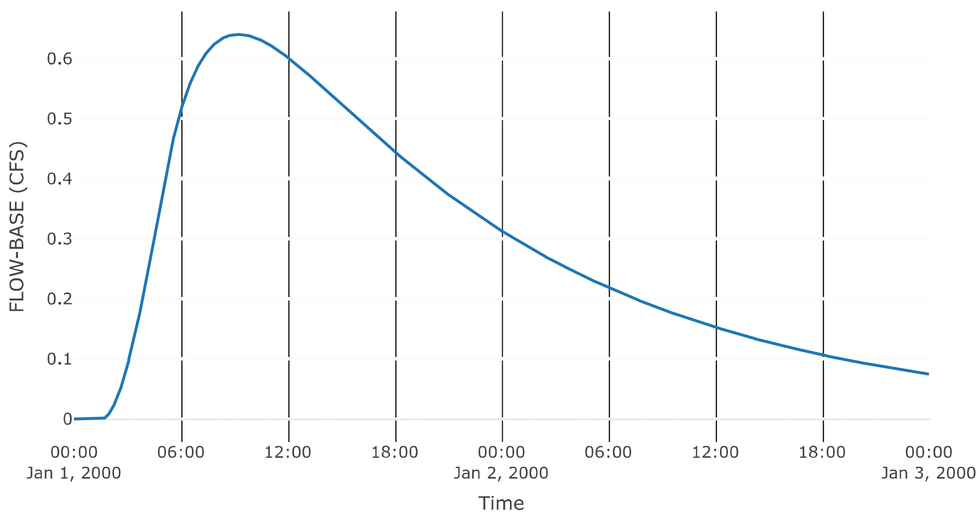


Cumulative Precipitation
PRECIP-CUM (IN)
0
2
4
6
8
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
00:00
Jan 3, 2000
Time

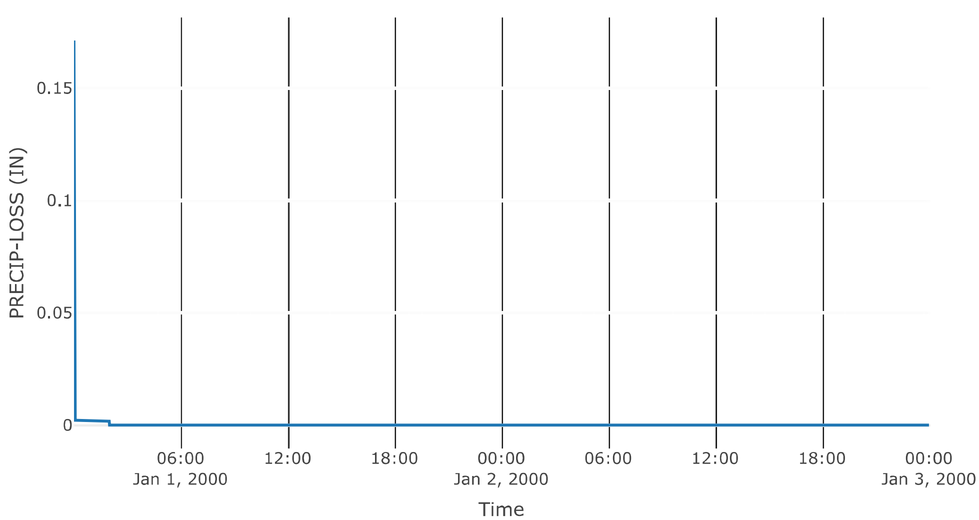


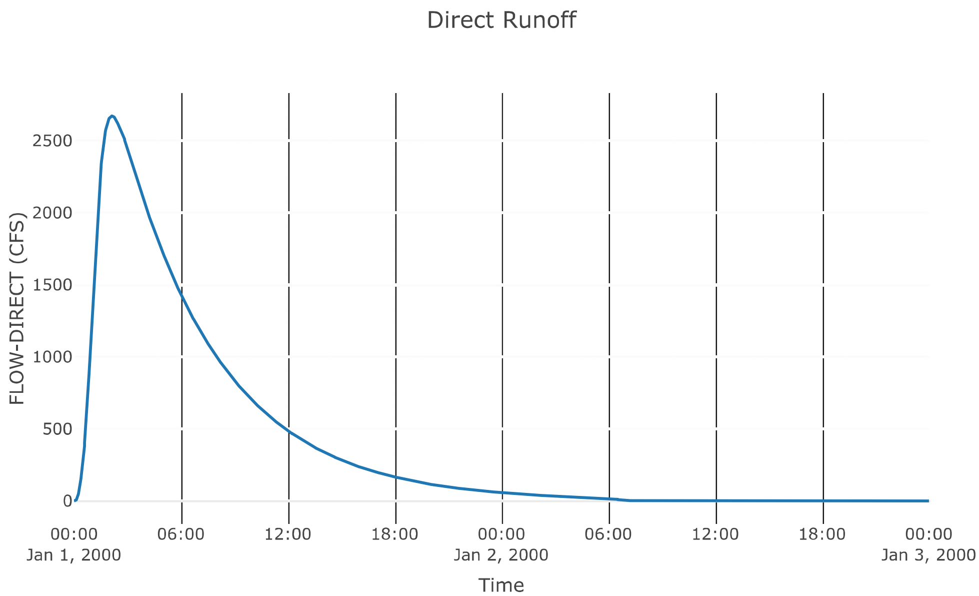
Cumulative Precipitation Loss
PRECIP-LOSS-CUM (IN)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
00:00
Jan 3, 2000
Time

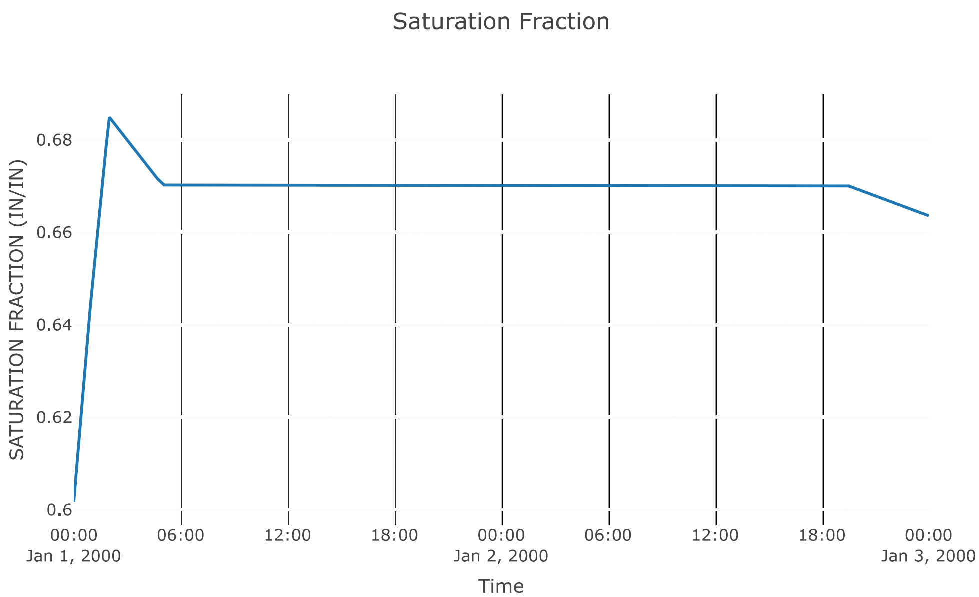
Baseflow

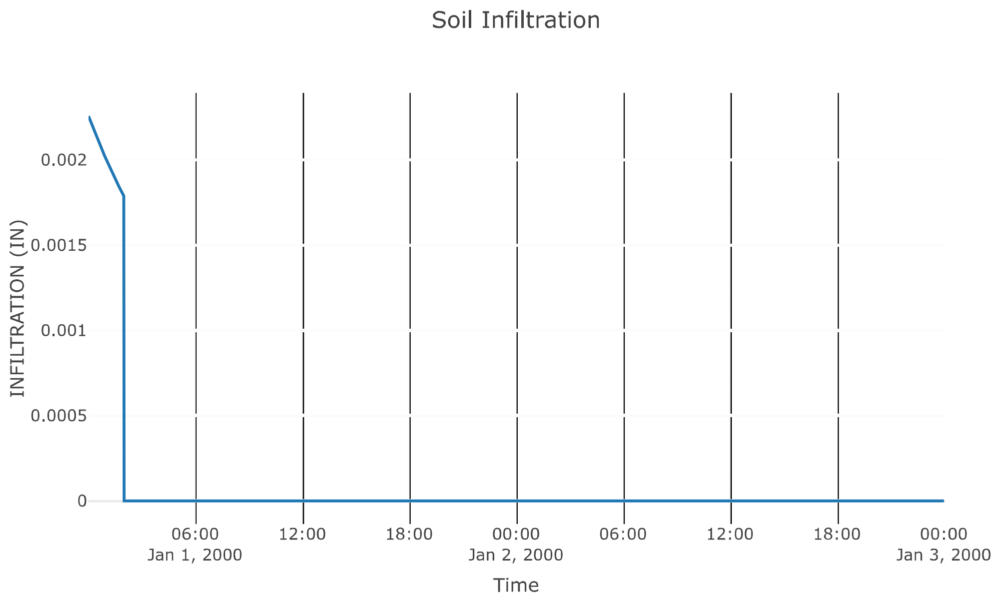


Precipitation Loss




Direct Runoff
FLOW-DIRECT (CFS)
0
500
1000
1500
2000
2500
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
00:00
Jan 3, 2000
Time


Saturation Fraction
SATURATION FRACTION (IN/IN)
0.6
0.62
0.64
0.66
0.68
00:00
Jan 1, 2000
06:00
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
00:00
Jan 3, 2000
Time



