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RIVER COMMISSION
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**Date: 4/21/2026**
**From: Rachel Musil**
**Subject: Provisional Accounting MOU Water Year 2025**

**Reviewed and concurred by the Bureau of Reclamation**

## Executive Summary

The Upper Basin Provisional Accounting Program, established under the December 2024 Memorandum of Understanding ("MOU") between the Upper Division States ("States") and the Bureau of Reclamation ("Reclamation"), provides a unified framework for quantifying, verifying, and reporting water contributed through approved Qualifying Activities. Water Year 2025 ("WY25") represents the first full year of implementation under this framework, with each Upper Division State identifying and accounting for actions consistent with Exhibit 1 methodologies.

Across the Upper Basin, Qualifying Activities in WY25 included reservoir storage forbearance, agricultural fallowing, and reservoir storage releases. All were evaluated using transparent, reproducible accounting methods that isolate conserved water, quantify associated losses, and determine net volumes eligible for provisional credit.

## Qualifying Activities

Table 1 summarizes the Qualifying Activities that were submitted by the States and approved by the Upper Colorado River Commission ("commission") that were implemented during WY25. This summary includes the activity name, the point of origin of the Qualifying Activity water, and the final expected destination for this water. This destination was not necessarily reached in WY25 and losses were reported based on the status at the end of WY25 (September 30, 2025). Lastly, Table 1 reports the provisional accounting activity type, demonstration or conservation, as defined in the Provisional Accounting MOU (Exhibit 1, section II), and the applied activity description

Table 2 documents the estimated volume of water contributed by an activity before implementing each of the Qualifying Activities ("Estimated Volume at Point of Origin"). After completion of each Qualifying Activity, the actual volume of water contributed at the origination location may be different than the planned volume ("Actual Volume at Point of Origin"). The transits losses ("Losses") from the point of origin to the destination on September 30, 2025 ("Volume at End of Season Destination") are also accounted for in Table 2. The Volume at the End of Season Destination for these Qualifying Activities is based on the volume of water that was measured and accounted for, using the methodologies documented in the Provisional Accounting methodology report and associated attachments. The final column of Table 2 ("Qualify for MOU Section 7 conversion") notes if the Qualifying Activity qualifies for MOU section 7 conversion.

**Table 1 WY25 Qualifying Activities**

| State | Activity Name | Water Point of Origin | Intended Water Destination | End of Water Year Water Destination | Provisional Accounting Activity Type | Activity Description |
|---|---|---|---|---|---|---|
| Colorado | Homestake Reservoir Test Release | Homestake Reservoir (Homestake Creek) | to the Utah State Line | to the Utah State Line in WY 2020 | Demonstration | Deferred transbasin diversions |
| Wyoming | Fontenelle Reservoir Test Release | Fontenelle Reservoir (Green River) | Flaming Gorge Reservoir | Flaming Gorge Reservoir | Demonstration | Release of Storage Water |
| Utah | Duchesne River Storage Forbearance | Wolf Creek/Twin Creek | Lake Powell | Starvation | Conservation | Defers transbasin diversion |
| Utah | Price River Storage Forbearance | Scofield Reservoir (Price River) | Lake Powell | Scofield | Conservation | Release of storage water |
| Utah | Price River Temporary Fallowing | Price River | Lake Powell | Lake Powell | Conservation | Fallowing fields |
| Utah | Green River and Bush Creek Temporary Fallowing | Green River, Brush Creek | Lake Powell | Lake Powell | Conservation | Partial season fallowing fields |
| New Mexico | Water Lease with Jicarilla Apache Nation | Navajo Reservoir (San Juan River) | Lake Powell | Lake Powell | Demonstration | Release of Storage Water |

**Table 2. WY25 Qualifying Activities**

| State | Activity Name | Estimated Volume at Point of Origin (AF) | Actual Volume at Point of Origin (AF) | Losses (AF) | Volume at End of Season Destination (AF) | Qualify for MOU Section 7 conversion |
|---|---|---|---|---|---|---|
| Wyoming | Fontenelle Reservoir Test Release | 2,975 | 2,435 | 35[a] | 2,400 | No |
| Utah | Duchesne River Storage Forbearance | 4,500 | 982 | 27[b] | 955 | Yes |
| Utah | Price River Storage Forbearance | 2,152 | 2,152 | 44[b] | 2,108 | Yes |
| Utah | Price River Temporary Fallowing | 2,613 | 2,149 | 166[c] | 2,743[c] | Yes |
| Utah | Green River and Bush Creek Temporary Fallowing | 1,345 | 760 | | | Yes |
| New Mexico | Jicarilla Apache Nation lease - Winter | 10,000 | 10,991 | 99[a] | 10,892 | Yes |
| New Mexico | Jicarilla Apache Nation lease -Summer | 10,000 | 10,161 | 1,240[a] | 8,921 | Yes |

[a] These losses are associated with transit losses

[b] These losses are associated with evaporation in a storage reservoir. Additional losses will occur when this water is released downstream to Lake Powell.

[c] Transit losses are determined jointly for fallowing activities.

## Accounting Summary

The detailed accounting for each of the Qualifying Activities is documented in the accounting spreadsheet that is attached hereto. A summary of the water contributed through the Qualifying Activities, at each of the activities' respective water sources' point of origin, the associated losses, and the final delivery volume at the end of WY25 to the respective water destination is provided below in a series of tables.

The Homestake Reservoir Test Release was not included in the accounting spreadsheet due to this being a previous study conducted during WY20. This Colorado Qualifying Activity is being used to demonstrate and inform the process and is included in the Provisional Accounting Methodology report for that purpose only.

### Fontenelle Reservoir Test Release

Wyoming coordinated with Reclamation to execute a test release from Fontenelle Reservoir in August 2025. This Qualifying Activity was conducted as a demonstration, and Wyoming will not seek future credit. Table 3 presents the total water released from Fontenelle, as measured at USGS gage 09211200, and then delivered to Flaming Gorge after accounting for transit losses.

**Table 3. Fontenelle Release and Transit Loss**

| | Total Released Water (AF) | Total Transit Loss (AF) | Total Delivered to Flaming Gorge (AF) |
|---|---|---|---|
| **August 2025** | 2,435 | 35 | 2,400 |

## Storage Forbearance

Forbearance of the consumptive use of storage water occurred in Utah in WY25 and was accounted for in the storage reservoirs with an incremental evaporation charge. Storage forbearance water was released downstream to Lake Powell after the irrigation season had ended and WY25 had concluded. The water released under these Qualifying Activities will be accounted for in the cumulative pool accounting in Lake Powell in the Water Year 2026 accounting.

Table 4 presents the storage forbearance that occurred on the Duchesne River due to foregone diversions into a collection system operated by the Central Utah Water Conservancy District (CUWCD) on tributaries to the Duchesne River after accounting for Starvation reservoir evaporation. That water was rediverted into Starvation Reservoir to be released after the irrigation season.

**Table 4. WY25 Duchesne River Storage Forbearance**

| | Total Inflow of Forgone Diversion Water (AF) | Total Evap Charge (AF) | Total Storage in Starvation (AF) | % Evap Loss |
|---|---|---|---|---|
| **WY25** | 982 | 27 | 955 | 2.76% |

Table 5 presents the storage forbearance that occurred on the Price River due to shareholders of Scofield reservoir water forgoing the use of that water and leaving it in the reservoir to be released after accounting for Scofield reservoir evaporation.

**Table 5. WY25 Price River Storage Forbearance**

| | Total Enrolled Storage (AF) | Total Evaporation Charge (AF) | Total Storage in Scofield (AF) | % Loss |
|---|---|---|---|---|
| **WY25** | 2,152 | 44 | 2,108 | 2.06% |

## Fallowing

Full and partial season fallowing occurred on two tributaries in Utah in WY25. When calculating the water delivered downstream, the lesser of either the available water, conserved consumptive use (“CCU”) calculation, or the measured volume delivered downstream was used. These numbers were estimated with pre-season CCU numbers and then adjusted after the irrigation season based on the actual post-season CCU numbers. Table 6 presents the estimated CCU (two sources of water related to the irrigation of the fallowed fields), the river water rights of the Price River, and the storage in Scofield reservoir. River water was only available for part of the season, and CCU was calculated for that period. Once river water supplies were exhausted, water was called from Scofield Reservoir, and the storage-based CCU is reflected in the table. The table reports actual CCU, which is the sum of the river water and storage CCU.

**Table 6. WY25 Price River Fallowing**

| | Estimated CCU (AF) | River water CCU (AF) | Storage CCU (AF) | Actual CCU (AF) |
|---|---|---|---|---|
| **Price River** | 2,631 | 914 | 1,235 | 2,149 |

Table 7 presents the estimated CCU and the actual CCU for the partial season fallowing on both Green River and Brush Creek.

**Table 7. WY25 Green River Tributary Fallowing**

| | Estimated CCU (AF) | Actual CCU (AF) |
|---|---|---|
| **Green River** | 656 | 299 |
| **Brush Creek** | 689 | 461 |
| **TOTAL** | **1,345** | **760** |

Table 8 demonstrates the transit losses for the combination of the Qualifying Activities for Utah. The source water was aggregated to calculate the transit losses of the total water that was delivered to Lake Powell.

**Table 8. WY25 Utah Transit Loss Summary**

| | Total Water at Point of Origin (AF) | Total Transit Loss (AF) | Total Delivered to Lake Powell (AF) |
|---|---|---|---|
| **WY 2025** | 2,909 | 166 | 2,743 |

## Jicarilla Apache Nation (JAN) Lease Water

The New Mexico Interstate Stream Commission (NMISC) can lease up to 20,000 acre-feet/yr of JAN water stored in Navajo Reservoir and place it in New Mexico’s Strategic Water Reserve by releasing that amount to the San Juan River to Lake Powell Reservoir. Two releases occurred in WY25, as shown in Table 9. Due to operational constraints, slightly higher volume than 10,000 acre-feet for each block was released.

**Table 9. WY25 JAN Release and Transit Loss**

| | Total Navajo Released Water (AF) | Total Transit Loss (AF) | Total Delivered to Lake Powell (AF) |
|---|---|---|---|
| **Winter 2024** | 10,991 | 99 | 10,892 |
| **Summer 2025** | 10,161 | 1,240 | 8,921 |

## Lake Powell Evaporation and Cumulative Pool Accounting

Qualifying Activity water was aggregated by State at a monthly timestep to inform the amount of water delivered to Lake Powell. Table 10 shows a monthly timestep accounting for the water that was delivered with an incremental evaporation charge.

**Table 10. WY25 Upper Basin Qualifying Activity Delivery to Lake Powell**

| Upper Basin Qualifying Activity Delivery to Lake Powell | | | | | | | |
|---|---|---|---|---|---|---|---|
| Time Period | New Mexico Qualifying Activities acre-feet | Utah Qualifying Activities acre-feet | Less Converted to system acre-feet | Less Spill acre-feet | Less Incremental Evaporation acre-feet | Total UB QA Delivered to Lake Powell acre-feet | Total UB QA Storage in Lake Powell<br>0 |
| Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov | 7,254 | 0 | 0 | 0 | -14 | 7,240 | 7,240 |
| Dec | 3,638 | 0 | 0 | 0 | -17 | 3,620 | 10,860 |
| Jan | 0 | 0 | 0 | 0 | -5 | -5 | 10,855 |
| Feb | 0 | 0 | 0 | 0 | -5 | -5 | 10,850 |
| Mar | 0 | 0 | 0 | 0 | -9 | -9 | 10,841 |
| Apr | 0 | 112.2 | 0 | 0 | -14 | 98 | 10,939 |
| May | 0 | 417.2 | 0 | 0 | -17 | 400 | 11,339 |
| Jun | 0 | 514.9 | 0 | 0 | -27 | 488 | 11,827 |
| Jul | 573 | 669.5 | 0 | 0 | -38 | 1,204 | 13,032 |
| Aug | 8,348 | 547.6 | 0 | 0 | -61 | 8,834 | 21,866 |
| Sep | 0 | 482.0 | 0 | 0 | -59 | 423 | 22,290 |
| Total | 19,813 | 2,743 | 0 | 0 | -267 | 22,290 | |

## Flaming Gorge Reservoir Evaporation and Cumulative Pool Accounting

Wyoming will not be seeking credit in the future for the Fontenelle Reservoir Test Release water in WY25. However, this is presented as a demonstration project of the methodology used to account for the water in Flaming Gorge reservoir with associated evaporation losses. This methodology informs the future process for water for which Wyoming would be seeking credit. Table 11 shows a monthly timestep accounting for the water that was delivered to Flaming Gorge, with an incremental evaporation charge.

**Table 11. WY25 Upper Basin Qualifying Activity Delivery to Flaming Gorge**

| Upper Basin Qualifying Activity Delivery to Flaming Gorge | | | | | | |
|---|---|---|---|---|---|---|
| | **Wyoming Qualifying Activities** | **Less Converted to system** | **Less Spill** | **Less Incremental Evaporation** | **Total UB QA Delivered to Flaming Gorge** | **Total UB QA Storage in Flaming Gorge** |
| **Time Period** | **acre-feet** | **acre-feet** | **acre-feet** | **acre-feet** | **acre-feet** | 0 |
| Oct | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug | 2,400 | 0 | 0 | -6 | 2,394 | 2,394 |
| Sep | 0 | 0 | 0 | -5 | -5 | 2,389 |
| Total | 2,400 | 0 | 0 | -11 | 2,389 | |

# PROVISIONAL ACCOUNTING

Water Year 2025 Methodologies

APRIL 21, 2026

UPPER COLORADO RIVER COMMISSION

Reviewed and concurred by the Bureau of Reclamation
April 9th 2026

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# Provisional Accounting Methodology Summary

## Overview

Under the Provisional Accounting Memorandum of Understanding (MOU) Exhibit 1, the Upper Division States must apply methods to quantify water from Qualifying Activities and account for any losses in order to seek potential credit from the Bureau of Reclamation for the contributed water. As specified, these methods include: (1) estimating conserved consumptive use (CCU) or release volumes using approved approaches such as eeMETRIC model or other state-derived methods; (2) calculating incremental conveyance and transit losses between the conservation site (Point A also termed the Point of Origin ) and the designated Upper Basin reservoir or delivery location (Point B also termed the End of Season Destination), considering factors such as proximity, intervening diversions, and timing; and (3) determining evaporation losses or spill impacts at the reservoir using state-derived estimates consistent with Reclamation's protocols or justified alternatives.

This document provides the water accounting methodologies, consistent with Provisional Accounting MOU Exhibit 1 (see attachment A), and the data sources used to verify and account for the Qualifying Activities implemented in Water Year 2025 by the Upper Division States in the Colorado River Basin. The sections that follow are organized by state and first present each state's Qualifying Activities, then the conserved/released volume, transit loss estimation, reservoir storage losses, and data sources. Each section represents the common accounting approach applied collectively to all Qualifying Activities within the Upper Division State.

## Colorado

### Qualifying Activities

Colorado put forth the following project as a Qualifying Activity:

- One storage release demonstration project:
    - Homestake Reservoir Test Release

#### *Homestake Reservoir Test Release*

In September 2020, the Colorado Division of Water Resources and municipal partners conducted a pilot release of 1,666.9 acre-feet from Homestake Reservoir to evaluate the process of tracking water to the Colorado–Utah state line. The release was managed to prevent downstream diversions and monitored using stream gage data and hydrograph analysis. Although this Qualifying Activity was performed during 2020, Colorado offered this study as a Qualifying Activity to help inform the accounting process. Colorado will not claim future credit for this Qualifying Activity and the accounting for this water was not included in this report since this Qualifying Activity occurred in water year 2020.

### *Conserved/Released Volume*

The total volume released from Homestake Reservoir for the study was 1,666.9 acre-feet. This water was released between September 23 and September 29, 2020, with a flow pattern that started at 29 CFS and peaked at 175 CFS before tapering off. Homestake reservoir is a transmountain diversion reservoir and the water that was released for this study was a result of action by certain cities, that would have otherwise taken this water for their municipal uses, forgoing the transmountain diversion.

### *Transit Loss Estimation*

Transit times ranged from 1 hour on Homestake Creek to 66 hours near Palisade, though the release could not be clearly identified at the state line due to ungaged inflows. Transit loss analysis showed a 20% loss over the first 18 miles and an additional 3% over the next 25 miles, in the Eagle River basin, while losses on the Colorado River were inconclusive. The Qualifying Activity confirmed the feasibility of shepherding releases and highlighted the need for improved infrastructure, gage calibration, and communication for future efforts. Details on the transit loss estimation are in *Summary of the Homestake Reservoir State Line Delivery Pilot Release Report* (Attachment B).

### *Reservoir Storage Losses*

Reservoir storage losses were not considered as part of this Qualifying Activity as it was a study that was performed in water year 2020.

### *Data Sources*

This demonstration Qualifying Activity relied on multiple data sources to ensure accurate tracking and analysis of the test release.

Colorado State Streamflow Gages

- *HOMGULCO: Homestake Creek*
- *EAGMINCO: Eagle River near Minturn*
- *EAGAVOCO: Eagle River at Avon*
- *EAGMILCO: Eagle River near Milk Creek*
- *EAGGYPCO: Eagle River at Gypsum*
- *COLDOTCO: Colorado River at Dotsero*
- *COLGLECO: Colorado River at Glenwood Springs*
- *COLCAMCO: Colorado River near Cameo*
- *COLPALCO: Colorado River near Palisade*
- *COLUTACO: Colorado River near Colorado–Utah State Line*

Reservoir Release Measurements

- Homestake Reservoir Release
- Granby Reservoir Release
- Wolford Reservoir Release
- Ruedi Reservoir Release

## Wyoming

### Qualifying Activities

In WY 2025 Wyoming had the following Qualifying Activities:

- One storage release demonstration project:
  - Fontenelle Reservoir Test Release

#### *Fontenelle Reservoir Test Release*

Wyoming coordinated with Reclamation to execute a test release of an estimated 2,975 acre-feet (AF) from Fontenelle Reservoir in August 2025 as part of this Qualifying Activity. Wyoming, in coordination with Reclamation, adjusted timing and flows to test the ability to track a known release for accounting purposes. While the plan provided a target release volume, the actual volume was lower than intended, as seen at USGS gage 09211200. Efforts are underway to determine the reason for this difference. The release was implemented within normal operational guidelines and designed to create a clear block of water that was detectable, verifiable, and attributed to the test release for accounting purposes. This qualifying activity was conducted as a demonstration and Wyoming will not seek future credit; however, the released water was accounted for using the released volumes at Flaming Gorge to further illustrate how future Qualifying Activities would contribute water and be stored within the system.

#### *Conserved/Released Volume*

Wyoming conducted a demonstration release of 2,435 AF from Fontenelle Reservoir storage water, as measured at USGS gage 09211200, that was part of normal operational releases. Operations included reducing flows to about 700 CFS for 10 days, increasing to 1,000 CFS for 5 days, and then returning to 700 CFS for 15 days before resuming standard releases. The test release supported efforts to refine Provisional Accounting methods by providing measurable data on flow tracking, transit losses, and operational feasibility. Total incremental transit loss: 0.94% (35 AF). Delivered to Flaming Gorge: 2,400 AF.

### *Transit Loss Estimation*

Wyoming's transit loss estimation uses an incremental approach to quantify additional losses incurred as the test release water moves from Fontenelle Reservoir to Flaming Gorge Reservoir. Rather than measuring total physical losses, the method isolates the incremental increase in riparian evapotranspiration and stream surface evaporation attributable to test release water flowing through the river reach. A RiverWare® model of the Upper Colorado River Basin was developed using USGS and State Engineer's Office gage data and simulated confluence points to calculate reach-specific losses based on riparian ET and surface water evaporation flow-to-loss relationships derived from OpenET data. For further details about the transit loss estimation, see *2025 Wyoming Provisional Accounting Final Report* (Attachment C).

### *Reservoir Storage Losses*

This Qualifying Activity was a demonstration project that was facilitated through the retiming of one month's release volume from Fontenelle Reservoir, and for which Wyoming will not be seeking credit. The water was accounted for as if it were delivered as an increase in volume and stored in Flaming Gorge. Furthermore, Wyoming demonstrated how additional water from a Qualifying Activity stored in Flaming Gorge, would increase the volume of water in Flaming Gorge and incur an incremental evaporation charge based on the increase in surface area in Flaming Gorge. Reservoir storage losses in Flaming Gorge are discussed in the Upper Initial Unit Reservoir Evaporation section towards the end of this document.

### *Data Sources*

The demonstration Qualifying Activity relied on multiple data sources to ensure accurate tracking and analysis of the test release.

<u>USGS Streamflow Gages</u>
- *09211200*: Below Fontenelle Reservoir (used to represent release flows).
- *09217000*: Green River near Green River, WY (final inflow point for Flaming Gorge).

<u>Manual Measurements</u>
- At USGS gages *09211200* and *09217000 to validate data*
- At the mouths of Big Sandy River and Bitter Creek to capture additional inflows.

<u>Evaporation Data</u>
- Western Regional Climate Center pan evaporation data.

<u>Evapotranspiration (ET) Data</u>
- SSEBop remote sensing model (Operational Simplified Surface Energy Balance) using monthly data from January 2000–December 2024 for transit loss estimation.
- Riparian vegetation extent from CO-RIP dataset (Woodward et al., 2018).

<u>Diversion and Return Flow Data</u>

- Bureau of Reclamation Consumptive Uses and Losses dataset (used as a proxy for diversion-return flow components).

Modeling Tools

- RiverWare® model for simulating physical flow and estimating incremental transit losses.

## Utah

### Qualifying Activities

In WY 2025 Utah had four Qualifying Activities:

- Two Reservoir storage forbearance conservation projects:
  - Duchesne River
  - Price River
- Two temporary fallowing conservation projects:
  - Price River Tributary Group
  - Green River and Brush Creek Tributary Group

#### Storage Forbearance

In 2025, Utah implemented two Storage Forbearance Qualifying Activities. First, the Duchesne River project, which is a trans-basin diversion from the Colorado River System to the Great Salt Lake Basin, agreed to forego diversions on two reaches, Wolf and Twin creeks. The water would have ultimately been stored in Strawberry Reservoir, where water is diverted trans-basin and used in the Great Salt Lake Basin. Those diversions did not take place and instead, the water was rediverted into Starvation Reservoir through the irrigation season, with release to Lake Powell occurring in November 2025. An estimated yield of 4,500 AF was not achieved by this Qualifying Activity due to hydrologic shortage. The water right associated with the two stream reaches had a priority distribution call early in the irrigation season. The total water that was available and stored in Starvation Reservoir at the end of the water year totaled 982 AF.

The second storage forbearance project occurred at the Price River project, where reservoir shareholders enrolled 2,152 AF in the program. This water was stored in Scofield Reservoir during the irrigation season and released to Lake Powell beginning in November 2025. The conserved consumptive use for the water stored in Scofield Reservoir is estimated to be 1,377 AF based on 64% of consumptive use associated with the shares. The water remained in Scofield Reservoir at the end of WY25. When this water is released to Lake Powell in WY26 only the 1,377 AF will be accounted for.

### Temporary Fallowing

In 2025, Utah also implemented two temporary fallowing qualifying activities. The Price River Tributary group project involved 1,841 acres of full or partial season fallowed agricultural land served by the Carbon Canal in Price, Utah. The Green River and Brush Creek tributary group project consisted of 1,520 acres of partial season fallowed land along the Green River near Ouray, Utah and Brush Creek near Jensen, Utah.

### Conserved/Released Volume

CCU for Utah's Qualifying Activities was calculated by comparing evapotranspiration (ET) under irrigated and fallowed conditions for the same fields across different years, using OpenET's eeMETRIC model and USDA methods for soil moisture and effective precipitation. Pre-season CCU was estimated from a seven-year historical lookback, while post-season actual CCU was computed by adjusting ET differences with a correction factor based on short crop reference ET.

For reservoir storage projects, CCU was assumed equal to enrolled volumes adjusted for conveyance and irrigation efficiencies, and for trans-basin diversion projects, CCU equaled 100 percent of delivered water. Post-season CCU estimates were verified using flow measurements at downstream USGS gages, ensuring that credited volumes reflected actual hydrologic conditions and accounted for intervening diversions and shortages. Full details on the methodology used to quantify Utah's CCU are included in the *Annual Report on the Utah Demand Management Pilot Program: Conserved Consumptive Use Estimates and Provisional Accounting Methodologies* (Attachment D).

### Transit Loss Estimation

Utah's transit loss estimation uses an incremental approach to quantify additional losses incurred as CCU water moves from project sites to Lake Powell. Rather than measuring total physical losses, the method isolates the incremental increase in riparian evapotranspiration attributable to CCU water flowing through river reaches. A RiverWare® model of the Upper Colorado River Basin was developed using USGS gage data and simulated confluence points to calculate reach-specific losses based on flow-to-loss relationships derived from OpenET data. This incremental loss is applied as an accounting adjustment, ensuring system water is not penalized for additional transit losses associated with conservation activities.  Full details on the methodology used to quantify Utah's transit loss are included in the *Annual Report on the Utah Demand Management Pilot Program: Conserved Consumptive Use Estimates and Provisional Accounting Methodologies* (Attachment D).

## Reservoir Storage Losses

Reservoir losses were estimated using an incremental evaporation method that isolates the additional evaporation attributable to CCU water stored alongside system water. The approach compared reservoir surface area with and without CCU water using elevation–volume and elevation–area tables to determine the incremental increase in surface area caused by CCU storage. This increase was then applied to total reservoir evaporation to calculate the portion of evaporation loss assigned to CCU water. Losses were tracked daily and aggregated over the storage period, ensuring accurate accounting adjustments, so that system water was not penalized for evaporation associated with conservation activities.

Reservoir storage losses *for Utah Projects that reached Lake Powell* are covered in the Upper Initial Unit Reservoir Evaporation section of this document.

## Data Sources

USGS Streamflow Gages

- *09263500*: Brush Creek near Jensen, UT
- *09272400*: Green River at Ouray, UT
- *09261000*: Green River near Jensen, UT
- *09379910*: Colorado River below Glen Canyon Dam, AZ
- *09314500*: Price River near Helper, UT
- *09314500*: Price River at Woodside, UT
- *09315000*: Green River at Green River, UT
- *09328920*: Green River at Mineral Bottom NR Cynlnds Ntl Park, UT
- *09328960:* Colorado River at Gypsum Canyon Near Hite, UT

Evaporation Data

- Recorded Total Reservoir Evaporation from the Administering entity of the reservoir
- Reservoir evaporation coefficients

Evapotranspiration (ET) Data

- eeMETRIC model for actual ET data for field-scale CCU calculations
- USDA methods for estimating effective precipitation and carryover soil moisture
- SSEBop remote sensing model (Operational Simplified Surface Energy Balance) used for transit loss estimation
- Riparian vegetation extent from CO-RIP dataset (Woodward et al., 2018).

Modeling Tools

RiverWare® model for simulating physical flow and estimating incremental transit losses.

Reservoir Data

- Reservoir evaluation volume and elevation area tables for both Scofield and Starvation Reservoirs
- Reservoir release data from Starvation Reservoir
- Reservoir release data from Scofield Reservoir

# New Mexico

## Qualifying Activities

In WY 2025 New Mexico had the following Qualifying Activities:

- One storage release demonstration project:
    - Jicarilla Apache Nation (JAN) Lease Water

### *Jicarilla Apache Nation (JAN) Lease Water*

New Mexico has a statutory tool, the Strategic Water Reserve (SWR), that allows the New Mexico Interstate Stream Commission (NMISC) to lease water that, among other things, can help ensure compact compliance. The NMISC and the Jicarilla Apache Nation (JAN or Nation) have entered into an agreement to lease up to 20,000 acre-feet per year from Nation's contract water in the Navajo Reservoir water supply. Reclamation owns and operates Navajo Reservoir. The leased water was released from Navajo Reservoir at the request of the NMISC. The NMISC coordinated with Reclamation to conduct two releases from Navajo Reservoir in November and December of 2024 ("November release") and in July and August ("July Release") of 2025.

### *Conserved/Released Volume*

In 1992, the State of New Mexico and the Nation settled the Nation's water rights claims. The settlement gives the Nation 34,195 acre-feet of depletion rights. Part of that water is stored in Navajo Reservoir, pursuant to a contract between the Nation and the Department of the Interior. Following the 1992 settlement, and until 2019, the Nation leased 24,700 acre-feet of that right to the Public Service Company of New Mexico (PNM) and Arizona Public Service (APS) for full consumptive use at the San Juan Generating Station and the Four Corners Generating Station. See the last two rows in Table 5.4-C below from the JAN chapter of the 2018 Tribal Water Study denote this use. The average annual estimated CU by the Nation as reported by the State for 2016-2022 was 30,709 acre-feet.

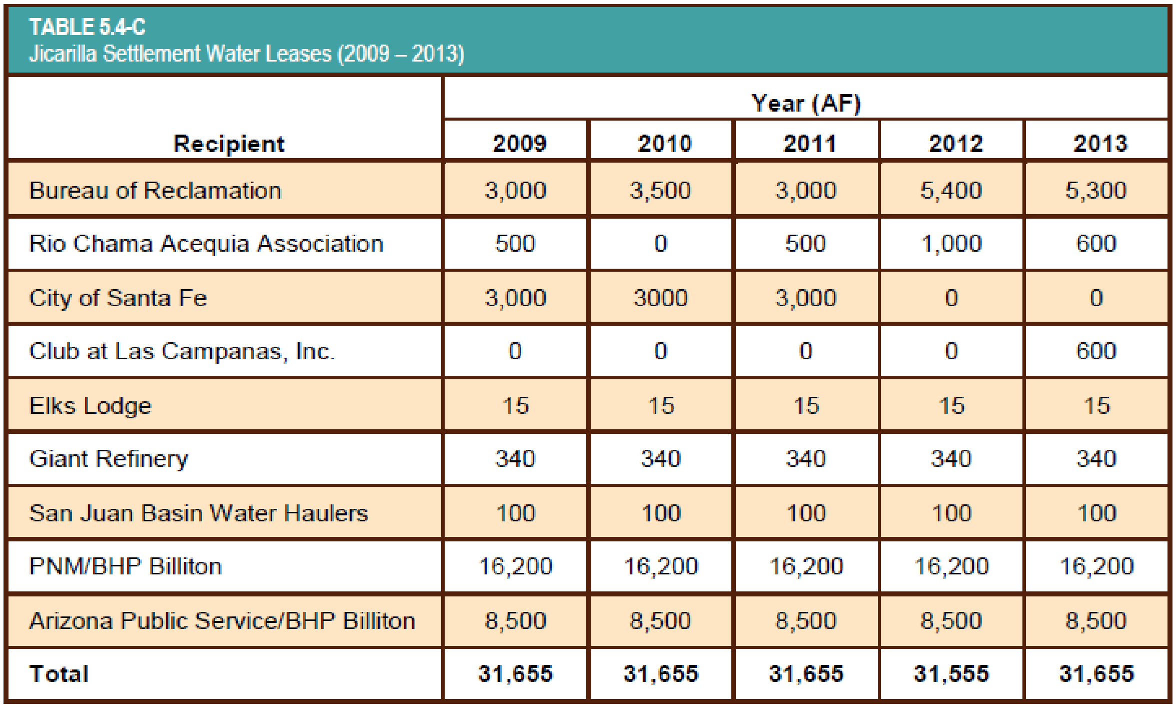


**TABLE 5.4-C**
Jicarilla Settlement Water Leases (2009 – 2013)

| Recipient | Year (AF) | | | | |
|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 |
| Bureau of Reclamation | 3,000 | 3,500 | 3,000 | 5,400 | 5,300 |
| Rio Chama Acequia Association | 500 | 0 | 500 | 1,000 | 600 |
| City of Santa Fe | 3,000 | 3000 | 3,000 | 0 | 0 |
| Club at Las Campanas, Inc. | 0 | 0 | 0 | 0 | 600 |
| Elks Lodge | 15 | 15 | 15 | 15 | 15 |
| Giant Refinery | 340 | 340 | 340 | 340 | 340 |
| San Juan Basin Water Haulers | 100 | 100 | 100 | 100 | 100 |
| PNM/BHP Billiton | 16,200 | 16,200 | 16,200 | 16,200 | 16,200 |
| Arizona Public Service/BHP Billiton | 8,500 | 8,500 | 8,500 | 8,500 | 8,500 |
| **Total** | **31,655** | **31,655** | **31,655** | **31,555** | **31,655** |

In 2022, the NMISC entered into a 10-year lease agreement with the Nation to lease, each year, up to 20,000 of the 24,700 acre-feet previously leased to and fully used by PNM and APS (16,200+8,500), and to place it in SWR. This is a forbearance scheme in which the Nation forbears using the water or leasing to other parties for full consumptive use and instead leases it to the NMISC. The resulting CCU of the JAN release is the total volume leased by New Mexico.

New Mexico conducted two releases from Navajo Reservoir under the JAN lease agreement, totaling 21,152 acre-feet during Water Year 2025. Due to operational constraints, slightly higher volume than the 10,000 AF for each block was released. The water was tracked using USGS gage data across nine San Juan River reaches. Transit losses from open water evaporation and riparian evapotranspiration estimates were computed using OpenET, which provides ET rates for the San Juan River corridor. Results showed that the November release of 10,991 acre-feet experienced minimal loss (1%), delivering 10,892 acre-feet to Lake Powell as measured at the San Juan River Piute Farms Wash USGS gage, while the July release of 10,161 acre-feet incurred higher losses (12%) due to summer conditions, delivering 8,921 acre-feet to Lake Powell.

### *Transit Loss Estimation*

The transit loss analysis for New Mexico's JAN lease releases focused on open water evaporation and riparian evapotranspiration as the primary loss factors along the 254.5-mile San Juan River route from Navajo Reservoir to Lake Powell. Using OpenET data and riparian mapping, riparian evapotranspiration losses were calculated for each reach and proportionally assigned to the JAN releases based on JAN release flows compared to the total USGS gage flows. Results showed minimal loss during the November release—about 1% (99 acre-feet)—due to cooler temperatures and low evaporation, while the July release experienced significantly higher losses of 12% (1,240 acre-feet) under hot and dry conditions. No irrigation interference was detected, and the accounting used evaporative losses as the transit loss and did not include groundwater interactions. Overall, the study confirmed that most leased water reached Lake Powell, with transit losses from seasonal open water evaporation and riparian evapotranspiration.  A detailed report on the transit loss estimation, *Jicarilla Apache Nation Lease Water Accounting Estimation for Water Year 2025*, can be found in Attachment E.

### *Reservoir Storage Losses*

Reservoir storage losses of the *JAN water in Lake Powell* is discussed in the Reservoir evaporation section of this document.

### *Data Sources*

The accounting of this water relied on multiple datasets and references to estimate transit losses and confirm delivery of leased water to Lake Powell:

USGS Streamflow Gages

- 09355500: San Juan River near Archuleta, NM
- 09357000: San Juan River at Bloomfield, NM
- 09357700: San Juan River at Bolack Ranch Bridge near Farmington, NM
- 09365000: San Juan River at Farmington, NM
- 09367540: San Juan River near Fruitland, NM
- 09368000: San Juan River at Shiprock, NM
- 09371010: San Juan River at Four Corners, CO
- 09379500: San Juan River near Bluff, UT
- 09379700: San Juan River below Piute Farms Wash near Monument Valley, UT

*Evapotranspiration (ET) Data*

- OpenET eeMETRIC Dataset – Provided daily evapotranspiration and evaporation rates, incorporating temperature, precipitation, and riparian land use conditions.
- New Mexico Riparian Habitat Map (2020), Utah DWRe Water-Related Land Use (2021), and USDA NASS Cropland Data Layer (2024)

Weather Data

- Temperature from Farmington Agricultural Science Center

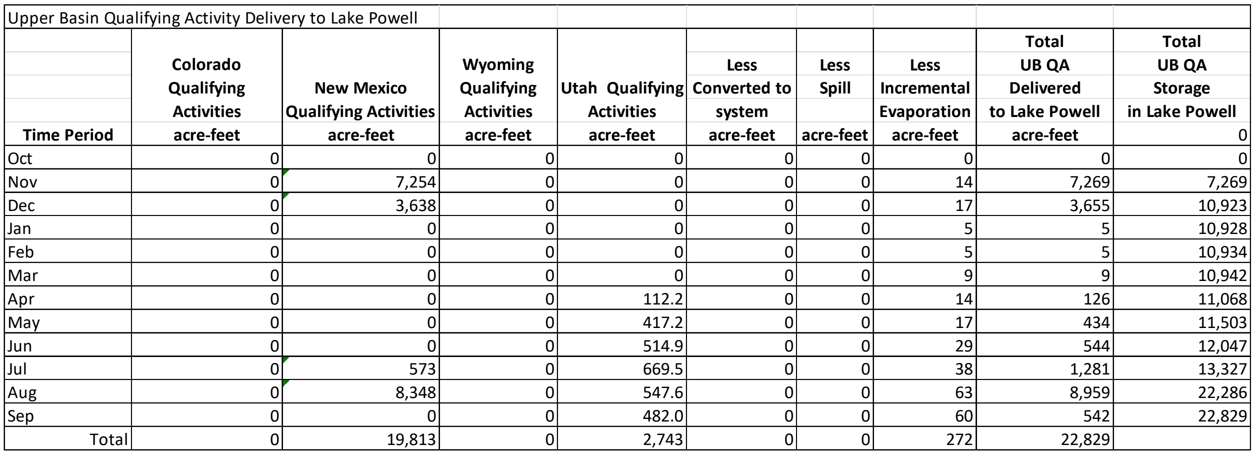
# Upper Initial Unit Reservoir Evaporation

## Lake Powell

The only three Qualifying Activities that delivered water to be stored in Lake Powell for WY2025 were the two Utah temporary fallowing projects and the New Mexico Jicarilla Apache Nation (JAN) Lease Water project. Water from the two Utah storage forbearance projects activities will be delivered to Lake Powell in WY2026. Reservoir losses at Lake Powell were estimated using an incremental evaporation method that isolates the additional evaporation attributable to the Qualifying Activities water stored alongside system water in Lake Powell. The approach compared reservoir surface area with and without Qualifying Activity water using the elevation–area-capacity tables for Lake Powell[1] to determine the incremental increase in surface area caused by storage of Qualifying Activity water. This increase was then applied to total reservoir evaporation to calculate the portion of evaporation loss assigned to the Qualifying Activity water. The total evaporation is taken from Reclamation's recorded evaporation for Lake Powell and summed for the month. The total monthly evaporation was then multiplied by the incremental increase in area divided by the total surface area.

$$Evap_{QA} = Evap_{Total} \times \frac{Acres_{QA}}{Acres_{Total}}$$

Losses were tracked at a monthly timestep, accounting for any Qualifying Activity water reaching Lake Powell in that month at full evaporation rates for that entire month and aggregated over the storage period.