Soil Infiltration
INFILTRATION (IN)
0.002
0.0015
0.001
0.0005
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
18:00
00:00
Jan 3, 2000
Time

Project: 20260294_SJWCD_Headwaters_D
Simulation Run: PMP 6-hr LS
Simulation Start: 31 December 1999, 24:00
Simulation End: 2 January 2000, 24:00

HMS Version: 4.11
Executed: 25 November 2025, 21:40

Global Parameter Summary - Subbasin

Location

Element Name	Longitude Degrees	Latitude Degrees
Subbasin - 1	-106.95	37.29

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	3.3

Downstream

Element Name	Downstream
Subbasin - 1	Sink - 1

Loss Rate: Soil Moisture Account

Element Name	Percent Impervious Area	Initial Soil Storage Percent	Initial Gw1 Storage Percent	Initial Gw2 Storage Percent	Soil Maximum Infiltration	Soil Storage Capacity	Soil Tension Capacity	Soil Maximum Percolation	Groundwater 1 Storage Capacity	Groundwater 1 Routing Coefficient	Groundwater 1 Maximum Percolation	Groundwate 2 Storage Capacity
Subbasin - 1	5	60.17	0	0	0.34	2.82	1.89	0.02	0.31	16.69	0.1	0

Canopy: Simple

Element Name	Allow Simultaneous Precip Et	Plant Uptake Method	Initial Canopy Storage Percent	Canopy Storage Capacity	Crop Coefficient
Subbasin - 1	No	Simple	0	0.17	1

Transform: Clark

Element Name	Clark Method	Time of Concentration	Storage Coefficient	Time Area Method
Subbasin - 1	Specified	1.39	5.56	Default

Baseflow: Linear Reservoir

Element Name	Number Reservoirs	Routing Coefficient	Initial Baseflow
Subbasin - 1			
Layer 1	1	16.69	0

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	3.3	2268.79	01Jan2000, 03:02	9.11

Sink - 1	3.3	2268.79	01Jan2000, 03:02	9.11

Subbasin: Subbasin-1

Area (MI2) : 3.3
Latitude Degrees : 37.29
Longitude Degrees : -106.95
Downstream : Sink - 1

Loss Rate: Soil Moisture Account

Percent Impervious Area	5
Initial Soil Storage Percent	60.17
Initial Gw1 Storage Percent	0
Initial Gw2 Storage Percent	0
Soil Maximum Infiltration	0.34
Soil Storage Capacity	2.82
Soil Tension Capacity	1.89
Soil Maximum Percolation	0.02
Groundwater 1 Storage Capacity	0.31
Groundwater 1 Routing Coefficient	16.69
Groundwater 1 Maximum Percolation	0.1
Groundwater 2 Storage Capacity	0
Groundwater 2 Routing Coefficient	0
Groundwater 2 Maximum Percolation	0

Canopy: Simple

Allow Simultaneous Precip Et	No
Plant Uptake Method	Simple
Initial Canopy Storage Percent	0
Canopy Storage Capacity	0.17
Crop Coefficient	1

Transform: Clark

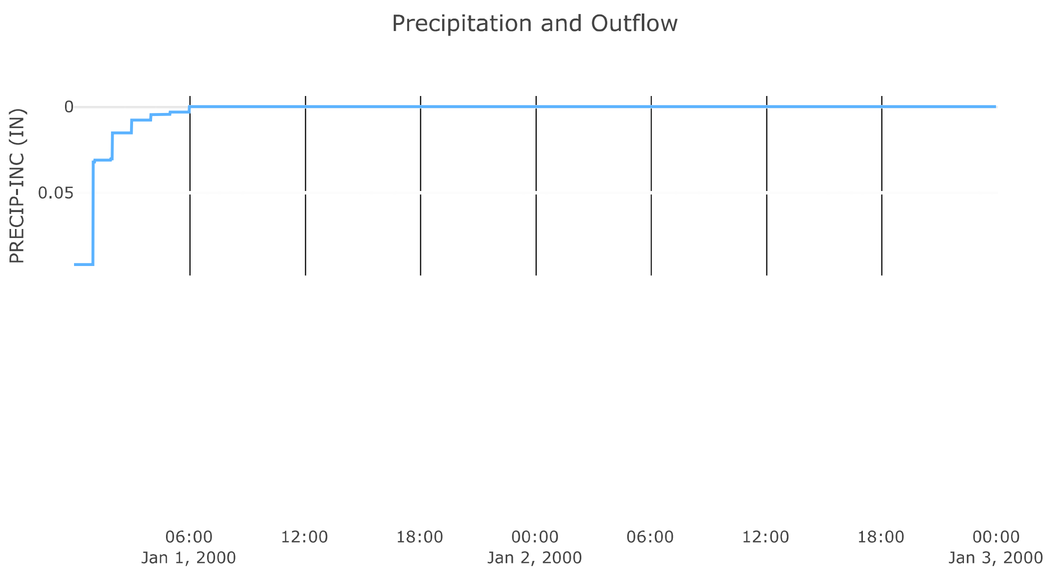
Clark Method	Specified
Time of Concentration	1.39
Storage Coefficient	5.56
Time Area Method	Default

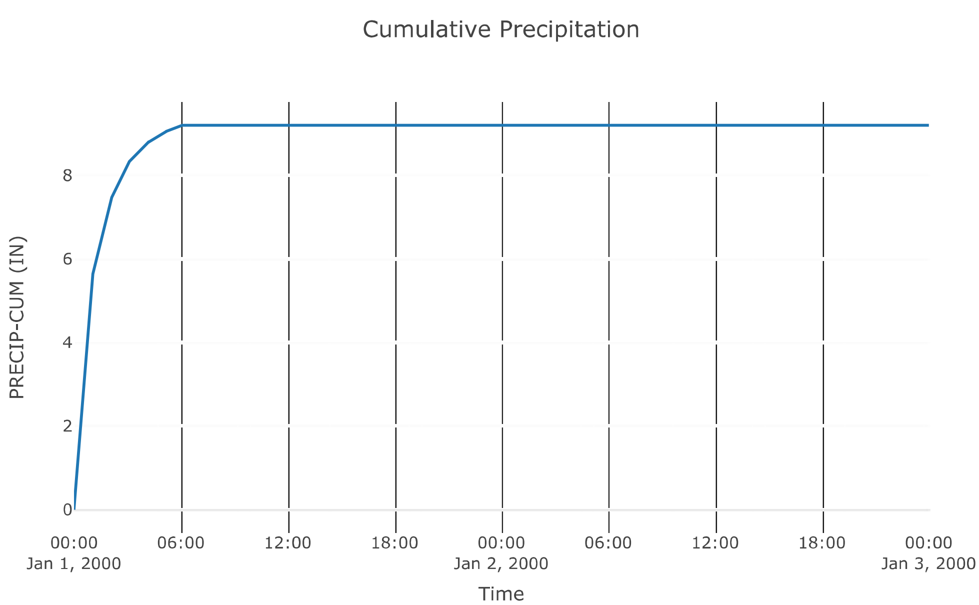
Baseflow: Linear Reservoir

Baseflow Layer List	1	GW - 1 Number Reservoirs	1
		GW - 1 Routing Coefficient	16.69
		GW - 1 Initial Baseflow	0

Results: Subbasin-1

Peak Discharge (CFS)	2268.79
Time of Peak Discharge	01Jan2000, 03:02
Volume (IN)	9.11
Precipitation Volume (AC - FT)	1617.24
Loss Volume (AC - FT)	128.62
Excess Volume (AC - FT)	1488.62
Direct Runoff Volume (AC - FT)	1488.62
Baseflow Volume (AC - FT)	8.53





Project: 20260294_SJWCD_Headwaters_D
Simulation Run: PMP 72-hr GS
Simulation Start: 31 December 1999, 24:00
Simulation End: 10 January 2000, 24:00

HMS Version: 4.11
Executed: 25 November 2025, 21:40

Global Parameter Summary - Subbasin

Location

Element Name	Longitude Degrees	Latitude Degrees
Subbasin - 1	-106.95	37.29

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	3.3

Downstream

Element Name	Downstream
Subbasin - 1	Sink - 1

Loss Rate: Soil Moisture Account

Element Name	Percent Impervious Area	Initial Soil Storage Percent	Initial Gw1 Storage Percent	Initial Gw2 Storage Percent	Soil Maximum Infiltration	Soil Storage Capacity	Soil Tension Capacity	Soil Maximum Percolation	Groundwater 1 Storage Capacity	Groundwater 1 Routing Coefficient	Groundwater 1 Maximum Percolation	Groundwate 2 Storage Capacity
Subbasin - 1	5	60.17	0	0	0.34	2.82	1.89	0.02	0.31	16.69	0.1	0

Canopy: Simple

Element Name	Allow Simultaneous Precip Et	Plant Uptake Method	Initial Canopy Storage Percent	Canopy Storage Capacity	Crop Coefficient
Subbasin - 1	No	Simple	0	0.17	1

Transform: Clark

Element Name	Clark Method	Time of Concentration	Storage Coefficient	Time Area Method
Subbasin - 1	Specified	1.39	5.56	Default

Baseflow: Linear Reservoir

Element Name	Number Reservoirs	Routing Coefficient	Initial Baseflow
Subbasin - 1			
Layer 1	1	16.69	0

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	3.3	925.64	02Jan2000, 16:25	8.36

Sink - 1	3.3	925.64	02Jan2000, 16:25	8.36

Subbasin: Subbasin-1

Area (MI2) : 3.3
Latitude Degrees : 37.29
Longitude Degrees : -106.95
Downstream : Sink - 1