Upper Basin Qualifying Activity Delivery to Lake Powell

| Time Period | Colorado Qualifying Activities acre-feet | New Mexico Qualifying Activities acre-feet | Wyoming Qualifying Activities acre-feet | Utah Qualifying Activities acre-feet | Less Converted to system acre-feet | Less Spill acre-feet | Less Incremental Evaporation acre-feet | Total UB QA Delivered to Lake Powell acre-feet | Total UB QA Storage in Lake Powell 0 |
|---|---|---|---|---|---|---|---|---|---|
| Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov | 0 | 7,254 | 0 | 0 | 0 | 0 | 14 | 7,269 | 7,269 |
| Dec | 0 | 3,638 | 0 | 0 | 0 | 0 | 17 | 3,655 | 10,923 |
| Jan | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 10,928 |
| Feb | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 10,934 |
| Mar | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 9 | 10,942 |
| Apr | 0 | 0 | 0 | 112.2 | 0 | 0 | 14 | 126 | 11,068 |
| May | 0 | 0 | 0 | 417.2 | 0 | 0 | 17 | 434 | 11,503 |
| Jun | 0 | 0 | 0 | 514.9 | 0 | 0 | 29 | 544 | 12,047 |
| Jul | 0 | 573 | 0 | 669.5 | 0 | 0 | 38 | 1,281 | 13,327 |
| Aug | 0 | 8,348 | 0 | 547.6 | 0 | 0 | 63 | 8,959 | 22,286 |
| Sep | 0 | 0 | 0 | 482.0 | 0 | 0 | 60 | 542 | 22,829 |
| Total | 0 | 19,813 | 0 | 2,743 | 0 | 0 | 272 | 22,829 | |

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[1] https://www.sciencebase.gov/catalog/item/614ccd07d34e0df5fb9868e2

Lake Powell Incremental Evaporation from UB QA Water

| Time Period | EOM Elevation feet | EOM Surface Area w/ UB QA Water acres | EOM Surface Area w/o UB QA Water acres | Incremental Increase in Surface Area acres | Total Evaporation acre-feet | Incremental Evaporation acre-feet |
|---|---|---|---|---|---|---|
| Oct | 3,576.88 | 77,612 | 77,612 | 0 | 24,864 | 0 |
| Nov | 3,575.23 | 76,863 | 76,817 | 46 | 24,069 | 14 |
| Dec | 3,571.99 | 75,358 | 75,290 | 68 | 18,942 | 17 |
| Jan | 3,566.75 | 73,066 | 73,001 | 66 | 5,468 | 5 |
| Feb | 3,562.75 | 71,227 | 71,159 | 68 | 5,621 | 5 |
| Mar | 3,559.30 | 69,814 | 69,748 | 66 | 9,331 | 9 |
| Apr | 3,557.90 | 69,243 | 69,178 | 65 | 14,684 | 14 |
| May | 3,558.98 | 69,682 | 69,612 | 70 | 17,123 | 17 |
| Jun | 3,561.30 | 70,627 | 70,554 | 73 | 27,719 | 29 |
| Jul | 3,555.36 | 68,205 | 68,126 | 79 | 32,746 | 38 |
| Aug | 3,548.18 | 65,364 | 65,232 | 133 | 31,131 | 63 |
| Sep | 3,544.69 | 64,020 | 63,881 | 139 | 27,771 | 60 |
| Year total | | | | | | 272 |

## Flaming Gorge

The only Qualifying Activity that stored water in Flaming Gorge was the Fontenelle Reservoir Test Release. Because it consisted only of a retiming of the daily Fontenelle Reservoir releases in August, there was no actual increase in the monthly volume in Flaming Gorge, or associated evaporation losses to be assessed for the test release. However, the following exercise was conducted to demonstrate the accounting that would be conducted had there been additional water sent to and stored within Flaming Gorge Reservoir.

Reservoir losses were estimated using an incremental evaporation method that isolates the additional evaporation attributable to the Qualifying Activity water stored alongside system water in Flaming Gorge. The approach compared reservoir surface area with and without Qualifying Activity water using the elevation–area-capacity table equation parameters and the reservoir storage capacity interpolation equations for Flaming Gorge[2] to determine the incremental increase in surface area caused by the storage of Qualifying Activity water. This increase was then applied to the evaporation coefficients to calculate the portion of evaporation loss assigned to the Qualifying Activity water. Losses were tracked at a monthly timestep, accounting for the Qualifying Activity water reaching Flaming Gorge Reservoir in that month at full evaporation rates for that entire month and aggregated over the storage period. Evaporation rates were provided by Reclamation to the

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[2] Flaming Gorge Reservoir 2019 Area and Capacity Tables

Upper Colorado River Commission in spreadsheet format from the Projects, Operations, and Modeling Division of the Upper Colorado Regional Office.

Upper Basin Qualifying Activity Delivery to Flaming Gorge

|  | Wyoming Qualifying Activities | Less Converted to system | Less Spill | Less Incremental Evaporation | Total UB QA Delivered to Flaming Gorge | Total UB QA Storage in Flaming Gorge |
|---|---|---|---|---|---|---|
| Time Period | acre-feet | acre-feet | acre-feet | acre-feet | acre-feet | 0 |
| Oct | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec | 0 | 0 | 0 | 0 | 0 | 0 |
| Jan | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar | 0 | 0 | 0 | 0 | 0 | 0 |
| Apr | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug | 2,400 | 0 | 0 | -6 | 2,394 | 2,394 |
| Sep | 0 | 0 | 0 | -5 | -5 | 2,389 |
| Total | 2,400 | 0 | 0 | -11 | 2,389 |  |

Flaming Gorge Incremental Evaporation from UB QA Water

| Time Period | EOM Elevation feet | EOM Surface Area w/ UB QA Water acres | EOM Surface Area w/o UB QA Water acres | Incremental Increase in Surface Area acres | Incremental Evaporation inches | Incremental Evaporation acre-feet |
|---|---|---|---|---|---|---|
| Oct | 6,026.69 | 35,647 | 35,647 | 0 | 2.28 | 0 |
| Nov | 6,026.64 | 35,633 | 35,633 | 0 | 1.15 | 0 |
| Dec | 6,026.05 | 35,475 | 35,475 | 0 | 0.62 | 0 |
| Jan | 6,025.15 | 35,234 | 35,234 | 0 | 0.58 | 0 |
| Feb | 6,025.97 | 35,453 | 35,453 | 0 | 0.71 | 0 |
| Mar | 6,026.41 | 35,572 | 35,572 | 0 | 1.04 | 0 |
| Apr | 6,026.72 | 35,655 | 35,655 | 0 | 1.59 | 0 |
| May | 6,027.90 | 35,979 | 35,979 | 0 | 2.50 | 0 |
| Jun | 6,027.51 | 35,871 | 35,871 | 0 | 3.29 | 0 |
| Jul | 6,026.01 | 35,464 | 35,464 | 0 | 4.12 | 0 |
| Aug | 6,024.21 | 34,985 | 34,967 | 18 | 3.96 | -6 |
| Sep | 6,022.58 | 34,560 | 34,542 | 18 | 3.39 | -5 |
| Year total |  |  |  |  | 25.22 | -11 |

## References

Jones, D.K., & Root, J.C. (2022). *Elevation-area-capacity tables for Lake Powell, 2018* [Data Release]. U.S. Geological Survey. https://doi.org/10.5066/P9O3IPG3

Collins, K., Hilldale, R. (2019) *Flaming Gorge Reservoir 2019 Area and Capacity Tables*, Technical Memorandum ENV-2021-112. 2019. Bureau of Reclamation. https://www.usbr.gov/tsc/techreferences/reservoir.html

## Attachments

Attachment A - Provisional Accounting MOU signed

Attachment B - Summary of the Homestake Reservoir State Line Delivery Pilot Release Report

Attachment C - 2025 Wyoming Provisional Accounting Final Report

Attachment D - Annual Report on the Utah Demand Management Pilot Program: Conserved Consumptive Use Estimates and Provisional Accounting Methodologies

Attachment E - Jicarilla Apache Nation Lease Water Accounting Estimation for Water Year 2025

# Memorandum of Understanding
# between the U.S. Bureau of Reclamation
# and the Upper Division States through the Upper Colorado River Commission

## I. Introduction

This Memorandum of Understanding ("MOU") is entered into by and between the United States of America, represented by the Secretary of the Interior, through the officials of the U.S. Bureau of Reclamation ("Reclamation") executing this MOU, and the Upper Division States of Colorado, New Mexico, Utah, and Wyoming, through the Upper Colorado River Commission ("UCRC"), each being referred to individually as a "Party" and collectively as the "Parties."

Since 2000, the Colorado River Basin has experienced drought conditions that have decreased water supplies in the Upper Colorado River Basin and increased uncertainty regarding the availability of water needed to sustain existing uses throughout the Basin. The Parties have been working together to mitigate the risks associated with drought in the Upper Basin.

In 2025 and 2026, the Upper Division States will implement conservation projects and demonstration projects ("Qualifying Activities") in the Upper Basin under various authorities. Qualifying Activities identified in accordance with this MOU and Exhibit 1 hereto may provide opportunities for the Parties to investigate ways to verify and account for volumes of water that can be provisionally accounted for to assess potential water savings. The Parties wish to develop and implement an approach that will allow for provisional accounting for these Qualifying Activities in accordance with Exhibit 1 ("Provisional Accounting"). It is the understanding of the Parties that the Upper Division States will seek credit for water that, as a result of these Qualifying Activities, flows to and is stored in Upper Colorado River Basin reservoirs. Accordingly, the Parties agree as follows:

## II. Terms

1. Defined Terms: The following definitions will apply for purposes of this MOU only.

    a. Credit means a benefit that the Upper Division States may seek as defined in Section 7 of this MOU.

    b. Criteria means the factors set forth in Section 3 of this MOU, which the Upper Division States, through the UCRC, will use to identify and select Qualifying Activities.

    c. Demand Management Storage Agreement or DMSA means the Agreement Regarding Storage at Colorado River Storage Project Act Reservoirs Under an Upper Basin Demand Management Program dated May 20, 2019.

    d. Provisional Accounting means the methodologies agreed to by the Parties as set forth in Section 5 and Exhibit 1 of this MOU to quantify the total amount of reduction in use of or demand for water supplies, or the amount of water in the Upper Colorado River Basin that otherwise results from Qualifying Activities.

   e. Qualifying Activities means conservation projects and/or demonstration projects that result in reductions in use or demand of water supplies, or inform accounting procedures or yield other helpful information, in the Upper Colorado River Basin. The Upper Division States, through the UCRC, will select Qualifying Activities for Provisional Accounting under Section 4 of this MOU.

2. <u>Performance Period</u>: Provisional Accounting as described in this MOU will be performed for Qualifying Activities initiated on or before December 31, 2026.

3. <u>Criteria for Qualifying Activities</u>: The Upper Division States, through the UCRC, in their sole discretion, shall identify and select the Qualifying Activities they will propose to Reclamation for Provisional Accounting. The following Criteria will inform the selection of Qualifying Activities:

   a. Regulatory considerations, including the comparative ease or difficulty of implementing the Qualifying Activity and required permits or approvals, if any;

   b. Volume and timing considerations, including the relative size of the Qualifying Activity in terms of the quantity of water at issue, or the likelihood that the Qualifying Activity will yield helpful information; and

   c. The likelihood that the Qualifying Activity will result in quantifiable reductions in use or demand of water supplies in the Upper Colorado River Basin, or inform accounting procedures, or provide multiple benefits.

4. <u>Process for Selection of Qualifying Activities by the Upper Division States through the UCRC</u>: The Parties anticipate Qualifying Activities in 2025 and 2026 that may qualify for Provisional Accounting. The Upper Division States, through the UCRC, will take the following steps in sequential order to identify those Qualifying Activities eligible for Provisional Accounting under this MOU:

   a. Each Upper Division State will review potential Qualifying Activities located within its geographic boundaries and identify those Qualifying Activities that satisfy the Criteria.

   b. Each Upper Division State, through the UCRC, will notify the other Upper Division States of the Qualifying Activities within their state that it has identified as satisfying the Criteria.

   c. The Upper Division States, through the UCRC, will review the Qualifying Activities identified pursuant to Section 4.b as satisfying the Criteria and then select those Qualifying Activities eligible for Provisional Accounting under this MOU.

d. The Upper Division States, through the UCRC, will propose to Reclamation a list of the Qualifying Activities selected under Section 4.c. If Reclamation identifies an issue with a Qualifying Activity on such proposed list the Parties will confer.

5. Provisional Accounting Methodology:

a. The Parties will conduct Provisional Accounting for the Qualifying Activities in accordance with Exhibit 1.

b. The Parties will periodically review the Provisional Accounting method and its application to assess its performance during the calendar year, as follows:

i. The UCRC will convene the Upper Division States and Reclamation for a mid-year "check in" on Provisional Accounting and related data;

ii. 60 days after final verification of completion of a Qualifying Activity, the Upper Division State where the Qualifying Activity is located will provide draft Provisional Accounting to the UCRC;

iii. The Upper Division States, through the UCRC, will review the Provisional Accounting provided by each Upper Division State;

iv. Within 90 days after review by the Upper Division States through the UCRC, the Parties will jointly review the proposed Provisional Accounting; and

v. Reclamation, in collaboration with the Upper Division States through the UCRC, will prepare a report that includes the components outlined in Section 1 of Exhibit 1: (a) describing the results of the Provisional Accounting for the 2025 water year as soon as reasonably practicable after the end of the water year; and (b) describing the results of the Provisional Accounting for the 2026 water year as soon as reasonably practicable after the end of the water year. The Parties may prepare interim reports as necessary.

c. The Parties will review the Provisional Accounting method and engage in appropriate consultations prior to proposing inclusion of the Provisional Accounting as described in this MOU into any agreement for Credit.

d. The Parties may agree to modify the terms of Exhibit 1 in writing without amending the MOU.

6. <u>No Influence on Reservoir Operations</u>: The Parties agree that the Provisional Accounting of water that flows to an Upper Colorado River Basin reservoir will not influence or otherwise affect the operations of that reservoir unless the Provisional Accounting is converted into Credit in accordance with Section 7.

7. <u>Conversion of Provisional Accounting into Credit</u>:

    a. Conversion of the Provisional Accounting, as reported pursuant to Section 5, into Credit will be negotiated and governed by the terms of the agreement or agreements creating such Credit. Such agreement or agreements may include the following:

        i. An agreement or agreements executed by the Upper Division States and Reclamation in conjunction with the post-2026 operations of Lakes Powell and Mead;

        ii. An agreement or agreements executed in accordance with the DMSA; or

        iii. Other appropriate agreements.

    b. The Parties agree to consult with the Lower Division States and others in accordance with applicable law and agreements.

    c. By executing this MOU, Reclamation takes no position on any future agreements or other efforts the Upper Division States may use to obtain Credit.

8. <u>Funding</u>: The Parties will perform the activities set forth in this MOU irrespective of a Qualifying Activity's funding source. Reclamation may provide funding for Qualifying Activities, including under the Inflation Reduction Act of August 16, 2022, Public Law 117-169, 136 Stat. 2053, including the funding made available under Section 50233(B)(2) of the Act.

9. <u>Miscellaneous</u>:

    a. **Disclosure of Information:** The Parties recognize that the information obtained or developed from activities performed under this MOU may be public information that is available for release upon request, except to the extent otherwise provided by applicable law.

    b. **Entire Agreement:** This MOU and its Exhibit 1 shall constitute the full and entire understanding and agreement between and among the Parties.

    c. **Amendment, Modification, and/or Supplement:** Except as otherwise provided in this MOU, no amendment, modification, or supplement will be binding unless it is in writing and signed by all Parties.

d. **Notices:** All notices required to be given hereunder will be in writing via email with confirmation of receipt or First-Class U.S. mail to a Party's principal representative at the address set forth below. Any Party from time to time may, by written notice, substitute addresses or persons to whom such notices will be sent. Unless otherwise provided herein, all notices will be effective upon receipt.

BUREAU OF RECLAMATION:

Bureau of Reclamation
Regional Director, Upper Colorado Region
125 South State Street, Room 6107
Salt Lake City, UT 84138-1147
WPullan@usbr.gov

UPPER COLORADO RIVER COMMISSION:

Upper Colorado River Commission
Charles R. Cullom, Executive Director
50 S 600 E, Suite 100
Salt Lake City, UT 84102
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With copies to:

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Interstate and Federal Water Information Section
Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203
amy.ostdiek@state.co.us

Ali Effati, Colorado River Basin Bureau Chief
New Mexico Interstate Stream Commission
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ali.effati@ose.nm.gov

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Jeff Cowley
Administrator, Interstate Streams

Wyoming State Engineer's Office
122 West 25th Street
Herschler Building
2nd Floor West
Cheyenne, Wyoming 82002
jeff.cowley@wyo.gov

A Party may change its address by giving the other Parties notice of the change in writing.

e. **Availability of Information:** Subject to applicable laws and regulations, each Party to this MOU will have the right during office hours to examine and make copies of the other Party's books and records relating to matters covered by this MOU.

f. **No Third-Party Beneficiaries:** This MOU and any agreements made, or actions taken, pursuant hereto are made solely for the benefit of the Parties. This MOU does not confer any right or entitlement to benefits from this MOU on any person or entity that is not signatory to this MOU, regardless of the legal theory on which such a claim is made.

g. **Counterparts:** This MOU may be executed in counterparts, each of which will be an original and all of which, together, will constitute only one MOU.

h. **Term:** The term of this MOU will begin on the date of execution by the last signatory and will end on December 31, 2026, unless the Parties agree in writing to extend the term.

i. **Dispute Resolution:** If any dispute arises regarding this MOU, the Parties agree to meet and to attempt to resolve the dispute in good faith. This MOU does not create any right or benefit, substantive or procedural, enforceable at law or in equity by or against any Party to this MOU.

j. **Conflicts:** If there is a conflict between the provisions of this MOU and any of its exhibits, the provisions of this MOU will govern.

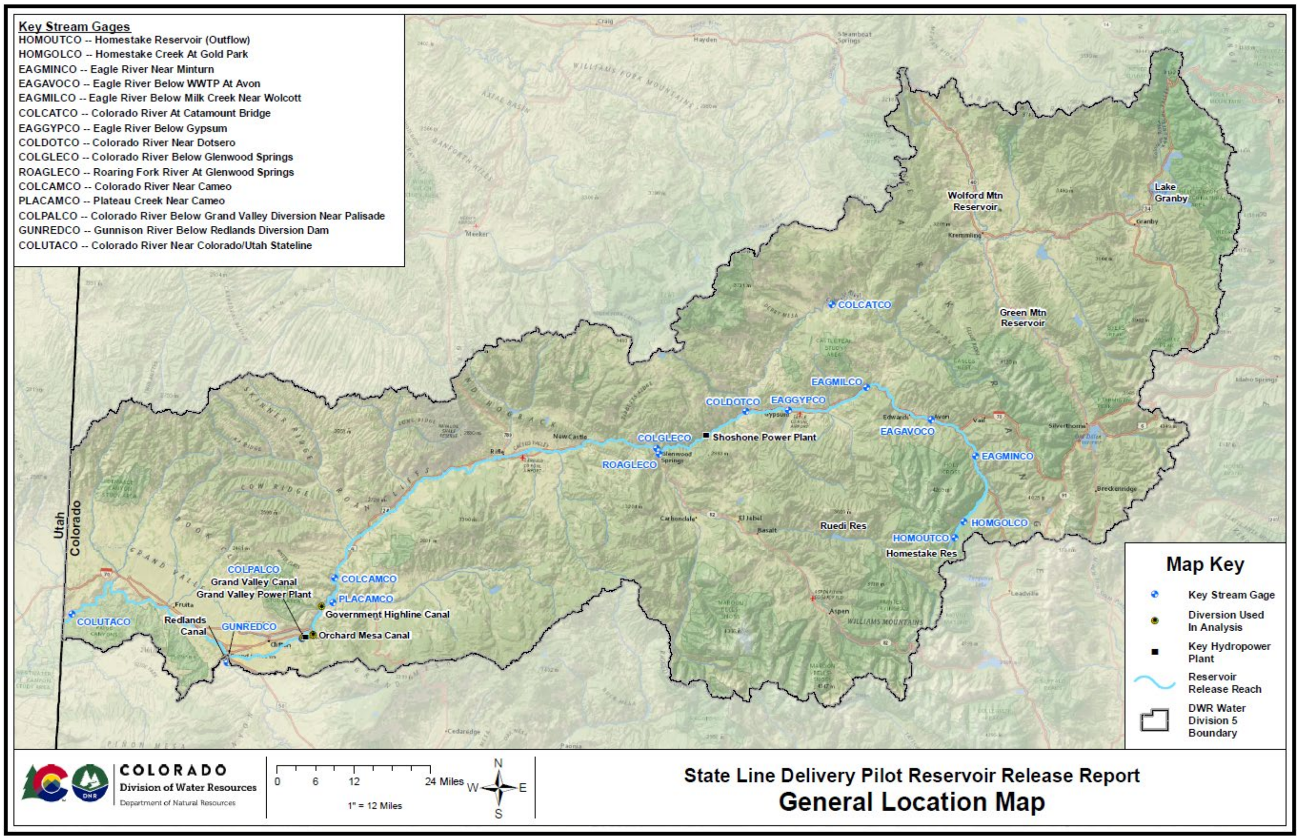
| | |
|---|---|
| THE UNITED STATES OF AMERICA | UPPER COLORADO RIVER COMMISSION |
| ____________________________ | ____________________________ |
| By: ________________________ | By: Charles R. Cullom |
| Its: ________________________ | Its: Executive Director |

# Summary of the Homestake Reservoir State Line Delivery Pilot Release Report

In September 2020, the Colorado Division of Water Resources (DWR) and a group of municipal water providers—Colorado Springs Utilities, Aurora Water, and the Pueblo Board of Water Works (collectively, "the Cities")—conducted a pilot project to test the process of releasing and tracking water from a Colorado reservoir to the Colorado-Utah state line. DWR created a report to document the process, results, and findings of the investigation.

## Background and Authority

The **Homestake System** is a trans-mountain diversion project that channels water from the Colorado River basin to the East Slope for municipal use. Because this water is consumed on the East Slope, it is considered a 100% depletive use on the Colorado River basin. The Cities proposed to release up to 1,800 acre-feet of water from Homestake Reservoir that they would have otherwise diverted to the East Slope, effectively reducing their consumption from the Colorado River system.



This release was administered by the State Engineer's Office (DWR). The purpose of the project was to allow a one-time release of water to allow the State Engineer to investigate important aspects of administration practices during a particular streamflow and hydrologic conditions and to record factors that may impact the timing and amount of arrival of the released water at the state line. This was done pursuant to authorities established in Colorado statute that provide the

State Engineer with authority to conduct such investigations. The project was an empirical test to gather information on transit times and water volume changes.

## Water Conserved and Release Operations

A total volume of **1,666.9 acre-feet** was released from Homestake Reservoir between September 23, 2020, and September 29, 2020. The release was gradual, starting at 29 cfs and peaking at 175 cfs before gradually decreasing.

This water was considered "conserved" because it was water the Cities would have otherwise diverted to the East Slope. The Cities proposed to verify this reduction in consumptive use by showing that the released water would have been delivered to the East Slope during the winter months. The verification plan included demonstrating that they had available storage space on the East Slope and that their Homestake Tunnel deliveries were reduced by the amount of the released water. The DWR concluded that the Cities' proposal for verification was intended to show that the release was an actual reduction in water use and would not result in an expansion of their water right.

Other entities also adjusted their operations during the release. The Upper Colorado River Endangered Fish Recovery Program (UCRIP) reduced their fish flow releases from Granby, Wolford, and Ruedi Reservoirs to take advantage of the increased flows from the Homestake release. Releases were reduced prior to the Homestake release to be able to distinguish the Homestake release from the other reservoirs' releases. Table 1 shows the releases from Granby, Wolford, and Ruedi Reservoirs with the Homestake Reservoir release values and the resulting reservoir flows at the 15-Mile Reach.

Table 1: Releases from Granby Reservoir, Wolford Reservoir, Ruedi Reservoir, and Homestake Reservoir and the corresponding flows at the 15-Mile Reach.

| | Granby Release (cfs) | Wolford Release (cfs) | Ruedi Release (cfs) | Homestake Release (cfs) | Total Reservoir Water in 15-Mile Reach (cfs), considering transit time and transit loss | |
|---|---|---|---|---|---|---|
| **9/15/2020** | 40 | 30 | 245 | 0 | 253 | |
| **9/16/2020** | 40 | 30 | 245 | 0 | 272 | |
| **9/17/2020** | 40 | 30 | 245 | 0 | 285 | |
| **9/18/2020** | 40 | 30 | 245 | 0 | 290 | |
| **9/19/2020** | 40 | 30 | 245 | 0 | 290 | |
| **9/20/2020** | 40 | 30 | 245 | 0 | 290 | |
| **9/21/2020** | 40 | 30 | 245 | 0 | 290 | |
| **9/22/2020** | 40 | 30 | 195 | 0 | 290 | |
| **9/23/2020** | 20 | 20 | 155 | 29 | 290 | |
| **9/24/2020** | 20 | 15 | 155 | 116 | 243 | |
| **9/25/2020** | 20 | 15 | 155 | 175 | 220 | |
| **9/26/2020** | 20 | 15 | 155 | 175 | 245 | |
| **9/27/2020** | 20 | 15 | 155 | 175 | 306 | |
| **9/28/2020** | 20 | 15 | 155 | 134 | 332 | |
| **9/29/2020** | 20 | 15 | 172 | 44 | 332 | |
| **9/30/2020** | 20 | 12 | 172 | 0 | 314 | |
| **10/1/2020** | 20 | 10 | 172 | 0 | 271 | |
| **10/2/2020** | 20 | 10 | 172 | 0 | 210 | |
| **10/3/2020** | 20 | 10 | 172 | 0 | 188 | |
| **10/4/2020** | 20 | 10 | 172 | 0 | 186 | |

## Tracking and Shepherding the Water

The DWR actively "shepherded" the released water to ensure it was not diverted or consumed by downstream water rights. On Homestake Creek and the Eagle River, where the release significantly increased flows, DWR water commissioners adjusted headgates to ensure that ditches did not take more water than they were legally entitled to before the release. DWR denied requests from other water users to exchange against the Homestake release, as these actions would have interfered with the study.

DWR used streamgage data to track the movement of the water. Initially, they estimated a 2-day transit time and 10% transit loss from Homestake Reservoir to the Colorado River near Cameo, CO, based on past administration of other reservoir releases. However, early observations showed a longer transit time on the Eagle River, so the estimates were adjusted to a 2.5-day transit time.

The released water was clearly distinguishable from normal flows in the Eagle River basin. The following transit times from Homestake Reservoir were determined based on visual transformation of hydrographs at stream gages:

| Gage | Transit Time (hrs) |
|---|---|
| HOMGULCO | 1 |
| EAGMINCO | 10 |
| EAGAVOCO | 15 |
| EAGMILCO | 22 |
| EAGGYPCO | 29 |

However, once the release reached the Colorado River, it became a much smaller proportion of the total flow, making it visually indistinguishable on hydrographs. To analyze the flow on the Colorado River, DWR used a "separation analysis" method to isolate the released water from the total streamflow. This analysis was only effective on the 175 cfs release and found the following transit times from Homestake Reservoir in the table below. It was also not possible to clearly identify the reservoir release based on gage flows at the *Colorado River near Colorado-Utah State Line, CO* gage due to the significant ungaged inflows to the Colorado River below the *Colorado River below Grand Valley Diversion near Palisade, CO* gage that could not be removed in the separation analysis.

| Gage | Transit Time (hrs) |
|---|---|
| COLDOTCO | 34 |
| COLGLECO | 40 |
| COLCAMCO | 59 |
| COLPALCO | 66 |
| COLUTACO | N/A |

## Transit Loss and Results

The report analyzed transit losses in the Eagle River basin by comparing the volume of water at various streamgages to the total volume released from Homestake Reservoir. The analysis found a **20% transit loss** over the approximately 18 miles from Homestake Reservoir to the Eagle River near Minturn, CO (1.1% per mile). An additional **3% loss** was observed over the next 25 miles on the Eagle River, between the Minturn and Milk Creek gages (0.12% per mile). The report notes that these findings are specific to the dry conditions present during the release and may not apply to other flow conditions.

Due to inconsistent operations of other reservoirs and the effects of a large, unplanned release from the Shoshone Power Plant forebay, DWR was unable to reliably determine transit losses on the Colorado River. It was also not possible to clearly identify the Homestake release at the final streamgage near the Utah state line due to significant ungaged inflows further downstream. Therefore, no final volume of water was quantified at the Utah state line.

Overall, the pilot project was deemed successful. It confirmed the effectiveness of many of the DWR's current administrative practices and highlighted areas where improvements could be made. The investigation provided valuable information for planning future actions. The findings suggest that better diversion structures, more frequent gage calibrations, and further transit time studies are needed, especially for high-flow conditions. Communication with water users and local communities was also identified as critical to avoid operational conflicts and address safety concerns related to large flow changes.

# 2025 Wyoming Provisional Accounting Final Report

## Introduction

In December of 2024, the Upper Division States (UDS), through the Upper Colorado River Commission (UCRC), and the Bureau of Reclamation (Reclamation), entered a Memorandum of Understanding (MOU) regarding provisional accounting of Upper Colorado River Basin water. The MOU provides opportunities to investigate ways to verify and account for volumes of water that can be provisionally accounted for to assess potential water savings.

Pursuant to the MOU, Wyoming proposed a Provisional Accounting Demonstration Project (Test Release) involving a release of water from Fontenelle Reservoir (represented by USGS gage 09211200 below Fontenelle Reservoir) to be tracked and accounted for downstream to Flaming Gorge Reservoir, with potential for release to Lake Powell. The purpose of this release was to inform accounting procedures and yield other information to help inform and develop Provisional Accounting methods described and defined in the MOU.

## Clarifications

For this Test Release, Wyoming did not propose to release water from Fontenelle Reservoir in addition to water that would be released during the water year under normal operations. Accordingly, Wyoming did not intend to seek future credit for the Test Release water under Section II.7 of the MOU. However, Wyoming continues to explore the potential of releasing water in addition to normal water year operational releases for which it would seek future credit.

## Test Release Details

This Test Release aimed to develop accurate quantification and accounting for reductions in water use, reductions in demand of water supplies, or water that otherwise results from Qualifying Activities that flows to and is stored in Upper Colorado River Basin reservoirs. This is demonstrated in the stream flow time series in Figure 1.

In order to accomplish the Test Release objectives, Wyoming coordinated with Reclamation to execute a test release of approximately 2,975 acre-feet of water from Fontenelle Reservoir. The Test Release adjustments were made to be within normal Fontenelle Reservoir operations. The plan for the Test Releases involved the following flow operation plan (which differs from the exact flows, as provided below): Prior to the test release, flows from Fontenelle Reservoir would be reduced to approximately 800 cubic feet per second (CFS) for 10 days. After this period, releases would be increased to approximately 1,100 CFS per day for 5 days in August 2025. This would result in an increase of approximately 300 CFS per day, or 2,975 acre-feet over the 5-day period. After the approximately 2,975-acre-foot volume had been released, flows would be drawn back down to 800 for 15 days, after which they would be increased back to static operational releases. This process ensured an identifiable and trackable signal for Test Release accounting (Figure 1). Test Release parameters also functioned within the guidelines for the annual operation of Fontenelle Reservoir, with consideration of water availability, the safety of the dam, and to minimize downstream impacts. Note that there is an inconsistency in flow rates between the Fontenelle release values and the USGS gage 09211200 immediately below Fontenelle Reservoir. Discussions and analysis are currently underway in order to determine the reason for the difference. For the Test Release analysis we chose to use USGS gage data to represent the Fontenelle releases. Therefore, subsequent data in this report will be slightly different than the values described in the plan above. The data for USGS gages 09211200 and 09217000 is provisional at the time of this report, and can be updated with corrected values after final USGS review.

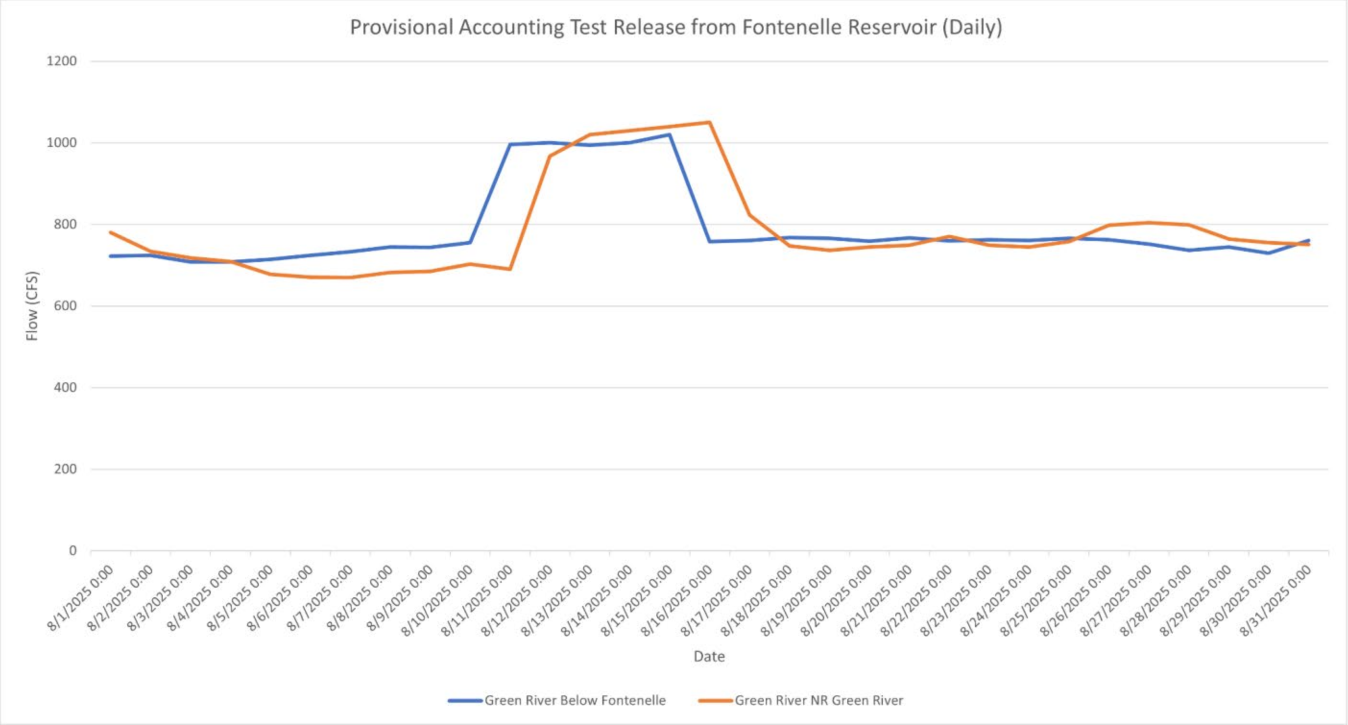
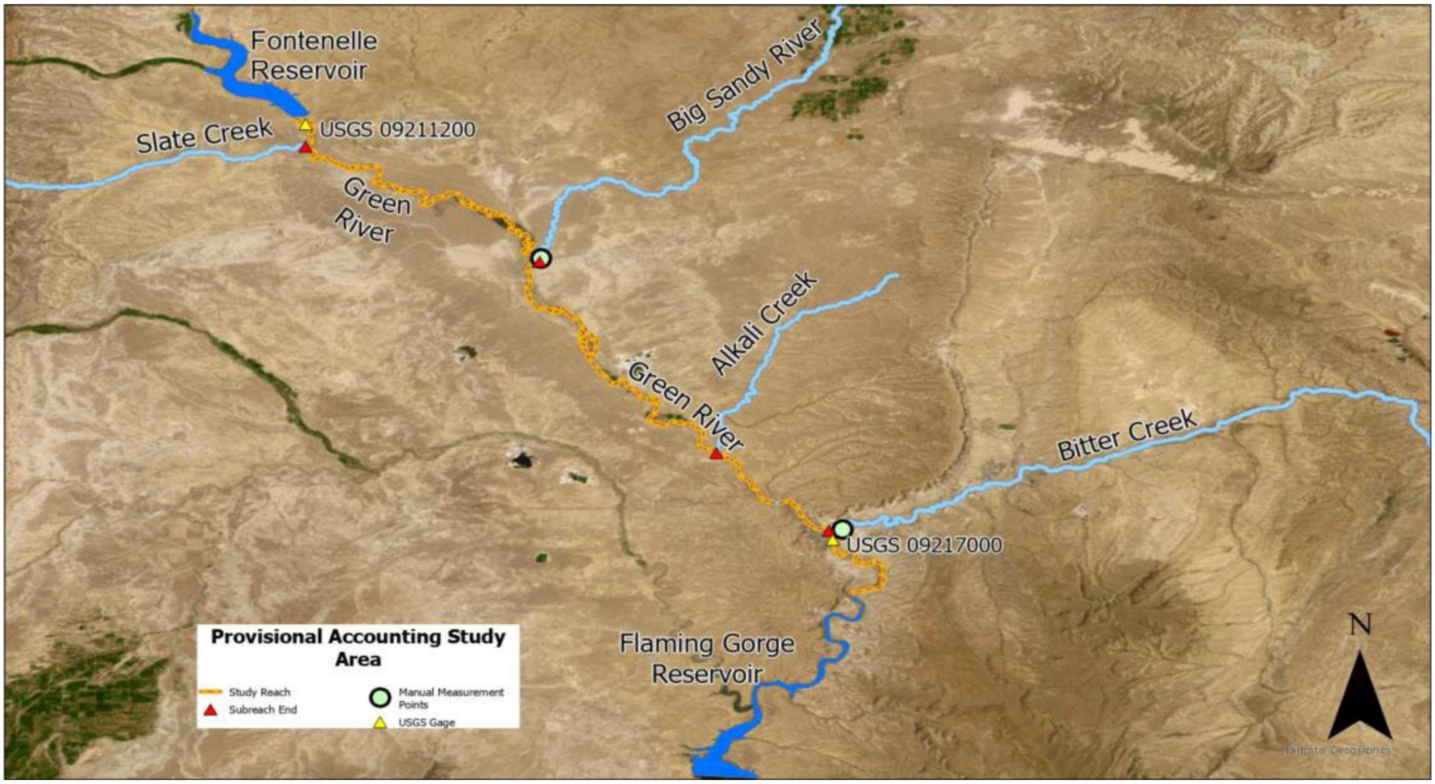