Loss Rate: Soil Moisture Account

Percent Impervious Area	5
Initial Soil Storage Percent	60.17
Initial Gw1 Storage Percent	0
Initial Gw2 Storage Percent	0
Soil Maximum Infiltration	0.34
Soil Storage Capacity	2.82
Soil Tension Capacity	1.89
Soil Maximum Percolation	0.02
Groundwater 1 Storage Capacity	0.31
Groundwater 1 Routing Coefficient	16.69
Groundwater 1 Maximum Percolation	0.1
Groundwater 2 Storage Capacity	0
Groundwater 2 Routing Coefficient	0
Groundwater 2 Maximum Percolation	0

Canopy: Simple

Allow Simultaneous Precip Et	No
Plant Uptake Method	Simple
Initial Canopy Storage Percent	0
Canopy Storage Capacity	0.17
Crop Coefficient	1

Transform: Clark

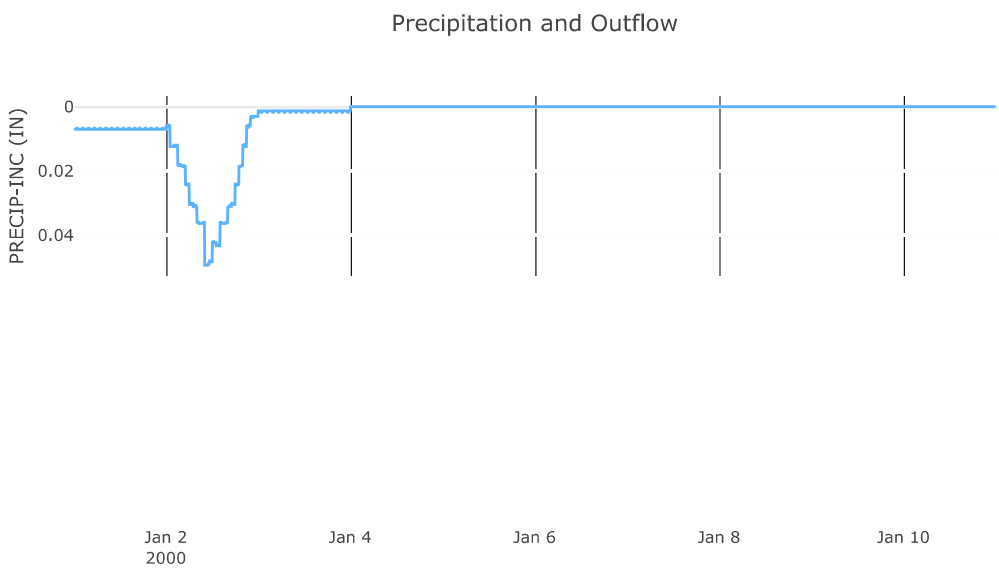
Clark Method	Specified
Time of Concentration	1.39
Storage Coefficient	5.56
Time Area Method	Default

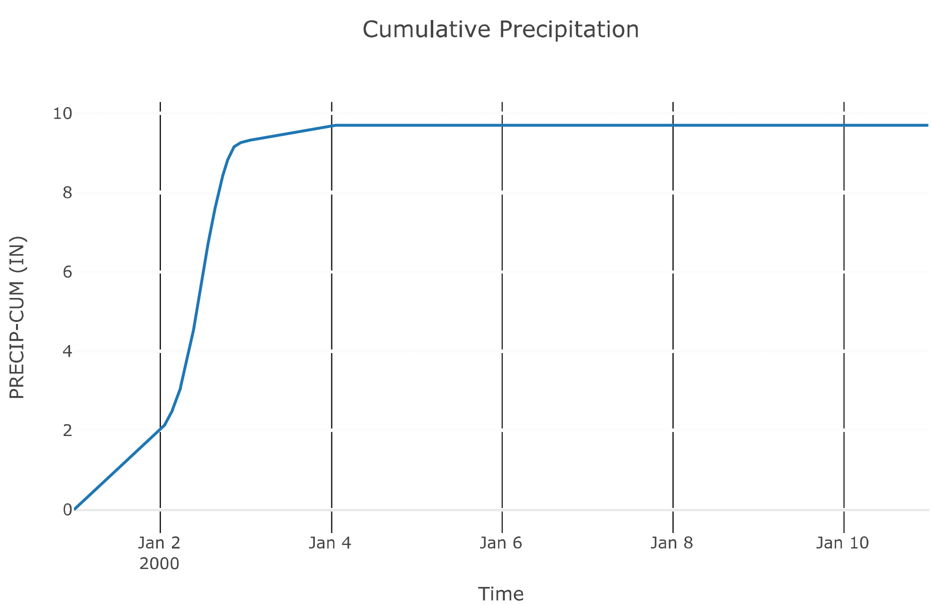
Baseflow: Linear Reservoir

Baseflow Layer List	1	GW - 1 Number Reservoirs	1
		GW - 1 Routing Coefficient	16.69
		GW - 1 Initial Baseflow	0

Results: Subbasin-1

Peak Discharge (CFS)	925.64
Time of Peak Discharge	02Jan2000, 16:25
Volume (IN)	8.36
Precipitation Volume (AC - FT)	1705.13
Loss Volume (AC - FT)	380.81
Excess Volume (AC - FT)	1324.32
Direct Runoff Volume (AC - FT)	1324.32
Baseflow Volume (AC - FT)	49.58





Project: 20260294_SJWCD_Headwaters_D
Simulation Run: PMP 72-hr TS
Simulation Start: 31 December 1999, 24:00
Simulation End: 10 January 2000, 24:00

HMS Version: 4.11
Executed: 25 November 2025, 21:40

Global Parameter Summary - Subbasin

Location

Element Name	Longitude Degrees	Latitude Degrees
Subbasin - 1	-106.95	37.29

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	3.3

Downstream

Element Name	Downstream
Subbasin - 1	Sink - 1

Loss Rate: Soil Moisture Account

Element Name	Percent Impervious Area	Initial Soil Storage Percent	Initial Gw1 Storage Percent	Initial Gw2 Storage Percent	Soil Maximum Infiltration	Soil Storage Capacity	Soil Tension Capacity	Soil Maximum Percolation	Groundwater 1 Storage Capacity	Groundwater 1 Routing Coefficient	Groundwater 1 Maximum Percolation	Groundwate 2 Storage Capacity
Subbasin - 1	5	60.17	0	0	0.34	2.82	1.89	0.02	0.31	16.69	0.1	0

Canopy: Simple

Element Name	Allow Simultaneous Precip Et	Plant Uptake Method	Initial Canopy Storage Percent	Canopy Storage Capacity	Crop Coefficient
Subbasin - 1	No	Simple	0	0.17	1

Transform: Clark

Element Name	Clark Method	Time of Concentration	Storage Coefficient	Time Area Method
Subbasin - 1	Specified	1.39	5.56	Default

Baseflow: Linear Reservoir

Element Name	Number Reservoirs	Routing Coefficient	Initial Baseflow
Subbasin - 1			
Layer 1	1	16.69	0

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	3.3	1055.53	02Jan2000, 16:30	11.53

Sink - 1	3.3	1055.53	02Jan2000, 16:30	11.53

Subbasin: Subbasin-1

Area (MI2) : 3.3
Latitude Degrees : 37.29
Longitude Degrees : -106.95
Downstream : Sink - 1

Loss Rate: Soil Moisture Account

Percent Impervious Area	5
Initial Soil Storage Percent	60.17
Initial Gw1 Storage Percent	0
Initial Gw2 Storage Percent	0
Soil Maximum Infiltration	0.34
Soil Storage Capacity	2.82
Soil Tension Capacity	1.89
Soil Maximum Percolation	0.02
Groundwater 1 Storage Capacity	0.31
Groundwater 1 Routing Coefficient	16.69
Groundwater 1 Maximum Percolation	0.1
Groundwater 2 Storage Capacity	0
Groundwater 2 Routing Coefficient	0
Groundwater 2 Maximum Percolation	0

Canopy: Simple

Allow Simultaneous Precip Et	No
Plant Uptake Method	Simple
Initial Canopy Storage Percent	0
Canopy Storage Capacity	0.17
Crop Coefficient	1

Transform: Clark

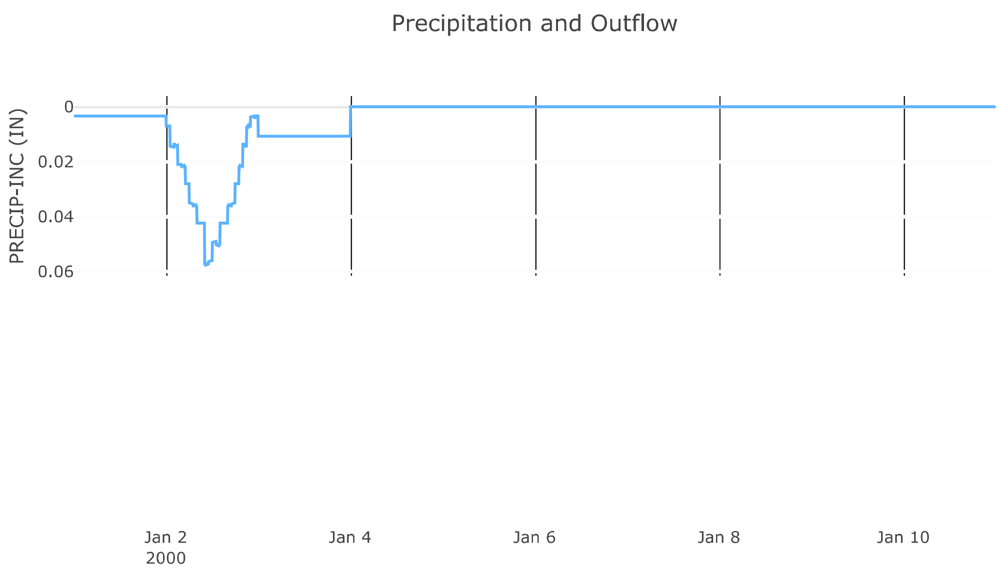
Clark Method	Specified
Time of Concentration	1.39
Storage Coefficient	5.56
Time Area Method	Default