Figure 1: This graph illustrates the timing and volume of the test release out of Fontenelle Reservoir measured via the USGS gage 09211200 below Fontenelle Reservoir and the corresponding signal at USGS gage 09217000 on the Green River near Green River, WY. In both lines, the test release is clearly visible in both gages, with the pulse arriving at Green River in about 25 hours.



# Test Release Map

Figure 2: The map above shows the Test Release area. The water released from Fontenelle Reservoir was recorded at USGS gage 09211200. To increase the accounting accuracy, manual measurements were taken at the mouths of the Big Sandy River and Bitter Creek. These measurements helped identify and incorporate any unpredicted additional water entering the system from these sources. Losses were calculated for each sub reach between Fontenelle Reservoir and the USGS Green River gage 09217000 at Green River, WY. USGS gage 09217000 was considered the final inflow point for Flaming Gorge for this Test Release, which is approximately 10 miles upstream of the reservoir and there are no significant diversions in this reach.

# MOU Criteria

The Test Release addressed the criteria put forth in Exhibit 1 of the MOU and provided critical information for the development of Provisional Accounting methods for Wyoming, Reclamation, and the UDS.

Under Section II.1.a. of the Exhibit, the Test Release informed the Provisional Accounting process by identifying and testing a volume of water that was large enough to be tracked, and accounted for, in a federally operated Upper Colorado River Basin reservoir. This released water served as an example of potential future releases of storage water, contributions from conserved consumptive use, or other demonstration projects in Wyoming. During The Test Release, the water from Fontenelle Reservoir traveled to Flaming Gorge Reservoir. The total volume of water found to enter Flaming Gorge Reservoir was totaled at the USGS gage 09217000 near Green River, WY. The Test Release was monitored and accounted for to help develop Provisional Accounting methods and help provide an opportunity for Wyoming to receive credit for releases or actions in the future.

Additionally, the Test Release addressed the criteria in Section II.1.b. of the Exhibit, specifically transit losses between the Qualifying Activity and the storage location; information that is important to the accounting process. The UCRC recently conducted a table-top exercise focused on gains and losses within this river segment to support this effort. In addition, the UCRC, through Infrastructure Investment and Jobs Act funding, may conduct a comprehensive transit loss study in the reach from Flaming Gorge to Lake Powell. Data and results collected from the Test Release will be compared against the transit loss study conducted by the UCRC, as well as future studies, to obtain the most precise transit loss estimates. In addition, Wyoming, in coordination with contractors and the UCRC, addressed all loss considerations listed in Section II.1.b. of the Exhibit through measurement and modeling efforts along the Green River between Fontenelle Reservoir and Flaming Gorge Reservoir. Wyoming also included information and analysis associated with intervening diversions and tributaries. Overall, these considerations helped identify additional measurements that are necessary to enhance the accuracy of water tracking for Provisional Accounting methods.

# Method and Analysis

In a stream setting there can be multiple inflows and/or outflows that must be considered when assessing transit losses. These include tributary inflows, as well as losses to deep groundwater seepage, evaporation on the stream surface, evapotranspiration (ET) in the riparian areas, as well as diversions from the stream.

Prior to the Test Release, Wyoming conducted analyses of our Green River and New Fork Rivers at 19 sub-reaches to understand these gain and loss factors, as part of Wyoming's Green River Transit Loss Water Balance study with Follum Hydrologic Solutions, LLC (Follum). The results indicate that it is largely a gaining system, based on a water balance analysis of flow data at each sub-reach.

Primary components in this analysis include tributary inflows, evaporation, and ET. Groundwater losses are assumed to be very small, if present.  Bank storage can account for significant initial conveyance reductions (Hanlin, 1988). However, the effects of bank storage stabilize after approximately 10 days, with stored water returning to the stream (Farber and Hasfurther, 1992). Therefore, the effects of bank storage are considered negligible within the water balance. Tributary inflows were measured at gaged locations.  Estimated inflows for ungaged tributaries were determined through simulation and spot checks as part of the Follum study and by SEO and USGS staff. Evaporation was calculated based on Western Regional Climate Center's pan evaporation data.

ET values in the riparian zone were estimated using the Operational Simplified Surface Energy Balance (SSEBop) model, the remote sensing-based model that quantifies and maps Actual Evapotranspiration over land surfaces. A recent study found this remote sensing model of ET to be the most accurate for estimating ET in wetland and riparian areas (Volk et al., 2024). The riparian area is computed for the region using the Colorado River riparian vegetation corridor extent polygon (CO-RIP) (Woodward et al., 2018). All remote sensing ET data utilizes monthly data from January 2000 through December 2024. Diversion and return flow data do not exist at most locations. Therefore, net consumptive use (including incidental uses) data of irrigated land, based on the Bureau of Reclamation Consumptive Uses and Losses data, is a proxy for the diversion-return flow component.

While the water balance approach is suitable for calculating total losses or gains, a different method was used to specifically estimate transit loss for the transport of Test Release water. This latter method known as the "incremental loss" method was applied to determine the losses for the August 2025 provisional accounting release from Fontenelle Reservoir. This method only includes the water balance components that change during a test release. These include ET in the riparian zone and evaporation of the stream surface, both of which are losses, and the mainstem stream flow. It is assumed that diversions do not increase during this time, since these rivers are always in free river conditions, and that diversions are not made in the non-growing season. Based on these components, a logarithmic correlation exists between losses (evaporation and ET) and streamflow (Figure 3) at all of the sub-reaches, with strong correlation based on conducting a five-fold R-squared cross-validation. Testing shows that there are strong relationships between flow and loss along the entire mainstem reaches of the Green and New Fork Rivers, upstream of Flaming Gorge (Table 1).

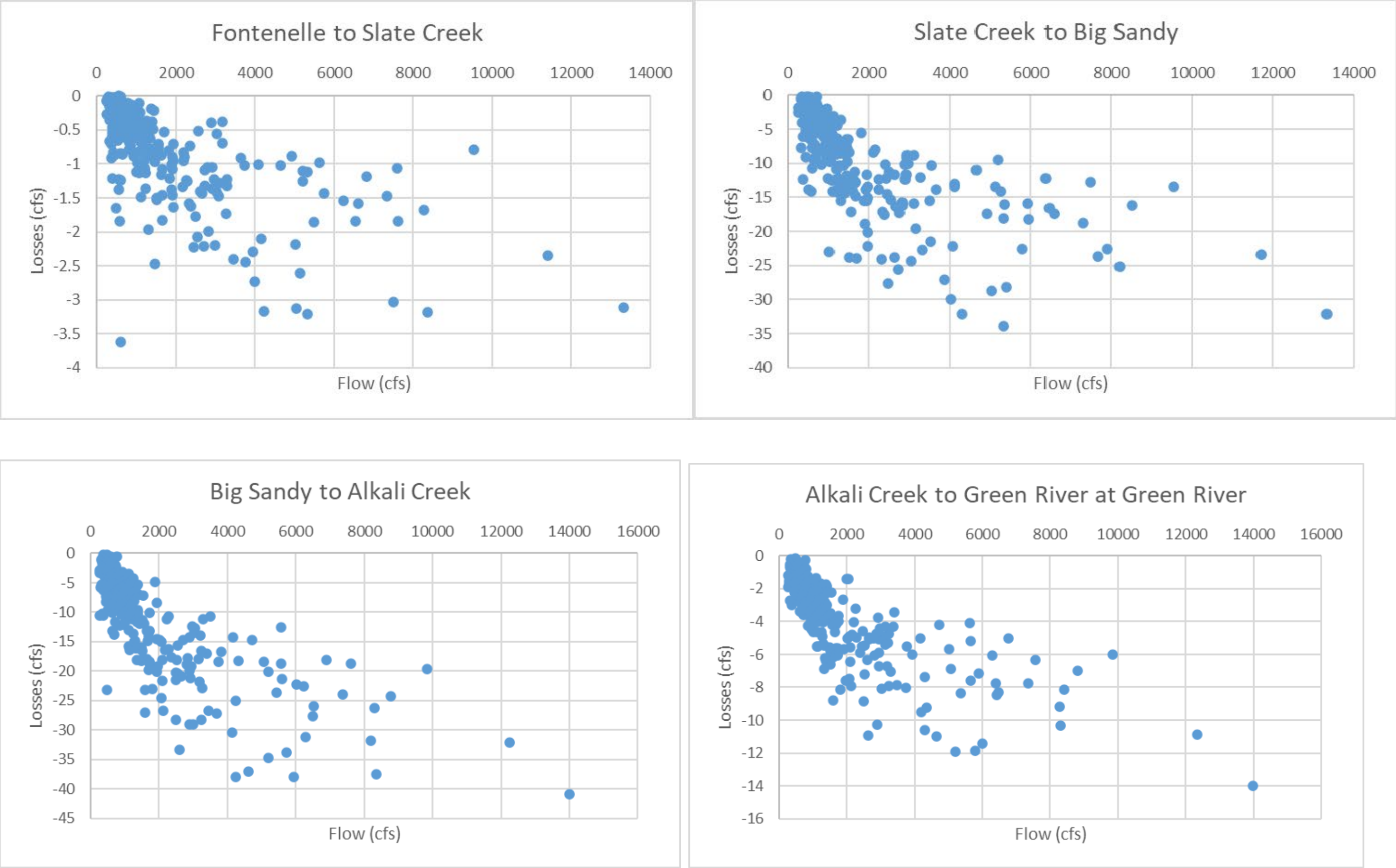
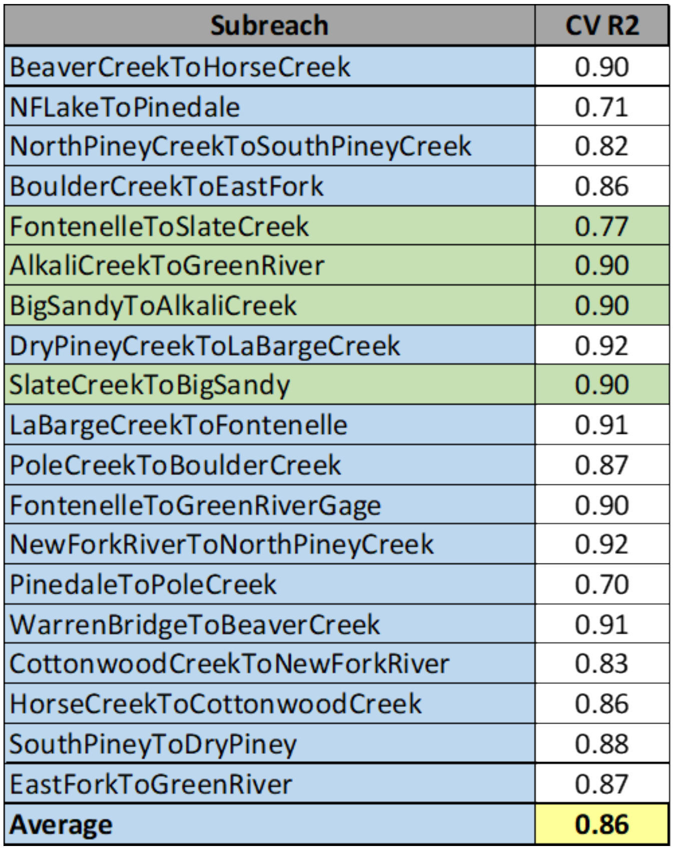


Figure 3. River flow vs transit loss draft data for the main subreaches between Fontenelle Reservoir and Green River.



| Subreach | CV R2 |
|---|---|
| BeaverCreekToHorseCreek | 0.90 |
| NFLakeToPinedale | 0.71 |
| NorthPineyCreekToSouthPineyCreek | 0.82 |
| BoulderCreekToEastFork | 0.86 |
| FontenelleToSlateCreek | 0.77 |
| AlkaliCreekToGreenRiver | 0.90 |
| BigSandyToAlkaliCreek | 0.90 |
| DryPineyCreekToLaBargeCreek | 0.92 |
| SlateCreekToBigSandy | 0.90 |
| LaBargeCreekToFontenelle | 0.91 |
| PoleCreekToBoulderCreek | 0.87 |
| FontenelleToGreenRiverGage | 0.90 |
| NewForkRiverToNorthPineyCreek | 0.92 |
| PinedaleToPoleCreek | 0.70 |
| WarrenBridgeToBeaverCreek | 0.91 |
| CottonwoodCreekToNewForkRiver | 0.83 |
| HorseCreekToCottonwoodCreek | 0.86 |
| SouthPineyToDryPiney | 0.88 |
| EastForkToGreenRiver | 0.87 |
| **Average** | **0.86** |

Table 1: Fivefold cross validated $R^2$ values for loss/flow data relationships for all of the sub-reaches analyzed on the Green River and New Fork River mainstems using data from 2000 to 2024. Highlighted sub-reaches indicate those analyzed during the Test Release.

While the incremental loss method analyzes all ranges of flows, only the losses in the “increment” of flow rates between the base flow and peak flow are charged as the transit loss from the transport of the conserved water. This is analogous to a situation where a lake has been increased in volume using a dam. Only the additional surface area caused by the increased elevation is charged evaporation losses, i.e., the “donut” surrounding the reservoir. This is shown in Figure 4 as additional water floating on top of the base flow. In other words, we are not responsible for any losses that may already be occurring in the baseflow condition. As described above, we use the regression relationship to analyze the losses at the base flow prior to the release and during the release.

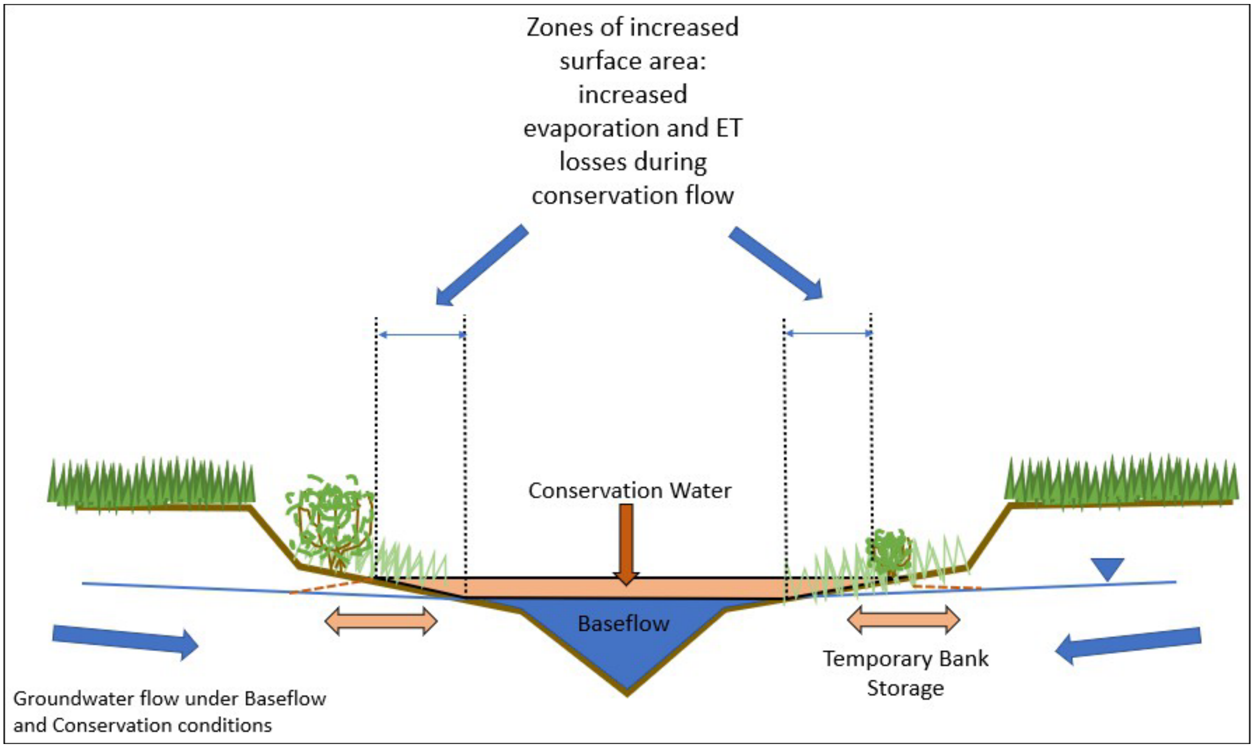


Figure 4. Cross section of the river showing baseflow in blue and water from the conservation on top in orange. Note the depiction of the conservation flow having additional surface area and interaction with riparian vegetation, resulting in incremental losses due to the increased flows.

A critical aspect of the method is to make it work on a monthly timescale in order to take into account seasonality. Since it uses evaporation and ET as the primary loss, it needs to factor in monthly changes due to variations in temperature, solar radiation, flow rate and vegetation growth. If one were to use only one regression curve for year-round use there would be an increased chance of inaccuracies. For example, the existing data for January is based on low flows and low losses. However, if one were to increase flows in January during a release, a single curve would result in high losses because the higher flow rates in the dataset are based on measurements that occurred later in the year. This would be an over-estimate of losses since evaporation, transpiration and solar radiation are reduced in January. In order to avoid this issue, we considered fitting a regression curve to each month's data, however, there were insufficient values at high flows to produce a reliable relationship. Therefore, the method relies on a separate multi-variable linear regression function for every month, each of which include a seasonality factor. The factor was estimated based on a modified sine wave that has been adjusted so that the phase peak amplitude correlates with estimates of the highest losses, with decreasing values in the cooler months (Figure 5). While this is a novel method for transit losses, the use of sine curves has been used in hydrologic analyses in the past (Dalinsky, 1971 and Xin et al., 2021).

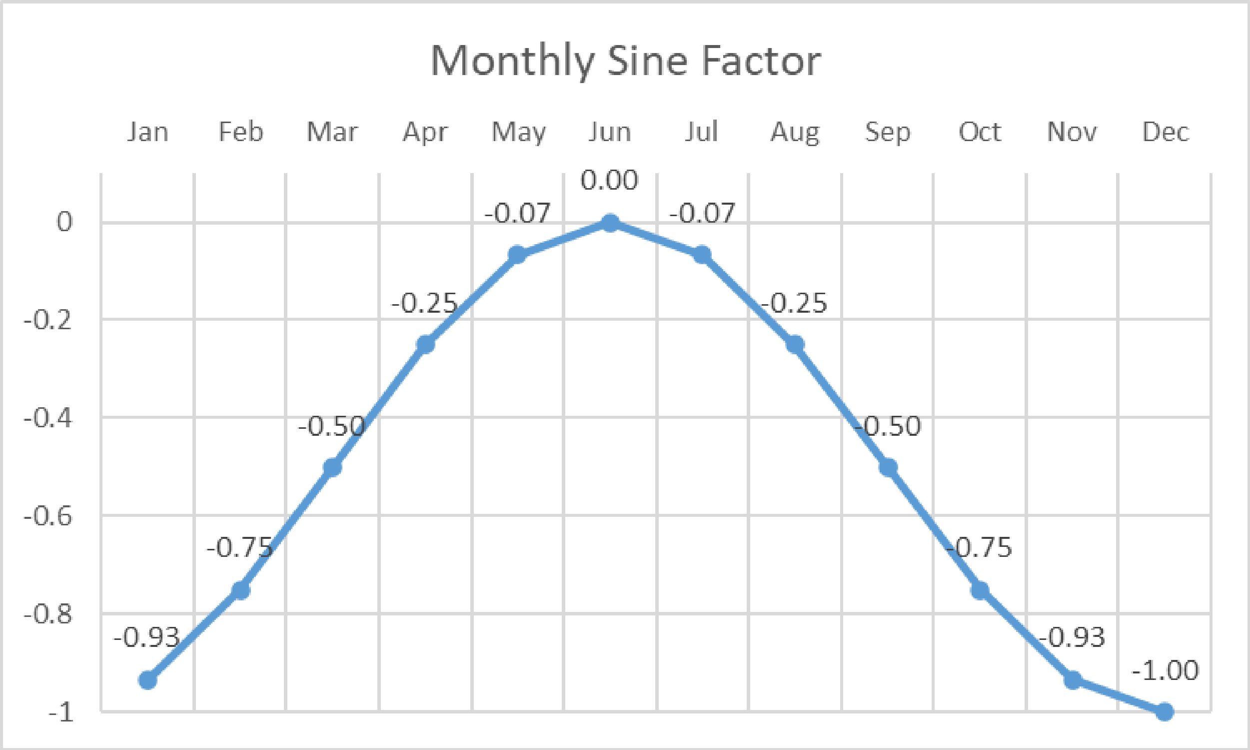
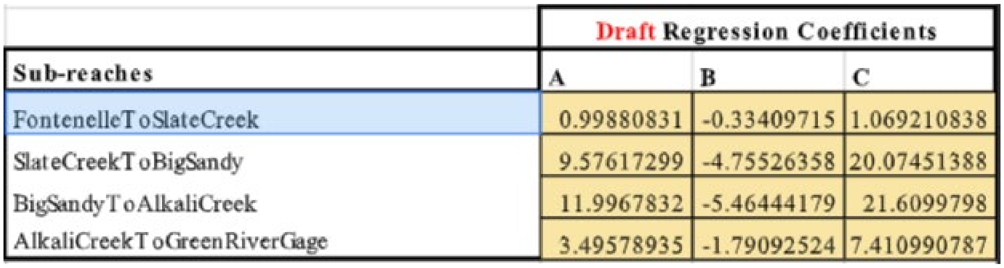


Figure 5. Sine factor input to the monthly regression equations. Note that ET losses generally are highest usually in July. However, the flow losses that are the source for the ET are estimated to occur about one month earlier; hence the curve peak in June rather than July.

The effect of incorporating different sine-based factors for each month results in a line-fitting regression of better agreement with measured data from that time of year, but also extrapolates loss value projections that would occur in that month at higher flows. This allows for loss estimates for any flow to be performed more accurately during any month of the year. This method could be improved once more data is collected, e.g., a high release during January; loss and flow data that doesn't currently exist. (Figure 6). The multi-factor linear regression equation is as follows:

**Y (loss) = [A] x (sine factor) - [B] x (Ln((Flow)) + [C].**

While the sine factors are consistent across all sub-reaches, the coefficients are different for each sub-reach (Table 2). These coefficients were calculated using the Linear regression Python package. Specifically, linear regression was performed on the historical streamflow and ET data observed at each respective reach gage.



| | Draft Regression Coefficients | | |
|---|---|---|---|
| **Sub-reaches** | **A** | **B** | **C** |
| FontenelleToSlateCreek | 0.99880831 | -0.33409715 | 1.069210838 |
| SlateCreekToBigSandy | 9.57617299 | -4.75526358 | 20.07451388 |
| BigSandyToAlkaliCreek | 11.9967832 | -5.46444179 | 21.6099798 |
| AlkaliCreekToGreenRiverGage | 3.49578935 | -1.79092524 | 7.410990787 |

Table 2. Multi-variable linear regression draft coefficients A-C for the sub-reaches

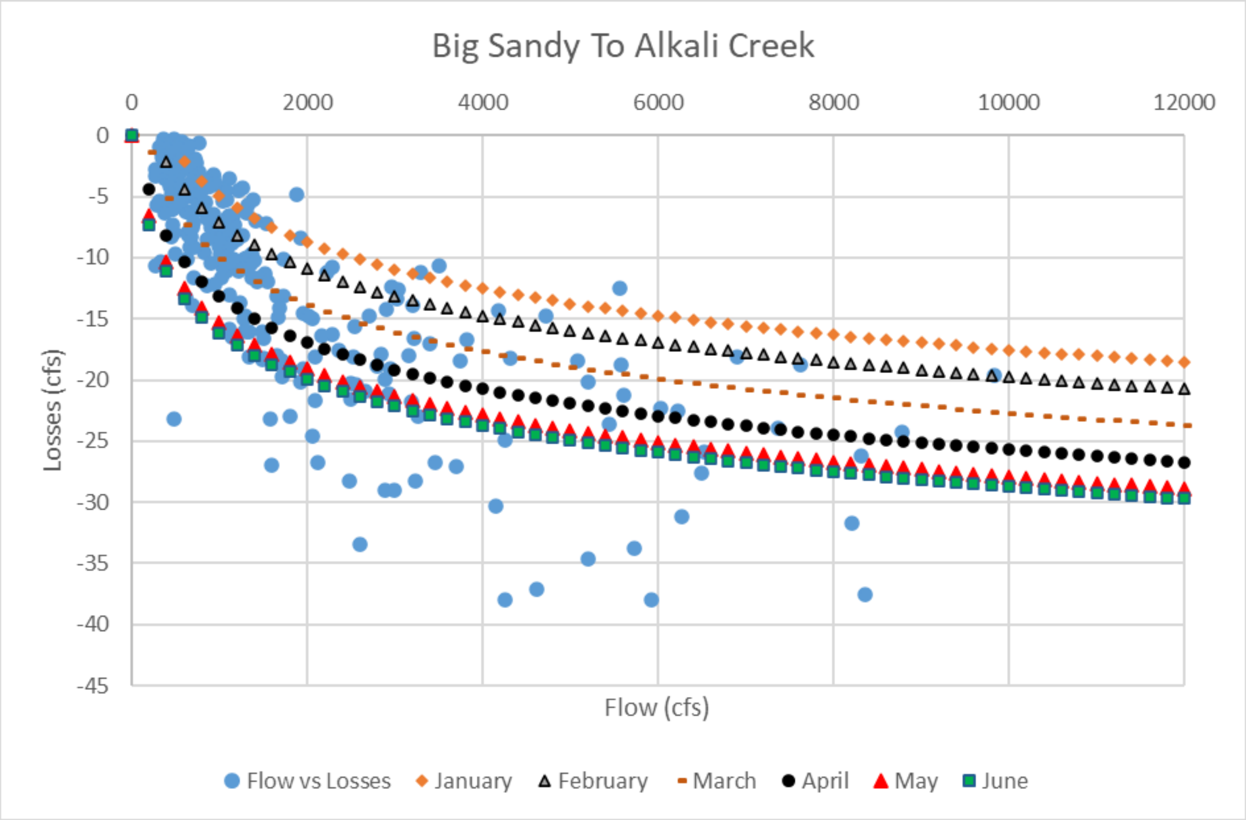


Figure 6. January through June monthly flow-loss regressions for Big Sandy to Alkali Creek. This demonstrates that the January regression mostly represents low loss (and low flow) data, which are more likely to occur in winter months with low flows and low ET and evaporation. Alternatively, the June regression is more representative of the high loss data, which is more likely in summer months with high ET and evaporation. Note that December through July are equivalent to January through June and therefore not shown here.

Physical flow and estimation of incremental loss between Fontenelle and Flaming Gorge reservoirs were simulated in a model built in RiverWare (RiverWare model, [https://riverware.org/index.html](https://riverware.org/index.html)), simulated gages at confluences, and the USGS gages below Fontenelle Reservoir and near Green River, WY (Figure 7).

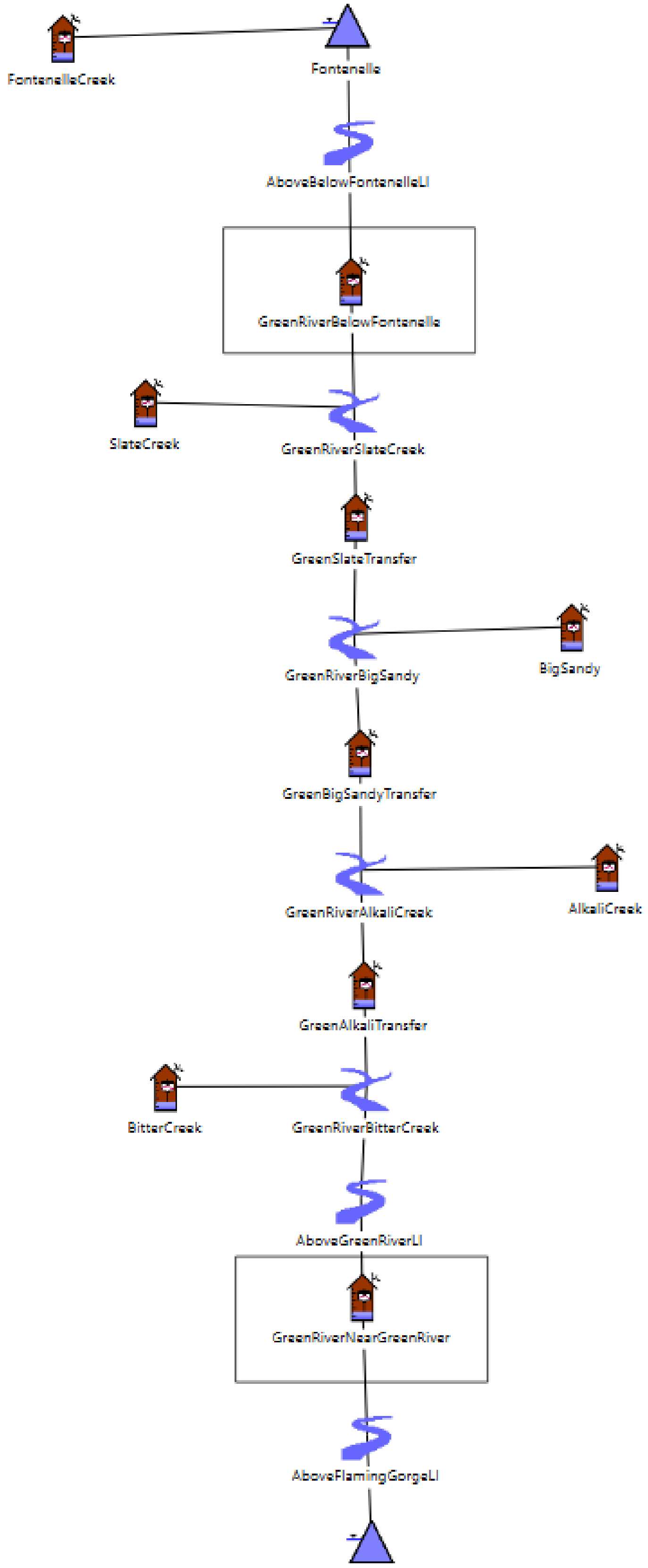


Figure 7: RiverWare workspace to estimate incremental transit loss between Fontenelle and Flaming Gorge

# Results

As described in approximate terms in the Test Release Details, a baseflow estimated based on the interpolated flow rate before and after the release resulting in an average of 756 cfs in addition to a conservation flow of approximately 246 cfs resulted in a total flow of approximately 1230 cfs for five days. This increase of 246 cfs converts to approximately 487 ac-ft per day and 2435 ac-ft for the entire 5 days, prior to transit losses.

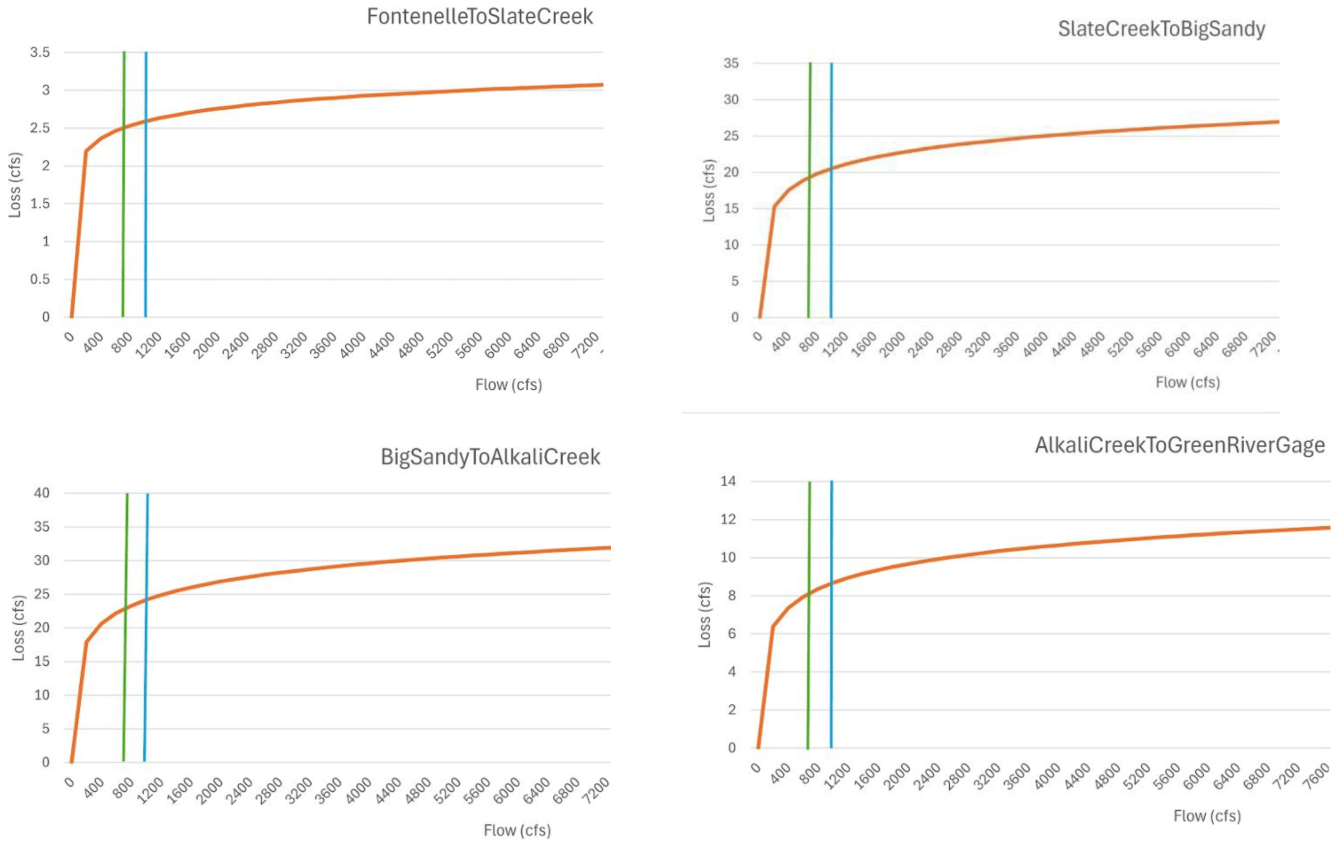
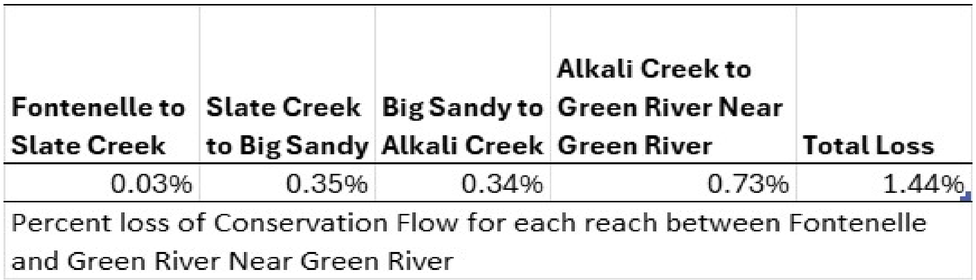