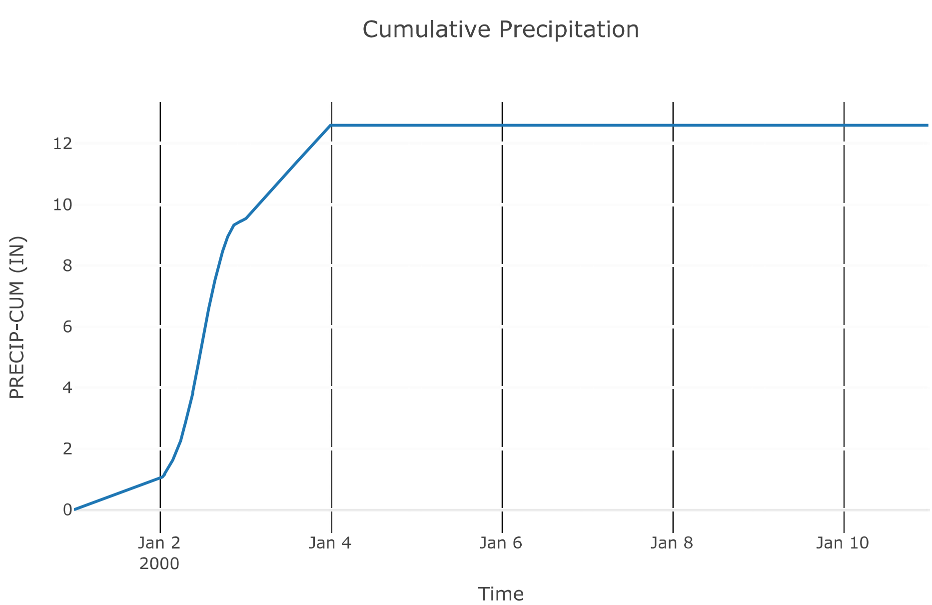
Baseflow: Linear Reservoir

Baseflow Layer List	1	GW - 1 Number Reservoirs	1
		GW - 1 Routing Coefficient	16.69
		GW - 1 Initial Baseflow	0

Results: Subbasin-1

Peak Discharge (CFS)	1055.53
Time of Peak Discharge	02Jan2000, 16:30
Volume (IN)	11.53
Precipitation Volume (AC - FT)	2214.91
Loss Volume (AC - FT)	367.4
Excess Volume (AC - FT)	1847.51
Direct Runoff Volume (AC - FT)	1847.51
Baseflow Volume (AC - FT)	47.35





APPENDIX C

ENVIRONMENTAL DESKTOP REVIEW MEMORANDUM

ERO

Consultants in Natural Resources and the Environment

Desktop Review Memorandum
Headwaters Dam Project
Archuleta County, Colorado

Prepared for—

RJH Consultants, Inc.
9800 Mt. Pyramid Court
Englewood, Colorado 80112

On behalf of—

San Juan Water Conservancy District
46 Eaton Drive, Suite 5
Pagosa Springs, Colorado 81147

Prepared by—

ERO Resources Corporation
835 East 2nd Avenue, Suite 314
Durango, Colorado 81301

ERO Project #25-286

January 9, 2026

Contents

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Desktop Review Memorandum
Headwaters Dam Project
Archuleta County, Colorado

January 9, 2026

Introduction

The San Juan Water Conservation District is proposing the construction of the Headwaters Dam Project (project) in Archuleta County, Colorado (project area). The proposed project would include construction of a reservoir, including a dam and other associated infrastructure. RJH Consultants Inc. retained ERO Resources Corporation (ERO) to assist in reviewing the environmental resources in the project area. This memorandum discusses potential environmental resources found in the project area.

Project Area Location

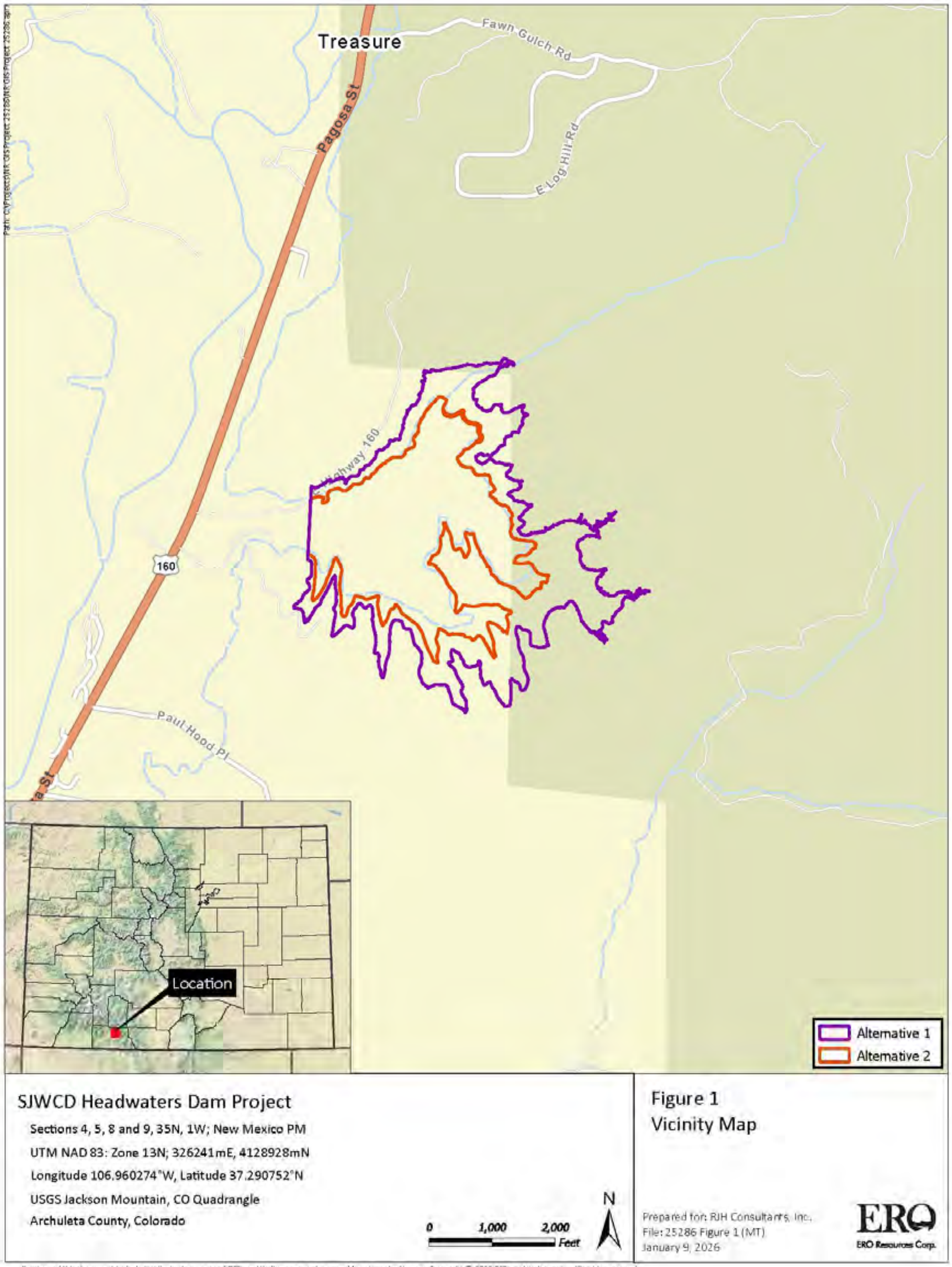
The project area is in Sections 4, 5, 8, and 9, Township 235 North, Range 1 West of the New Mexico Principal Meridian in Archuleta County, Colorado. The UTM coordinates for the approximate center of the project area are 326241mE, 4128928mN, Zone 13 North. The longitude/latitude of the project area is 106.960274°W/ 37.290752°N. The elevation of the project area ranges from 7,250 to 7,350 feet above sea level.

Project Area Description

The project area is approximately 2.5 miles northeast of Pagosa Springs in Archuleta County, Colorado (Figure 1). The project area is in the Dry Gulch valley, east of U.S. Highway 160 and the San Juan River. Two action alternatives are currently under review. Alternative 1 is a larger proposed reservoir based on the 7,350-foot contour, which would result in approximately 321.70 acres of inundation area. Alternative 2 is a smaller proposed reservoir based on the 7,320-foot contour, which would result in approximately 168.80 acres of inundation area.

The analysis below pertains only the inundation areas for Alternative 1 and Alternative 2. Future analysis and pedestrian survey would need to include any additional disturbance areas associated with the project including, but not limited to, temporary construction areas, staging areas, new access roads, relocation of Park Ditch, dam features, and borrow areas.

Figure 1. Project Location



Land Use and Vegetation

The overall project area consists of a mix of open grasslands, forests, wetlands, Park Ditch, and gravel roads, with private property and San Juan National Forest lands located east of the U.S. Highway 160 corridor and the San Juan River. The disturbed and moist grasslands in the project area are commonly dominated by blue grama (*Bouteloua gracilis*), ricegrass (*Achnatherum hymenoides*), galleta (*Hilaria jamesii*), water sedge (*Carex aquatilis*), beaked sedge (*Carex utriculata*), Baltic rush (*Juncus balticus*), western wheatgrass (*Pascopyrum smithii*), needle-and-thread grass (*Hesperostipa comata*), bottlebrush squirreltail (*Elymus elymoides*), junegrass (*Koeleria macrantha*), mutton grass (*Poe fendleriana*), smooth brome (*Bromus inermis*), and cheatgrass (*Bromus tectorum*). In the forested portions of the project area, ponderosa pine (*Pinus ponderosa*) with scattered juniper (*Juniperus osteosperma* and *J. scopulorum*) are present. Other common species in the project area include rabbitbrush (*Ericameria nauseosa*), Gambel oak (*Quercus gambelii*), big sagebrush (*Artemisia tridentata*), Woods' rose (*Rosa woodsii*), antelope bitterbrush (*Purshia tridentata*), serviceberry (*Amelanchier alnifolia*), and willow (*Salix* spp.) along the edges of Park Ditch. Additional herbaceous vegetation includes common mullein (*Verbascum thapsus*), Canada thistle (*Cirsium arvense*), yarrow (*Achillea millefolium*), fleabane (*Erigeron* spp.), lupine (*Lupinus* spp.), and other species. Several species listed by the state of Colorado as noxious weeds occur in the project area including common mullein, Canada thistle, and cheatgrass.