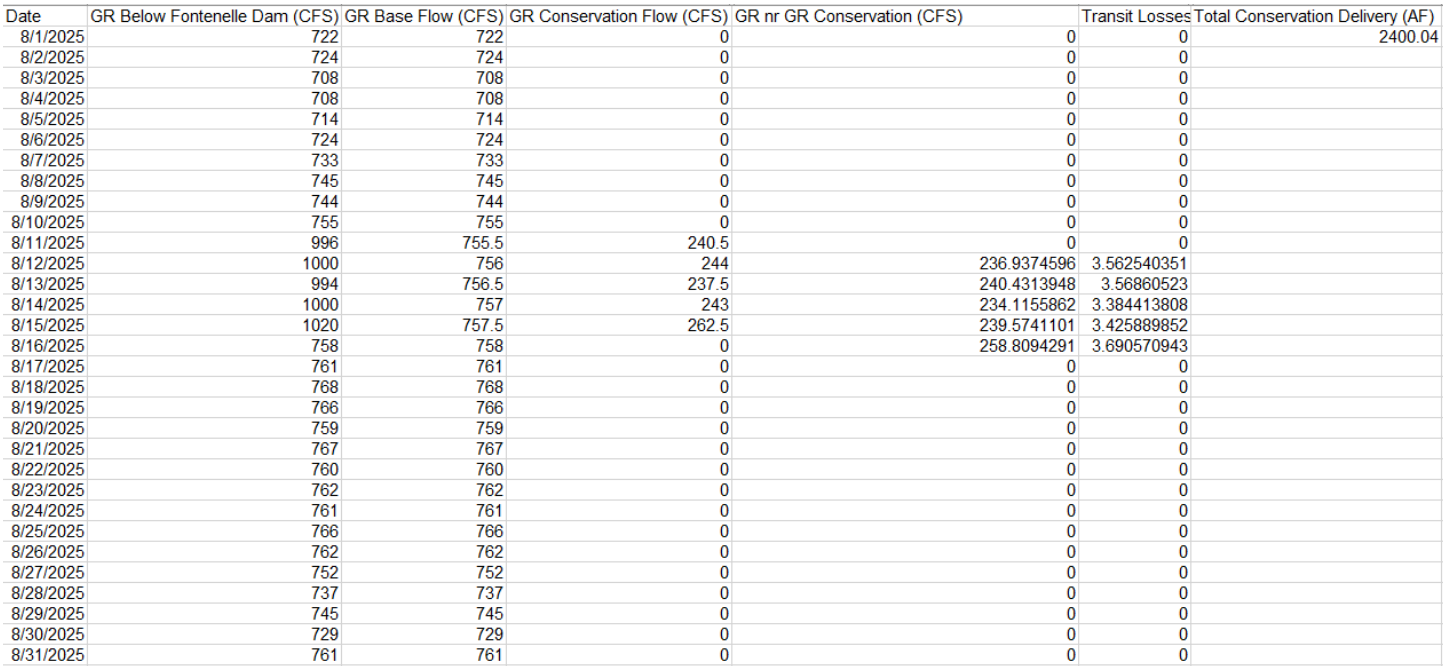
Figure 8. Draft August flow-loss relationship curve (orange line) with losses at base flow (left green line) and at peak flow of release (right blue line) for the entire reach. Note that since the Bitter Creek to Green River sub-reach is so short, it was removed in this analysis.



| Fontenelle to Slate Creek | Slate Creek to Big Sandy | Big Sandy to Alkali Creek | Alkali Creek to Green River Near Green River | Total Loss |
|---|---|---|---|---|
| 0.03% | 0.35% | 0.34% | 0.73% | 1.44% |

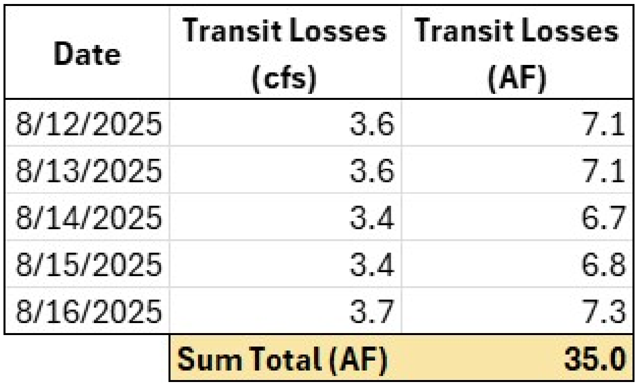
Percent loss of Conservation Flow for each reach between Fontenelle and Green River Near Green River

Table 3: Draft individual loss percentages for each sub-reach between Fontenelle and Green River, with a summed total of the loss for the conservation flow for the entire distance (~72 miles).



| Date | GR Below Fontenelle Dam (CFS) | GR Base Flow (CFS) | GR Conservation Flow (CFS) | GR nr GR Conservation (CFS) | Transit Losses | Total Conservation Delivery (AF) |
|---|---|---|---|---|---|---|
| 8/1/2025 | 722 | 722 | 0 | 0 | 0 | 2400.04 |
| 8/2/2025 | 724 | 724 | 0 | 0 | 0 | |
| 8/3/2025 | 708 | 708 | 0 | 0 | 0 | |
| 8/4/2025 | 708 | 708 | 0 | 0 | 0 | |
| 8/5/2025 | 714 | 714 | 0 | 0 | 0 | |
| 8/6/2025 | 724 | 724 | 0 | 0 | 0 | |
| 8/7/2025 | 733 | 733 | 0 | 0 | 0 | |
| 8/8/2025 | 745 | 745 | 0 | 0 | 0 | |
| 8/9/2025 | 744 | 744 | 0 | 0 | 0 | |
| 8/10/2025 | 755 | 755 | 0 | 0 | 0 | |
| 8/11/2025 | 996 | 755.5 | 240.5 | 0 | 0 | |
| 8/12/2025 | 1000 | 756 | 244 | 236.9374596 | 3.562540351 | |
| 8/13/2025 | 994 | 756.5 | 237.5 | 240.4313948 | 3.56860523 | |
| 8/14/2025 | 1000 | 757 | 243 | 234.1155862 | 3.384413808 | |
| 8/15/2025 | 1020 | 757.5 | 262.5 | 239.5741101 | 3.425889852 | |
| 8/16/2025 | 758 | 758 | 0 | 258.8094291 | 3.690570943 | |
| 8/17/2025 | 761 | 761 | 0 | 0 | 0 | |
| 8/18/2025 | 768 | 768 | 0 | 0 | 0 | |
| 8/19/2025 | 766 | 766 | 0 | 0 | 0 | |
| 8/20/2025 | 759 | 759 | 0 | 0 | 0 | |
| 8/21/2025 | 767 | 767 | 0 | 0 | 0 | |
| 8/22/2025 | 760 | 760 | 0 | 0 | 0 | |
| 8/23/2025 | 762 | 762 | 0 | 0 | 0 | |
| 8/24/2025 | 761 | 761 | 0 | 0 | 0 | |
| 8/25/2025 | 766 | 766 | 0 | 0 | 0 | |
| 8/26/2025 | 762 | 762 | 0 | 0 | 0 | |
| 8/27/2025 | 752 | 752 | 0 | 0 | 0 | |
| 8/28/2025 | 737 | 737 | 0 | 0 | 0 | |
| 8/29/2025 | 745 | 745 | 0 | 0 | 0 | |
| 8/30/2025 | 729 | 729 | 0 | 0 | 0 | |
| 8/31/2025 | 761 | 761 | 0 | 0 | 0 | |

Table 4. Draft daily flow data as measured at the USGS gage 09211200 below Fontenelle Reservoir for the Test Release that occurred from 8/11/2025 to 8/15/2025. Column two is the base flow, estimated by interpolating the flow rates before and after the release. Column 3 presents the flows in addition to the base flows. Column 4 presents the estimated flows at Green River after subtracting transit losses. Column 5 presents the transit losses during the release period.



| Date | Transit Losses (cfs) | Transit Losses (AF) |
|---|---|---|
| 8/12/2025 | 3.6 | 7.1 |
| 8/13/2025 | 3.6 | 7.1 |
| 8/14/2025 | 3.4 | 6.7 |
| 8/15/2025 | 3.4 | 6.8 |
| 8/16/2025 | 3.7 | 7.3 |
|  | **Sum Total (AF)** | **35.0** |

Table 5. Draft daily and total transit loss data for the Test Release event in cfs and acre-feet.

## Conclusion

The incremental loss method produces a loss rate that differs from the rate obtained by solely using the difference between USGS gages, which would be a total loss method. There are problems with using only stream gages. For one, the downstream gage would not account for the immediate loss occurring due to bank storage, i.e., the temporary losses where increased flow will seep into the river bank, returning later after water levels decrease. In addition, it should be recognized that losses to a conservation flow occur regardless of whether it occurs in a losing or a gaining reach. If it is the latter, and the downstream gage shows higher flows than the upstream gage, it is very difficult to estimate the losses. Finally, the difference between stream gages estimates the total losses, which may be much greater than the losses that are due only to the incremental increase in flows.

For the calculation of transit losses, based on the difference of the losses between the Test Release and the baseflow for August at each sub-reach (Figure 8) the total losses summed to 1.44%, with individual sub-reach losses shown in Table 3, and presented in daily time step in Table 4. These percentages of loss sum to a total loss of 34.96 ac-ft (Table 5), and a net Test Release delivery to Flaming Gorge Reservoir (after the subtraction of losses) of approximately 2400.04 ac-ft.

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THE COLORADO RIVER AUTHORITY OF UTAH

# Annual Report on the Utah Demand Management Pilot Program:

## Conserved Consumptive Use Estimates and Provisional Accounting Methodologies

### Water Year 2025

The Colorado River Authority of Utah
60 East South Temple, Suite 850
Salt Lake City, UT 84111

January 8, 2026

THE COLORADO RIVER AUTHORITY OF UTAH
P W R E
PRECISION WATER RESOURCES ENGINEERING
Jacobs

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AF | acre-foot or -feet |
| Authority | Colorado River Authority of Utah |
| CCU | conserved consumptive use |
| cfs | cubic foot or feet per second |
| DRP | depletion reduction potential |
| DWRi | Utah Division of Water Rights |
| EAT | elevation-area table |
| ET | evapotranspiration |
| EVT | elevation-volume table |
| N/A | not applicable or available |
| NHD | National Hydrography Dataset |
| Provisional Accounting MOU | Provisional Accounting Memorandum of Understanding |
| QA/QC | quality assurance/quality control |
| Reclamation | Bureau of Reclamation |
| U.S. | United States |
| UCRB | Upper Colorado River Basin |
| UCRC | Upper Colorado River Commission |
| USDA | U.S. Department of Agriculture |
| USGS | United States Geological Survey |
| UT DMPP | Utah Demand Management Pilot Program |
| WY | water year |

# 1 INTRODUCTION

The Colorado River Authority of Utah (Authority) is conducting a Utah Demand Management Pilot Program (UT DMPP) to explore temporary, voluntary, compensated, and protected agricultural water conservation strategies in the Upper Colorado River Basin (UCRB) portion of the state by temporarily securing water supplies to evaluate water conservation strategies that support Utah's continued 1922 Colorado River Compact compliance. UT DMPP conservation activities are entirely state-funded through a 2023 $5 million appropriation from the Utah Legislature. The Authority is supported in this effort by the Jacobs Project Team, which comprises professionals from Jacobs Engineering Group Inc., Utah State University Extension, Precision Water Resources Engineering, Hansen Allen & Luce, and M.Cubed.

An essential component of the UT DMPP is the implementation of conservation strategies through temporary fallowing projects and lease change or storage forbearance projects implemented in 2025 and 2026. The Authority's goal with each project is to achieve water conservation through reduced water depletion. The Authority is following relevant state law and federal processes to test demand management, which include distributing and accounting for conserved water such that the State of Utah could be eligible to receive credit for the savings that can be used to maintain 1922 Colorado River Compact compliance.

## 1.1 Background

In the latter half of 2024, the Jacobs Project Team provided administrative support to the Authority, focusing on developing market-based compensation rate structures, creating evaluation criteria for project applications, and refining methodologies associated with using OpenET-based depletion reduction estimates for on-farm conservation activities.

Following this administrative phase, the Authority held an initial application submittal period from December 2024 through January 2025 for the UT DMPP's three project categories. The response to the application period was significant, with a total of 27 applications received: 19 for fallowing projects and 8 for lease change/storage forbearance projects. The Authority also solicited irrigation system conservation projects but no applications were received. The Jacobs Project Team analyzed information provided in the applications to estimate the potential depletion reduction potential (DRP) volume associated with each application (Appendix A includes the detailed method).

Subsequently, an evaluation committee reviewed and scored the applications based on previously established scoring criteria. The selection process culminated in a special session of the Authority's Board on March 13, 2025, during which four pilot projects were selected for implementation (selected applicants herein referred to as participants): two temporary fallowing pilot projects and two lease change/storage forbearance pilot projects. Notably, one temporary fallowing project and one lease change/storage forbearance project involved combining multiple water company shareholder applications into single pilot projects that each span 2 years. The Authority and UT DMPP participants entered into implementation agreements in May and June 2025. Implementation agreements outline the provisions of UT DMPP participation and compensation and procedures for project verification.

The Authority, with support from the Jacobs Project Team, developed a pilot project plan for each selected UT DMPP project to manage and oversee the entire life cycle of UT DMPP water conservation efforts. Extending beyond on-site verification, these pilot project plans support compliance under any approved water right change applications administered by the Utah Division of Water Rights (DWRi) and demonstrate how UT DMPP pilot projects meet the requirements of qualifying activities under the 2024 Provisional Accounting Memorandum of Understanding between the Upper Colorado River Commission and the U.S. Bureau of Reclamation (Provisional Accounting MOU).

## 1.2 Intended Audience and Use of this Report

This annual report for water year (WY) 2025 (October 1, 2024, through September 30, 2025) was prepared by the Jacobs Project Team for submission to the UCRC. It summarizes key elements of the UT DMPP in accordance with the Provisional Accounting MOU and includes the following information:

- Overview of project locations, pre-season estimates of DRP, and post-season estimates of conserved consumptive use (CCU)
- Description of methodologies used to quantify both pre-season DRP and post-season CCU estimates using OpenET data
- Proposed methodology for evaluating transit losses specific to water conservation programs in Utah's UCRB (Instead of measuring total physical water losses throughout the river system, this approach estimates the incremental increase in transit losses resulting from the addition of conserved water, an important distinction for administrative and accounting purposes)
- Presentation of preliminary results for WY 2025 and project parameters for WY 2026

The data and figures in this report, particularly those in Section 4, are preliminary and provided as proof of concept to demonstrate the methodology. UT DMPP relies on the best available information to develop estimates at the time of submission. However, since project-end verification and post-season UT DMPP reporting and analysis are still in progress, new data may become available that could affect the final results.

The Provisional Accounting MOU requires annual reporting for each WY (October 1 through September 30). Under UT DMPP agreements, temporary fallowing and reservoir storage forbearance activities generally occur both during the irrigation season, which in some cases runs between March 1 and November 30, and during the winter period following the irrigation season, December 1 through March 1.

Consequently, CCU, transit loss, and evaporation estimates for temporary fallowing projects reflect post-season results for the WY only, not the full irrigation season. For storage forbearance projects, transit and evaporation loss estimates may not be available until spring 2026 due to the timing and duration of winter reservoir releases.

# 2 QUALIFYING ACTIVITIES, LOCATIONS, AND ESTIMATES

In WY 2025, the UT DMPP had the following four qualifying activities:

- Two Temporary Fallowing projects:
  - SE Tributary Group
  - E Tributary
- Two Reservoir Storage Forbearance projects:
  - Duchesne River
  - Price River

The Temporary Fallowing – SE Tributary Group pilot project consists of 1,841 acres of full or partial season fallowed agricultural land serviced by the Carbon Canal in Price, Utah. The Temporary Fallowing – E Tributary pilot project consists of 1,520 acres of partial season fallowed agricultural land along the Green River near Ouray and Brush Creek near Jensen, Utah. Both Temporary Fallowing projects are shown on Figure 2-1.