Soil Classification

Soil types in the project are have been identified by the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) (U.S. Department of Agriculture, Natural Resources Conservation Service 2025). Several soil types are mapped in the project area and primarily include, but are not limited to:

- Herm family, clay loam, cool, 3 to 12 percent slopes
- Herm family-Echolake complex, 3 to 10 percent slopes
- Echolake clay loam, cool, 3 to 12 percent slopes
- Herm family-Echolake, cool complex, 3 to 10 percent slopes
- Herm family clay loam, warm, 12 to 25 percent slopes
- Carracas clay loam, cool, 3 to 35 percent slopes

Herm family complex is found on hillslopes and side slopes, is considered well drained, and consists primarily of clay loams that are nonhydric. Echolake clay loam is found on hillslopes and foot slopes and is considered well drained and nonhydric. Carracas clay loam is found on hillslopes and side slopes, consists primarily of clay loams or clay, and is considered well drained and nonhydric.

Methods

On November 11, 2025, ERO archaeologist Kathy Croll and biologist Carly Bentley assessed the project area for potential environmental issues (2025 site visit). In addition to the 2025 site visit, ERO reviewed U.S. Geological Survey (USGS) topographic quadrangle maps (USGS 2022), aerial photography, the U.S.

Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) website (USFWS 2025a), the National Wetlands Inventory (NWI; USFWS 2025b), Colorado's Conservation Data Explorer (CODEX) (Colorado Natural Heritage Program [CNHP] 2025), U.S. Forest Service (USFS) Region 2 Threatened, Endangered, and Sensitive Plants and Animals (USFS 2023), the Colorado Office of Archaeology and Historic Preservation (OAHP) online COMPASS database (OAHP 2025), and reports from previous cultural surveys (Fuller 2017) in the project area to determine the presence of environmental resources. This records review included water resources (including wetlands), threatened and endangered species, USFS sensitive species, wildlife habitat, raptors and migratory birds, archaeological and historical resources, and other potentially sensitive or listed species with the potential to occur in the project area.

Results

Water Resources

Streams and Open Waters

The USGS Jackson Mountain, Colorado topographic quadrangle map and the NWI show multiple unnamed intermittent drainages with eventual connections to the San Juan River and one ditch (Park Ditch) in Dry Gulch in the project area (USGS 2022; USFWS 2025b). During the 2025 site visit, these features did not have flowing water; however, the drainage features with associated wetlands were observed in the project area as described in more detail below.

Wetlands

Wetlands in the project area are categorized as riverine, freshwater emergent wetlands, and freshwater ponds (Cowardin et al. 1979) and are described in further detail below. Alternative 1, the larger potential inundation area of 321.70 acres, includes approximately 12.16 acres of Park Ditch, which is considered riverine; 53.92 acres of freshwater emergent wetlands; and 1.16 acres of freshwater ponds (Table 1). Alternative 2, the smaller inundation area of 168.80 acres, includes approximately 7.27 acres of Park Ditch, 53.75 acres of freshwater emergent wetlands, and 1.16 acres of freshwater ponds (Table 1). Table 1 summarizes each of the potential waters of the U.S. (WOTUS) features and includes the Cowardin classification for each potential WOTUS in the proposed project alternatives and Figure 2 shows each alternative and the NWI-mapped wetlands.

Figure 2. NWI Existing Conditions.

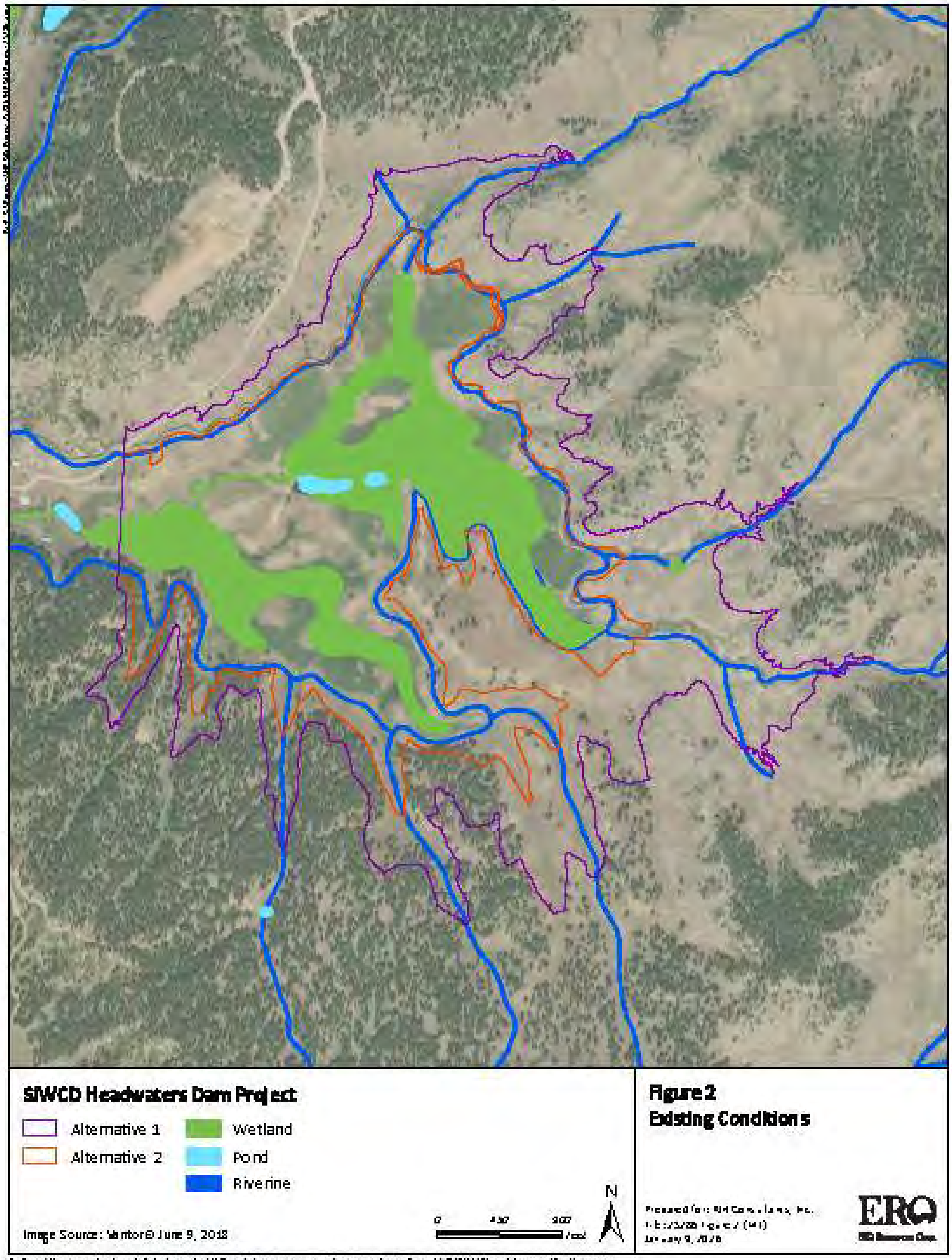


Table 1. Stream, open water, and wetland size and classification in the project area.

Water/Wetland	Alternative 1 Wetlands/Water Size (acres)	Alternative 2 Wetlands/Water Size (acres)	Cowardin Classification[1]
Park Ditch (riverine)	12.16	7.27	R4SBC, R4SBCx, R5UBH
Freshwater emergent wetland	53.92	53.75	PEM1B, PEM1C
Freshwater pond	1.16	1.16	PABFh
Total Wetlands and Open Water Areas[2]	67.24	62.18	-

[1]R4SBC and R4SBCx – Riverine Intermittent Streambed Seasonally Flooded Excavated, x – Excavated; R5UBH – Riverine Unknown Perennial Permanently Flooded Unconsolidated Bottom; PEM1B and PEM1C – Palustrine Emergent Persistent Seasonally Saturated; PABFh – Palustrine, Aquatic Bed, Semipermanently Flooded, Diked/Impounded.
[2]Reported acres are rounded and may be slightly different than the sum of the components.
Source: USFWS 2025b.

The Clean Water Act (CWA), under the jurisdiction of the Environmental Protection Agency, establishes a program to protect the chemical, physical, and biological quality of WOTUS including wetlands. The U.S. Army Corps of Engineers' (Corps) Regulatory Program administers and enforces Section 404 of the CWA. Under Section 404, a Corps permit is required for the discharge of dredged or fill material into wetlands and other WOTUS (streams, ponds, and other waterbodies). Wetland delineations and an associated report would need to be completed for the proposed project. Consultation with the Corps would determine which wetlands, if any, in the project area are jurisdictional based on the most recent definition of WOTUS and, therefore, what mitigation could be required for implementation of the project.

Endangered Species Act Compliance

During the 2025 site visit, ERO assessed the project area for potential habitat for threatened, endangered, proposed, and candidate (T&E) species listed under the Endangered Species Act (ESA) of 1973, as amended (16 United States Code 1531 et seq.). Adverse effects on a federally listed T&E species or its habitat require consultation with the USFWS under Section 7 or 10 of the ESA. The USFWS IPaC resource list for the project area identifies several T&E species with potential habitat in the project area or with potential to be affected by the project (Table 2). Federally listed T&E species are analyzed based on the location and available habitat in the project area, not by alternative.

Table 2. Federally listed T&E species potentially found in the project area or potentially affected by the project.

Common Name	Scientific Name	Status[1]	Habitat	Suitable Habitat Present or Potential to be Affected by Project
Mammals				
Canada lynx	*Lynx canadensis*	T	Spruce-fir; typically in boreal and montane regions dominated by coniferous or mixed forest with thick undergrowth, but also sometimes enters open forest, rocky areas, and tundra; subalpine and upper montane forests zones from 8,000 to 12,000 feet in elevation.	No suitable habitat is present in the project area, but habitat is present nearby.
Gray wolf	*Canis lupus*	EXPN	A wide variety of habitats including forests, mountains, tundra, and grasslands.	Habitat is present in the project area, but the species is not known to be present in the project area.
New Mexico meadow jumping mouse	*Zapus hudsonius preblei*	E	Dense riparian habitats with at least 24 inches of herbaceous vegetation, with adjacent upland habitats with shrub and other vegetation cover for hibernacula.	No suitable habitat is present in the project area.
Birds				
Mexican spotted owl	*Strix occidentalis lucida*	T	Mixed conifer forests with closed canopies and steep rocky canyons.	No suitable habitat is present in the project area.
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	Riparian and wetland thickets, typically willows (*Salix* spp.), tamarisk (*Tamarix* spp.), or Russian olive (*Elaeagnus angustifolia*).	No suitable habitat is present in the project area.
Yellow-billed cuckoo	*Coccyzus americanus*	T	Cottonwood forests or other woodlands, with dense understory of shrubs such as willow.	No suitable habitat is present in the project area.
Insects				
Monarch butterfly	*Danaus plexippus*	PT	Dependent on milkweeds (*Asclepiadoideae*) as host plants and forage on blooming flowers; a rare summer resident.	The project area is outside of the migration corridors for this species, and monarch butterflies are not typically observed in Archuleta County (Western Monarch Milkweed Mapper 2025; USFWS 2025c). However, if surveys of the project area observe milkweed, consultation with the USFWS would be advised.

Common Name	Scientific Name	Status[1]	Habitat	Suitable Habitat Present or Potential to be Affected by Project
Silverspot	*Speyeria nokomis nokomis*	T	Occurs between 5,200 and 9,300 feet in elevation in moist habitats that support their host plant, bog violets (*Viola nephrophylla/V. sororia* var. *affinis*).	Potential habitat is present in the project area in the form of wetlands, and surveys for host species should be conducted during project planning. If host species are not found to be present, silverspots would not have the potential to be present in the project area. If host species are found to be present, consultation with the USFWS would be advised.
Suckley's cuckoo bumble bee	*Bombus suckleyi*	PE	Various habitats such as prairies, grasslands, meadows, and woodlands between 6,000 and 10,500 feet in elevation, where suitable host colonies of other bumble bees are present.	Habitat is present in the project area, but the species is not known to be present in the region (Gissing and Salamack 2025).
Fish				
Colorado pikeminnow	*Ptychocheilus lucius*	E	Various habitat types in large rivers of the Colorado basin such as the White, Yampa, and Green Rivers.	Habitat is present in the San Juan River downstream of the project area below the Navajo Reservoir Dam, but Colorado pikeminnows are not known from the adjacent portion of the San Juan River [2].
Razorback sucker	*Xyrauchen texanus*	E	Mainstem river channels, reservoirs, turbid inflow areas, and floodplain wetlands.	Habitat is present in the San Juan River downstream of the project area below the Navajo Reservoir Dam, but razorback suckers are not known from the adjacent portion of the San Juan River[2].

[1]T = Federally Threatened Species; E = Federally Endangered Species; PE = Proposed Endangered Species; PT = Proposed Threatened Species; EXPN = Experimental Population.
[2]New water depletions in the Upper San Juan River may affect the species or critical habitat in downstream reaches in other counties or states. It is anticipated that existing diversions for Park Ditch would be used to fill the proposed reservoir, and that no additional depletions would impact San Juan River fish species; however, consultation with the USFWS may be needed if depletions are anticipated.
Source: USFWS 2025a; CNHP 2025.

The proposed reservoir location would not likely directly affect the Canada lynx, gray wolf, New Mexico meadow jumping mouse, Mexican spotted owl, southwestern willow flycatcher, yellow-billed cuckoo, or Suckley's cuckoo bumble bee due to the lack of habitat or presence in the project area. There is potential habitat for monarch butterfly and silverspot in the project area; however, further surveys would be needed determine if host plant species are present that could result in the presence of the monarch butterfly or silverspot and, therefore, potential impacts on the species if the project were to occur. If host species are observed during surveys, further consultation with the USFWS would be required and a biological assessment (BA) would be required.

For Colorado pikeminnow and razorback sucker, populations are known from downstream below the Navajo Reservoir Dam in the San Juan River. Depletions from diversions for the proposed reservoir may result in reduced water availability or could result in adverse impacts, but further analysis of diversion amounts and anticipated impacts downstream would need to be described in the BA. Consultation with the USFWS would be necessary to determine effects, and additional analysis should include review of and implementation of the *San Juan River Basin Recovery Implementation Program Final Program Document* and the associated *Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish in the San Juan River Basin* (USFWS 2022).

U.S. Forest Service Sensitive Species

Table 3 includes USFS Region 2 sensitive wildlife species with potential to occur on San Juan National Forest lands in the project area that could be affected by the proposed project. Those species that do not occur in the project area or that do not have habitat needs met are not included in Table 3. USFS sensitive species are not analyzed by alternative but based on habitat availability in the project area.

Table 3. USFS sensitive species potentially found in the project area or potentially affected by the project.

Common Name	Scientific Name	Habitat	Suitable Habitat Present or Potential to be Affected by Project
Mammals			
Fringed myotis	*Myotis thysanodes*	Occurs in coniferous forests and woodlands below 7,500 feet in elevation. Typical habitat includes ponderosa pine, pinyon-juniper, and scrub oak. The fringed myotis roosts in rock crevices, mines, bridges, buildings, and trees and are known to hibernate in caves and buildings.	Suitable habitat is present in the project area.
Gunnison's prairie dog	*Cynomys gunnisoni*	Grasslands and semi-desert and montane shrublands. This species occurs in southwest and south-central Colorado at elevations from 6,000 to 12,000 feet.	Suitable habitat is present in the project area.
Hoary bat	*Lasiurus cinereus*	A wide variety of habitats including aspen woodlands, ponderosa pine forests, mountain meadows, riparian woodlands, and pinyon-juniper woodlands where the bats roost in trees.	Suitable habitat is present in the project area.
River otter	*Lontra canadensis*	River otters live in riparian habitats with permanent water and abundant food resources of fish and crustaceans.	Suitable habitat is not present in the project area; however, depletions in the adjacent San Juan River could impact river otters.
Spotted bat	*Euderma maculatum*	Ponderosa pine, pinyon-juniper woodland, and shrub desert where areas with cliffs and water are preferred.	Suitable habitat is present in the project area.
Townsend's big eared bat	*Corynorhinus townsendii*	Occur in a wide variety of habitats including semi-desert shrublands, pinyon-juniper woodlands, coniferous forests, and riparian areas up to 10,800 feet in elevation. Typically found near caves, mines, and other structures for roosting. Often forage over water.	Suitable foraging habitat is present in the project area, but roosting habitat is not present.

Common Name	Scientific Name	Habitat	Suitable Habitat Present or Potential to be Affected by Project
		Birds	
American bald eagle	*Haliaeetus americanus*	Found throughout much of the state during both the summer and winter and often occur near large reservoirs and along major rivers.	Suitable foraging habitat is present in the project area, and potential nesting habitat is present due to the proximity to the San Juan River.
American bittern	*Botaurus lentiginosus*	Marsh, swamp, or bog with cattails, rushes, grasses, and sedges.	Breeding habitat is not present in the project area; however, some wetlands could provide foraging habitat outside of breeding season.
American goshawk	*Accipiter atricapillus*	Occur in mature stands of aspen, lodgepole pine, and spruce-fir forests at elevations from 7,500 to 11,000 feet.	Suitable habitat is present in the project area, primarily for foraging, as breeding habitat is typically more dense forests.
American peregrine falcon	*Falco peregrinus anatum*	Prefer open spaces and favor cliffs in mountain ranges overlooking rivers.	Suitable foraging habitat is present in the project area, but the cliffs preferred for nesting are not present.
Brewer's sparrow	*Spizella breweri*	Shrubland/chapparal, strongly associated with sagebrush with scattered shrubs and short grass.	Suitable habitat is present in the project area.
Ferruginous hawk	*Buteo regalis*	Prairies, deserts, and open range with grassland and sagebrush-steppe habitats. The presence of prairie dogs and other rodents is an important component of suitable habitat.	Suitable overwintering habitat is present in the project area; however, suitable breeding habitat is not present.
Flammulated owl	*Otus flammeolus*	Old growth or mature ponderosa pine and Douglas-fir forests and, in some cases, aspen stands.	Minimal suitable habitat is present in the project area, but more dense forests in the surrounding areas could provide suitable habitat.
Lewis' woodpecker	*Melanerpes lewis*	Ponderosa pine, riparian, and rural cottonwood habitats up to 9,200 feet in elevation.	Suitable habitat is present in the project area and the surrounding areas.
Loggerhead shrike	*Lanius ludovicianus*	Open country with short vegetation and shrubby or wooded areas nearby. Typically nest in dense shrubs or trees and forage in open areas.	Suitable habitat is present in the project area.
Northern harrier	*Circus cyaneus*	Breeding habitat includes open wetlands, grasslands, marshes, agricultural areas, and cold desert shrub-steppe communities.	Suitable nesting and breeding habitat is present in the project area.
Olive-sided flycatcher	*Contopus cooperi*	Coniferous and mixed conifer forests; most often associated with forest edges and openings.	Suitable habitat is present in the project area.
Short-eared owl	*Asio flammeus*	Open habitats including grasslands, marsh edges, shrub-steppe, and agricultural lands; requires taller grass cover.	Suitable habitat is present in the project area.

Common Name	Scientific Name	Habitat	Suitable Habitat Present or Potential to be Affected by Project
Western burrowing owl	*Athene cunicularia*	Prairie dog colonies with vacant burrows in grasslands, shrublands, and deserts.	Potential suitable habitat is present in the project area, but surveys should be conducted prior to project implementation to determine the presence of prairie dog colonies or individuals.
Amphibians			
Northern leopard frog	*Lithobates (Rana) pipiens*	Wet meadows and the banks and shallows of marshes, ponds, glacial kettle ponds, beaver ponds, lakes, reservoirs, streams, and irrigation ditches up to 11,000 feet in elevation.	Potential suitable habitat is present in the project area.
Insects			
Monarch butterfly	*Danaus plexippus*	Discussed above in Table 2.	
Silverspot	*Speyeria nokomis nokomis*	Discussed above in Table 2.	
Western bumble bee	*Bombus occidentalis*	Generally, occur between 5,000 and 10,000 feet in elevation in open meadow habitat, requiring flowering resources during their flight season, from late April through late September. This species nests in abandoned rodent burrows and, primarily, underground.	Potential suitable habitat is present in the project area.
Fish			
Bluehead sucker	*Catostomus disobolus*	Sometimes occupies areas of suitable habitat in larger, low-elevation, mainstem streams. It is most commonly collected in small or midsized tributaries of the Upper Colorado River Basin with heavy sediment loads, high annual peak flows, rocky substrate, and low base flows.	Potential suitable habitat is present in the San Juan River adjacent to the project area where diversions could impact habitat.
Flannelmouth sucker	*Catostomus latipinnis*	Typically found in slower, warmer rivers in plateau regions of the Colorado River drainage in the mainstem of moderate to large rivers but are occasionally found in small streams.	Potential suitable habitat is present in the San Juan River adjacent to the project area where diversions could impact habitat.
Roundtail chub	*Gila robusta*	Occupies suitable mid-elevation mainstem streams with complex pool and riffle habitats in the Upper Colorado River Basin that contain heavy sediment loads, high annual peak flows, woody debris, and low base flows.	Not known from this portion of the San Juan River in the project area but is present downstream where impacts could occur from diversion.
Plants			
Aztec milkvetch	*Astragalus proximus*	Ponderosa pine, pinyon-juniper, and mountain shrubland.	Potential suitable habitat is present in the project area.
Cushion bladderpod	*Physaria pulvinate*	Shale outcrops in sagebrush and juniper between 7,500 and 8,500 feet in elevation.	Potential suitable habitat is present in the project area.
Frosted bladderpod	*Lesquerella (Physaria) pruinose*	Grassland or shrubland hillsides on soils derived from Mancos Shale between 6,500 and 8,300 feet in elevation.	Potential suitable habitat is present in the project area.
Lesser panicled sedge	*Carex diandra*	Along the edges of ponds and in fens or marshes.	Potential suitable habitat is present in the project area where ponds are present.

Common Name	Scientific Name	Habitat	Suitable Habitat Present or Potential to be Affected by Project
Missouri milkvetch	*Astragalus missouriensis var. humistratus*	Pinyon-juniper woodlands, ponderosa pine forests, and Gambel oak shrublands where Mancos Shale is present.	Potential suitable habitat is present in the project area.

Sources: Ackerfield 2022; Armstrong et al. 2011; CNHP 2025; Colorado Bat Working Group 2025; USFS 2023.

Other Wildlife, Raptors, and Migratory Birds

In 2021, Colorado Parks and Wildlife (CPW) released a High Priority Habitat (HPH) table that identifies species and habitats, as well as recommendations to avoid and minimize impacts on wildlife from land use development (CPW 2023). Data from CPW map databases available on CODEX (CNHP 2025) were reviewed, and HPH in the project area includes elk migration corridor, elk winter concentration area, and mule deer migration corridor. These HPH habitats overlap both alternatives. ERO recommends discussing the project with CPW early in the process to determine impacts on elk and mule deer and potential mitigation measures to reduce or offset impacts.

Additionally, raptor species and bald and golden eagles that are protected under the Bald and Golden Eagle Protection Act have the potential to occur in the project area, such as red-tailed hawk (*Buteo jamaicensis*), bald eagle, golden eagle (*Aquila chrysaetos*), ferruginous hawk, American peregrine falcon, northern harrier, American goshawk, and osprey (*Pandion haliaetus*). Surveys should be completed to identify any active nests that should be avoided during construction or other proposed project activities, and avoidance measures should be followed as outlined by CPW recommendations (CPW 2020) and any other input from the USFS or U.S. Bureau of Reclamation (BOR).

Migratory birds, as well as their eggs and nests, are protected under the Migratory Bird Treaty Act (MBTA). The MBTA does not contain any prohibition that applies to the destruction of a bird nest alone (without birds or eggs), provided that no possession occurs during the destruction. While destruction of a nest by itself is not prohibited under the MBTA, nest destruction that results in the unpermitted take of migratory birds or their eggs is illegal and fully prosecutable under the MBTA (USFWS 2003). The regulatory definition of a take means to pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect (50 Code of Federal Regulations 10.12). Therefore, prior to construction or other disturbing activities, migratory bird surveys should be completed during the breeding season to identify active nests and determine avoidance or other mitigation needs.

Cultural Resources

ERO reviewed available data on known and potential cultural resources in the project area. The file search with Compass showed that no previous inventories have been conducted in the project area and no sites have been documented; however, La Plata Archaeological Consultants (LPAC) surveyed 1,257 acres from 2007 to 2009 at the request of Pagosa Area Water and Sanitation District and Harris Engineering. A report was prepared and submitted to San Juan Water Conservancy District in 2017

(Fuller 2017). The report does not appear to have been submitted to the State Historic Preservation Office (SHPO); no site state numbers were assigned and there is no record of the project on Compass.

LPAC documented 50 sites during the 2007-2009 survey. A total of 30 sites fall within one or both proposed reservoir footprints (Table 4). A total of 15 resources fall within the smaller reservoir footprint (Alternative 1). These sites are primarily prehistoric artifact scatters (n=12), with 2 multicomponent sites with both precontact and historic components and 1 historic artifact scatter. Many of these sites had diagnostic artifacts indicative of an Archaic Period association. Two sites were recommended eligible and six sites were recommended needs data (undetermined). The remaining seven sites are officially not eligible (n=1) or recommended not eligible.

The remaining 15 sites from the LPAC 2007-2009 survey are located outside of the smaller reservoir but within the boundaries of the larger reservoir footprint (Alternative 2) and are all precontact artifact scatters. Two of these sites were recommended eligible and nine sites were recommended needs data (undetermined). The remaining four sites were recommended not eligible.

Table 4. Previously recorded cultural resources in or intersecting the reservoir footprints.

Temporary Site No.	Resource Name/Type	NRHP Eligibility Recommendation	Alternative
2	Multicomponent: Archaic scatter with features/historic camp	Eligible	Both reservoir footprints
3	Archaic artifact scatter	Undetermined	Both reservoir footprints
4	Precontact artifact scatter with feature	Undetermined	Both reservoir footprints
5	Archaic artifact scatter	Undetermined	Both reservoir footprints
6	Precontact artifact scatter	Not Eligible	Both reservoir footprints
7	Archaic/Late Prehistoric artifact scatter	Undetermined	Larger reservoir
8	Archaic artifact scatter with feature	Undetermined	Both reservoir footprints
9	Archaic artifact scatter	Undetermined	Larger reservoir
10	Historic artifact scatter with feature	Not Eligible	Both reservoir footprints
11	Archaic artifact scatter	Eligible	Both reservoir footprints
12	Archaic artifact scatter	Not Eligible	Both reservoir footprints
13	Archaic artifact scatter	Undetermined	Both reservoir footprints
14	Archaic artifact scatter	Not Eligible	Both reservoir footprints
15	Multicomponent: Precontact scatter with features/historic camp	Not Eligible	Both reservoir footprints
16	Precontact artifact scatter	Not Eligible	Both reservoir footprints
17	Precontact artifact scatter	Undetermined	Larger reservoir
18	Archaic artifact scatter with features	Eligible	Larger reservoir
19	Precontact artifact scatter	Undetermined	Larger reservoir
20	Precontact artifact scatter	Undetermined	Both reservoir footprints
21	Archaic artifact scatter	Undetermined	Larger reservoir
27	Archaic artifact scatter	Undetermined	Larger reservoir
28	Precontact artifact scatter	Undetermined	Larger reservoir
29	Precontact artifact scatter	Not Eligible	Larger reservoir
33	Archaic artifact scatter	Undetermined	Larger reservoir
34	Archaic artifact scatter	Not Eligible	Larger reservoir
36	Precontact artifact scatter	Not Eligible	Larger reservoir
38	Archaic artifact scatter	Eligible	Larger reservoir
42	Precontact artifact scatter	Undetermined	Larger reservoir
50	Late Precontact artifact scatter	Not Eligible	Larger reservoir
5AA3419	Park Ditch	Officially Not Eligible (2015)	Both reservoir footprints

In addition to the OAHP file search, ERO conducted a review of historical maps, historic aerials, Colorado Division of Water Resource records, and General Land Office (GLO) records to assess the potential for unknown historical resources, such as roads, ditches, and buildings, in the project area. No additional resources were observed in the records reviewed.

Because these survey results were never finalized, SHPO consultation is incomplete, and the survey is more than 15 years old, a new cultural resource survey would be required and SHPO consultation would need to be completed.

Conclusion and Expected Needs

Overall, adverse impacts could be possible for T&E species, USFS sensitive species, and cultural resources, and consultation with the associated agency is recommended to determine mitigation requirements. The project has two potential federal nexuses:

1. A Special Use Permit (SUP) from the USFS will be required.
2. The project may receive funding from the Bureau of Reclamation.

Projects on federal lands or federally funded projects require compliance with the National Environmental Protection Act (NEPA), the Clean Water Act (CWA), the Endangered Species Act (ESA), and the National Historic Preservation Act (NHPA) at a minimum. If both agencies are involved, coordination between the agencies to determine which agency is lead would be required.

The following are the anticipated surveys, documentation, and consultation needs; however, additional information and planning may reveal the need for further survey, reporting, or permitting requirements.

- A Standard Form (SF) 299 will be required for the USFS to apply for a SUP.
- Preparation of the appropriate NEPA document (Categorical Exclusion, Environmental Assessment, or Environmental Impact Statement) as determined by the lead agency to satisfy NEPA compliance.
  - Analysis of effects on resources would be conducted using the results from the surveys below as well as additional desktop reviews (including but not limited to hazardous materials; air quality; transportation; recreation and land use; socioeconomics; geology; paleontology; vegetation; wildlife; threatened and endangered species; and noise and light pollution)
  - Once written and reviewed by all cooperating agencies, a FONSI would be issued by the lead agency to allow the project to proceed.
- Natural resource surveys and reports to support the SUP, BOR environmental permitting, and ESA Section 7 consultation process:
  - Conduct a general habitat assessment survey and necessary species-specific surveys to determine habitat and individual presence and required avoidance measures (as required by the USFWS, USFS, BOR, or other cooperating agencies).
  - Biological Assessment for submittal to the USFWS to review T&E species and informal/formal consultation with the USFWS Section 7 consultation as required by the ESA. Determine mitigation needs, as necessary.
  - Biological Evaluation for submittal to the USFS to review impacts on USFS sensitive species and determine mitigation needs, if necessary.
  - Discussion with CPW on HPH species (mule deer and elk) and potential mitigation for HPH if required.
- Wetland surveys and reporting for compliance with Section 404 of the CWA:

- A wetland delineation would be conducted following the methods for routine on-site wetland determinations as described in the 1987 Corps of Engineers Wetlands Delineation Manual (1987 Manual), and will use methods in the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0), to record data on vegetation, soils, and hydrology on routine determination forms.
- The wetland delineation report and associated forms would be submitted to the Army Corps of Engineers (Corps) to begin consultation.
- A Preconstruction Notification form (PCN) would also be prepared.
- Consultation with the Army Corps of Engineers (Corps) will determine if any documented wetlands are jurisdictional and whether a Nationwide or Individual Permit would be required. Wetland mitigation in the form of paying into or creating a wetland mitigation bank could be required, depending on Corps decisions and current WOTUS regulations

- Cultural Resource surveys and reporting for NHPA compliance:
  - A Class III cultural resource survey that complies with the Colorado State Historic Preservation office (SHPO) and agency requirements and covers the entire reservoir pool and any additional disturbance areas (e.g., temporary construction areas, staging areas, the new location of Park Ditch, and access roads) will be needed to support the SUP, BOR permitting, and Section 404 permitting.
  - Results would be compiled in a report that meets SHPO and agency standards, and site and isolated find forms would be completed. The cultural deliverables would be submitted to the lead agency, who would conduct consultation with the SHPO. Based on the preliminary results summarized above, it is likely that historic properties (eligible or needs data) are within the reservoir pool that would not be avoidable. The proposed project would likely result in adverse effects on these resources, and mitigation of these resources would be required.
- Phase I Environmental Site Assessment may also be required by agencies for NEPA compliance.
- Potential compliance with Archuleta Land Use Regulations or additional county permits, as necessary.

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APPENDIX D

COST OPINION INFORMATION

San Juan Headwaters Storage Project
Configuration 1 - Dry Gulch Site

Item	Description	Unit	Total Quantity	Unit Price	Extension
1	Mobilization @ 10% of BCS	LS	1	$ 5,534,278	$ 5,534,000
2	Clearing and Grubbing	AC	350	$ 4,000	$ 1,400,000
3	Site Reclamation	AC	25	$ 5,000	$ 125,000
4	Erosion Control	LS	1	$ 300,000	$ 300,000
5	Dewatering	LS	1	$ 150,000	$ 150,000
6	Stream Control/Cofferdam	LS	1	$ 250,000	$ 250,000
7	Surveying	LS	1	$ 200,000	$ 200,000
8	Dam Crest Aggregate Surfacing	CY	850	$ 60	$ 51,000
9	Drain Gravel and Filter Sand	CY	49,000	$ 120	$ 5,880,000
10	Embankment Fill from Reservoir Basin	CY	903,000	$ 10	$ 9,030,000
11	Core Trench Excavation	CY	125,000	$ 8	$ 1,000,000
12	Grout Curtain	SF	87,000	$ 100	$ 8,700,000
13	Riprap and Riprap Bedding	CY	54,000	$ 120	$ 6,480,000
14	Embankment Fill from Spillway Excavation	CY	100,000	$ 15	$ 1,500,000
15	Spillway Control Weir - Reinforced Concrete	CY	20	$ 2,500	$ 50,000
16	36" Welded Steel Pipe (encased in reinforced concrete)	LF	825	$ 4,500	$ 3,712,500
17	Gates, Valves, and Controls	LS	1	$ 1,000,000	$ 1,000,000
18	Low-Level Intake Structure	LS	1	$ 300,000	$ 300,000
19	Terminal Discharge Facilities	LS	1	$ 600,000	$ 600,000
20	Park Ditch Bypass Pipeline	LF	800	$ 600	$ 480,000
21	Park Ditch Bypass Pipeline Discharge Structure	LS	1	$ 200,000	$ 200,000
22	Park Ditch Pump Station / Diversion Structure	LS	1	$ 8,000,000	$ 8,000,000
23	Park Ditch Pump Station Discharge Pipeline	LF	1,000	$ 400	$ 400,000
Base Construction Subtotal (BCS)					**$ 55,340,000**
Bonds/Insurance (2% of BCS)					$ 1,110,000
Permitting (5% of BCS)					$ 2,770,000
Design Engineering (15% of BCS)					$ 8,300,000
Construction Engineering and Management (12% of BCS)					$ 6,640,000
Contingencies (40% of BCS)					$ 22,140,000
Opinion of Probable Construction Cost (OPCC)					**$ 96,300,000**

Note: Costs rounded to nearest 10,000.

CONSULTANTS, INC.

San Juan Headwaters Storage Project
Configuration 2 - Dry Gulch Site

Item	Description	Unit	Total Quantity	Unit Price	Extension
1	Mobilization @ 10% of BCS	LS	1	$ 2,952,017	$ 2,952,017
2	Clearing and Grubbing	AC	200	$ 4,000	$ 800,000
3	Site Reclamation	AC	20	$ 5,000	$ 100,000
4	Erosion Control	LS	1	$ 300,000	$ 300,000
5	Dewatering	LS	1	$ 120,000	$ 120,000
6	Stream Control/Cofferdam	LS	1	$ 250,000	$ 250,000
7	Surveying	LS	1	$ 200,000	$ 200,000
8	Dam Crest Aggregate Surfacing	CY	640	$ 60	$ 38,400
9	Drain Gravel and Filter Sand	CY	30,000	$ 120	$ 3,600,000
10	Embankment Fill from Reservoir Basin	CY	385,000	$ 10	$ 3,850,000
11	Core Trench Excavation	CY	72,000	$ 8	$ 576,000
12	Grout Curtain	SF	53,000	$ 100	$ 5,300,000
13	Riprap and Riprap Bedding	CY	23,000	$ 120	$ 2,760,000
14	Embankment Fill from Spillway Excavation	CY	40,000	$ 18	$ 720,000
15	Spillway Excavation to Waste	CY	170,000	$ 12	$ 2,040,000
16	Spillway Control Weir - Reinforced Concrete	CY	40	$ 2,500	$ 100,000
17	30" Welded Steel Pipe (encased in reinforced concrete)	LF	825	$ 3,750	$ 3,093,750
18	Gates, Valves, and Controls	LS	1	$ 840,000	$ 840,000
19	Low-Level Intake Structure	LS	1	$ 250,000	$ 250,000
20	Terminal Discharge Facilities	LS	1	$ 500,000	$ 500,000
21	Park Ditch Bypass Pipeline	LF	800	$ 600	$ 480,000
22	Park Ditch Bypass Pipeline Discharge Structure	LS	1	$ 200,000	$ 200,000
23	Park Ditch Diversion Structure	LS	1	$ 250,000	$ 250,000
24	Park Ditch Reservoir Inflow Pipeline	LF	500	$ 400	$ 200,000
Base Construction Subtotal (BCS)					**$ 29,520,000**
Bonds/Insurance (2% of BCS)					$ 590,000
Permitting (5% of BCS)					$ 1,480,000
Design Engineering (15% of BCS)					$ 4,430,000
Construction Engineering and Management (12% of BCS)					$ 3,540,000
Contingencies (40% of BCS)					$ 11,810,000
Opinion of Probable Construction Cost (OPCC)					**$ 51,370,000**

Note: Costs rounded to nearest 10,000.