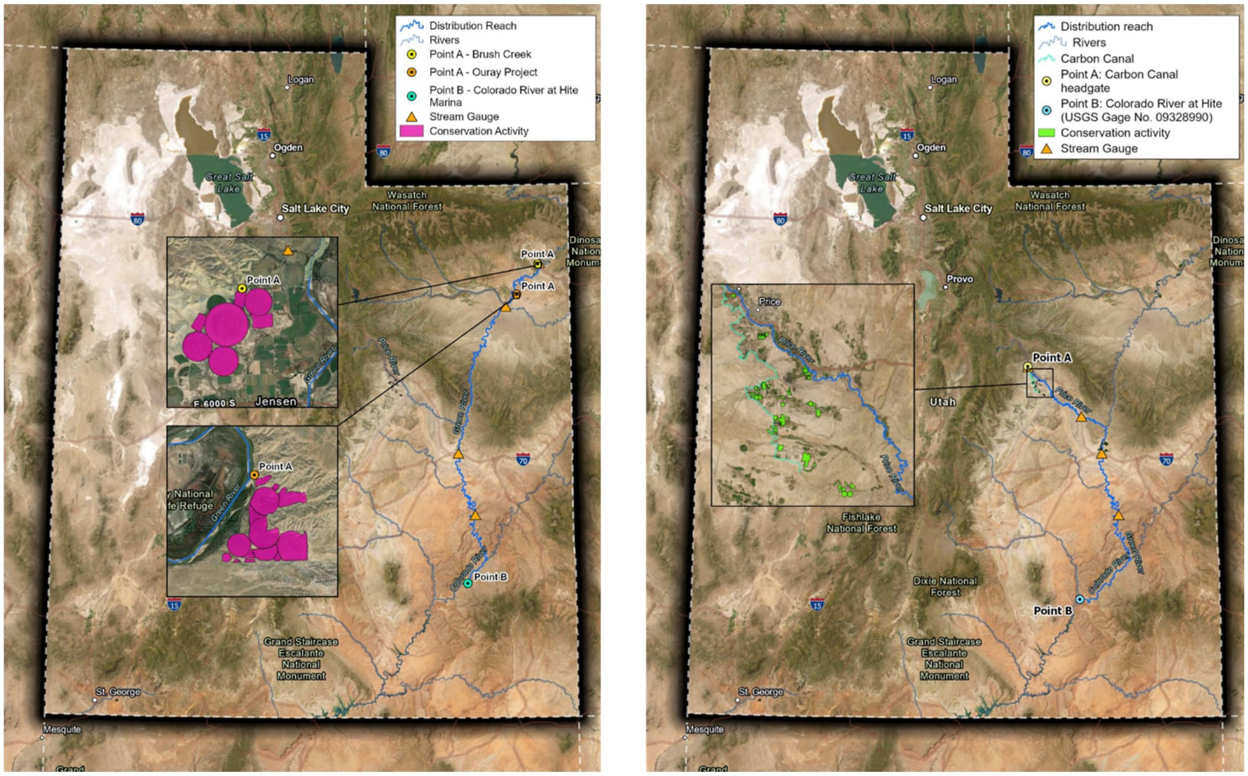

Figure 2-1. Location Maps for the Utah Demand Management Pilot Program Temporary Fallowing – SE Tributary Group (right) and E Tributary (left) Pilot Projects

For the Storage Forbearance – Duchesne River pilot project, the associated water right allows for trans-basin diversion from the Colorado River System to the Great Salt Lake basin, with a 100-percent consumptive use rate. This pilot project seeks to divert all available water each year (up to 4,500 acre-feet [AF]) from the Wolf Creek and Twin Creek sources to Lake Powell. The pilot project water was held in Starvation Reservoir through the irrigation season and then released in November 2025. For the Storage Forbearance – Price River pilot project, reservoir water shareholders enrolled 2,152 AF in the UT DMPP associated with an estimated depletion reduction of 1,377 AF for 2025. This pilot project water was held in Scofield Reservoir through the irrigation season and released starting in November 2025.

For each UT DMPP pilot project, pre-season DRP and post-season CCU are estimated at the location of the qualifying activity (referred to as Point A). Transit losses are then calculated for the movement of CCU from Point A to Lake Powell (Point B). Table 2-1 presents the pre-season DRP estimates, while Table 2-2 summarizes the post-season CCU estimates.

Table 2-1. Pre-season Estimates of Diversion and Depletion Reduction Opportunities for Four Qualifying Activities under Utah Demand Management Pilot Program, Water Year 2025

| Project Name | Minimum Enrollment Volume Required for UT DMPP at 100%[a] (AF) | Estimated Pre-Season DRP (April through October, v2[b]) at Point A (AF) | Estimated Pre-Season DRP WY 2025 (April through September, v2.1[c]) at Point A (AF) |
|---|---|---|---|
| Temporary Fallowing – SE Tributary Group | 4,111 | 2,631 | 2,530 |
| Temporary Fallowing – E Tributary | 3,186 | 2,039 | 1,832 |
| Fallowing Total | 7,297 | 4,670 | 4,362 |
| Storage Forbearance – Price River[d] | 2,152 | 1,377 | 1,377 |
| Storage Forbearance – Duchesne River[d] | Up to 4,500[e] | Up to 4,500[f] | Up to 4,500[f] |
| Storage Forbearance Total | 6,652 | 5,877 | 5,877 |
| *UT DMPP Total* | *13,949* | *Up to 10,547* | *Up to 10,239* |

[a] *Minimum diversion volume required UT DMPP enrollment is pre-season DRP adjusted by combined efficiency factor to account for conveyance and irrigation losses. Both conveyance and irrigation efficiencies were assumed 80 percent (with 20-percent loss each), resulting in combined efficiency factor of 64 percent.*

[b] *This estimate was included in UT DMPP implementation agreements, and it pertains to the full irrigation season (April through October).*

[c] *Methodology was updated to provide UCRC with estimated DRP for the WY (April through September) rather than UT DMPP implementation period (April through October). As a result, the WY estimate is lower than estimate for the full irrigation season under UT DMPP.*

[d] *Reservoir release will occur in WY 2026.*

[e] *Minimum enrollment is not required because trans-basin water right is 100-percent consumptive.*

[f] *This value depends on annual hydrologic yield of water right.*

*N/A = not applicable*

Table 2-2. Post-Water Year Estimates of Diversion Reduction and Conserved Consumptive Use for Four Qualifying Activities under Utah Demand Management Pilot Program, Water Year 2025

| Project Name | Total Diversion Volume of Water Realized by UT DMPP WY 2025 (AF) | Estimated WY 25 Post-season CCU (v2.2) (AF) | CCU Realized (before transit losses (AF) | Total Volume of Water Entering Lake Powell (AF) |
|---|---|---|---|---|
| Temporary Fallowing – SE Tributary Group | 4,425[a] | 2,222 | 2,149 | 2,743[b] |
| Temporary Fallowing – E Tributary | 756 | 997 | 760[d] | |
| Fallowing Total | 5,181[a] | 3,219 | 2,908 | 2,743[b] |
| Storage Forbearance – Price River | To Be Delivered in WY 2026 – See Discussion in Section 4.4[c] | | | |
| Storage Forbearance – Duchesne River[d] | To Be Delivered in WY 2026 – See Discussion in Section 4.4[c] | | | |
| Storage Forbearance Total | N/A[c] | N/A[c] | N/A[c] | N/A[c] |
| *WY 25 Total* | *N/A[a]* | *3,219* | *2,908* | *2,743[b]* |

[a] *Provisional number; applicant records detailing water movement through canal were incomplete, requiring further clarification and discussion.*
[b] *Only the combined volume of water entering Lake Powell is available, due to the nature of the model output.*
[c] *Reservoir release will occur in WY 2026.*
[d] *See Section 5 for a discussion on the discrepancy between pre-season and post-season estimates*

*N/A = not available*

# 3 METHODS

This section provides a high-level overview of the methodology used to estimate water savings for temporary fallowing and storage forbearance pilot projects. Section 3.1 outlines the approach for estimating CCU volumes (in AF), for temporary fallowing and reservoir storage projects implemented under the UT DMPP during WY 2025. The methodology includes pre-season DRP, which is estimated using data from a 7-year historical lookback period and post-season CCU, which is calculated using WY 2025 data. Complete methodology, including equations, data sources, references, and quality assurance/quality control (QA/QC) procedures, is documented in *Estimated Depletion Reduction Calculation Methodology v2.2* (Appendix A). Section 3.2 describes the process for quantifying incremental transit losses as CCU moves from the conservation site to Lake Powell. Section 3.3 details the methods used to estimate evaporation losses while CCU is stored in a reservoir.

## 3.1 Estimating Conserved Consumptive Use

For temporary fallowing pilot projects, field-scale depletion is calculated using the Hill equation (Hill 1989), which subtracts carry-over soil moisture and effective precipitation from crop-specific growing-season evapotranspiration (ET). Unlike the original Hill approach, which relies on theoretical ET values from literature, actual ET values for each field were obtained using OpenET's eeMETRIC model. Carry-over soil moisture was estimated using winter precipitation, winter ET, crop rooting depth, and soil water capacity, while effective precipitation was calculated monthly using U.S. Department of Agriculture methods (USDA 1970). Equation 1 provides the monthly depletion calculation at the field scale, adapted from Hill (1989):

$$DRO = ETmon - SMco, mon - Peff$$ Equation 1

Where:

$DRP$ = median annual depletion volume (inches) over a 7-year look-back period
$ET_{mon}$ = monthly OpenET eeMETRIC actual evapotranspiration (inches) (Melton et al. 2021)
$P_{eff}$ = monthly effective precipitation (inches)
$SM_{co,\ mon}$ = carry-over soil moisture at start of the month (inches)

Pre-season DRPs were estimated as the median annual depletion volume for a given area (in AF) over a 7-year historical period, and post-season CCU savings were typically estimated by comparing water use under irrigated conditions to water use under fallowed conditions. This comparison can be made in two ways:

1. Same year, different fields: Compare an irrigated field to a nearby fallowed field.
2. Same field, different years: Compare water use in a previously irrigated year to a fallowed year.

For the UT DMPP, the second approach was used, comparing the same field across two different years. Because hydrologic conditions vary between years, an adjustment factor was applied. This factor is derived from the ratio of short crop reference ET between the median look-back year and the UT DMPP growing season. The method is automated, reproducible, and uses this ratio as a correction factor. ET was used in Equation 2 instead of depletion for simplicity, assuming effective precipitation and carry-over soil moisture remain constant under irrigated and nonirrigated conditions; thus, end-of-season CCU was approximately equal to the difference in ET between irrigated and fallowed conditions:

$$\mathrm{CCU} \approx ET_{preseason} * \left(\frac{ET_{o,after}}{ET_{o,preseason}}\right) - ET_{after} \qquad \text{Equation 2}$$

Where:

$CCU$ = conserved consumptive use due to fallowing (inches per month)
$ET_{preseason}$ = evapotranspiration for DRP period (inches per month)
$ET_{o,after}$ = short-reference ET for UT DMPP growing season (inches)
$ET_{o,preseason}$ = short-reference ET for DRP period (inches)
$ET_{after}$ = evapotranspiration during UT DMPP implementation (inches per month)

For the reservoir storage forbearance pilot projects, the pre-season DRP volume was estimated using the same methodology as System Conservation Pilot Program (UCRC 2023), where the estimated release volume (AF) was adjusted by a combined efficiency factor to account for conveyance and irrigation losses. Both conveyance and irrigation efficiencies were assumed to be 80 percent (with 20-percent loss each), resulting in a combined efficiency factor of 64 percent (additional details are provided in Appendix A). For the transbasin diversion pilot project, post-season CCU was assumed to equal 100 percent of the water delivered to the UT DMPP.

## 3.2 Incremental Transit Loss

All volumes of CCU will incur loss over time, depending on the type of waterbody they occupy. As CCU flows through a river reach (that is, a segment of river), the CCU adds a volume of physical water that changes the physical processes (in the quantities involved, not types of processes) the reach would have experienced had the CCU not been present. This same concept applies when CCU is temporarily stored in a reservoir. In both scenarios, the CCU volume is treated as “floating on top” of the existing water (system water). To visualize this, consider a vertical cross-section of a river reach or reservoir. In this cross-section, the CCU water would be a thin volume at the top stretching from bank to bank, and the remaining water would lie beneath it stretching from bank to bank (Figure 3-1).

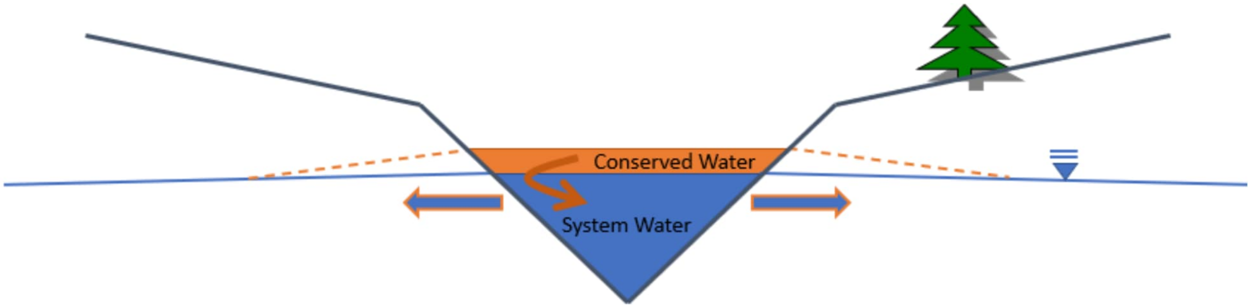

Figure 3-1. River/Reach Cross-Section Representing Basics of Incremental Transit Loss Reduction Incurred by Conserved (Conserved Consumptive Use) Water

When CCU water flows through a river system, a network of reaches is established and delineated according to locations of United States Geological Survey (USGS) gages. For each reach, historical monthly riparian ET data from OpenET and monthly average flow at the upstream reach boundary were used to develop a relationship between ET and flow. Then, incremental loss was quantified proportional to an observed change in ET given the change in flow through a modeled reach when conserved water is added to system water. The loss was then applied to the CCU volume by transferring the loss volume to the system water.

To simulate physical flow and estimate incremental transit loss through the Colorado River Basin in Utah, a model of the UCRB was built in RiverWare[5] with a network of USGS gages (Lake Powell, Scofield Reservoir, and Starvation Reservoir). These three reservoirs were included because they are storing project water for the UT DMPP. To transfer loss estimates in the RiverWare accounting space, additional gages were simulated at major confluences throughout the basin. The geographic extent of this RiverWare model with USGS and simulated gage locations is shown on Figure 3-2, and the RiverWare workspace representation of this geographic extent is shown on Figure 3-3.

The following parameters were required for each river reach in the system to implement the incremental transit loss method:

1. Amount of CCU water at a designated upstream location to begin assessing transit loss (for example, the program source, Point A)
2. Reach length and travel time through the reach
3. Loss volume (estimated volume of riparian ET); the loss volume is associated with various flow rates

These parameters are detailed in Sections 3.2.1 through 3.2.3. Development of these parameters varied for reaches defined by two USGS gages with historical flow records and those defined by simulated gage locations at confluences without historical flow records.

### 3.2.1. Amount of Conserved (Conserved Consumptive Use) Water

For full- or partial-season temporary fallowing projects, CCU water volume entered the river system as inflow and was reduced according to the incremental transit loss calculation described in Section 3.2.4. This process was applied at each reach until the water reached its destination reservoir (that is, Lake Powell), where additional reductions occurred due to incremental evaporation over time (Section 3.3).

For reservoir storage projects, CCU was determined following the methods summarized in Section 3.1. Water was stored in project reservoirs (Starvation and Scofield) until scheduled release after the irrigation season. While stored, CCU was reduced by incremental evaporation (Section 3.3). After release, the same incremental transit loss process was applied through each reach until Lake Powell, where evaporation reductions continued during storage.

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[5] https://riverware.org/index.html

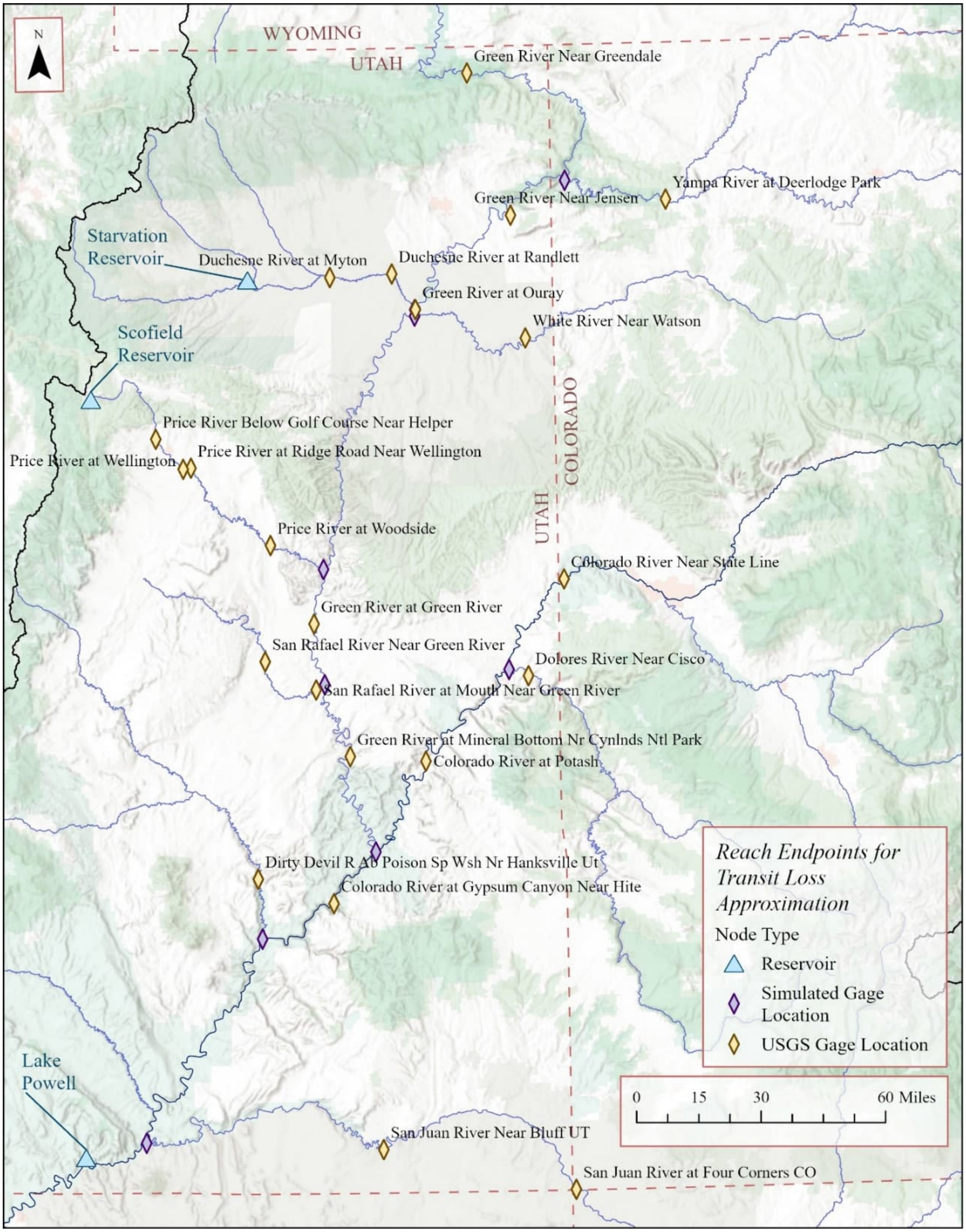

Figure 3-2. Extents of the Colorado River Basin Model Developed for Transit Loss Calculations

*Note: Simulated gage locations (purple) are used at confluences when the RiverWare implementation requires reaches that are not established at either the upstream or downstream boundaries by USGS gages. These additional reaches are used to transfer water at confluence locations so that incremental transit loss can be computed accounting for potentially different types of water flowing into a confluence.*

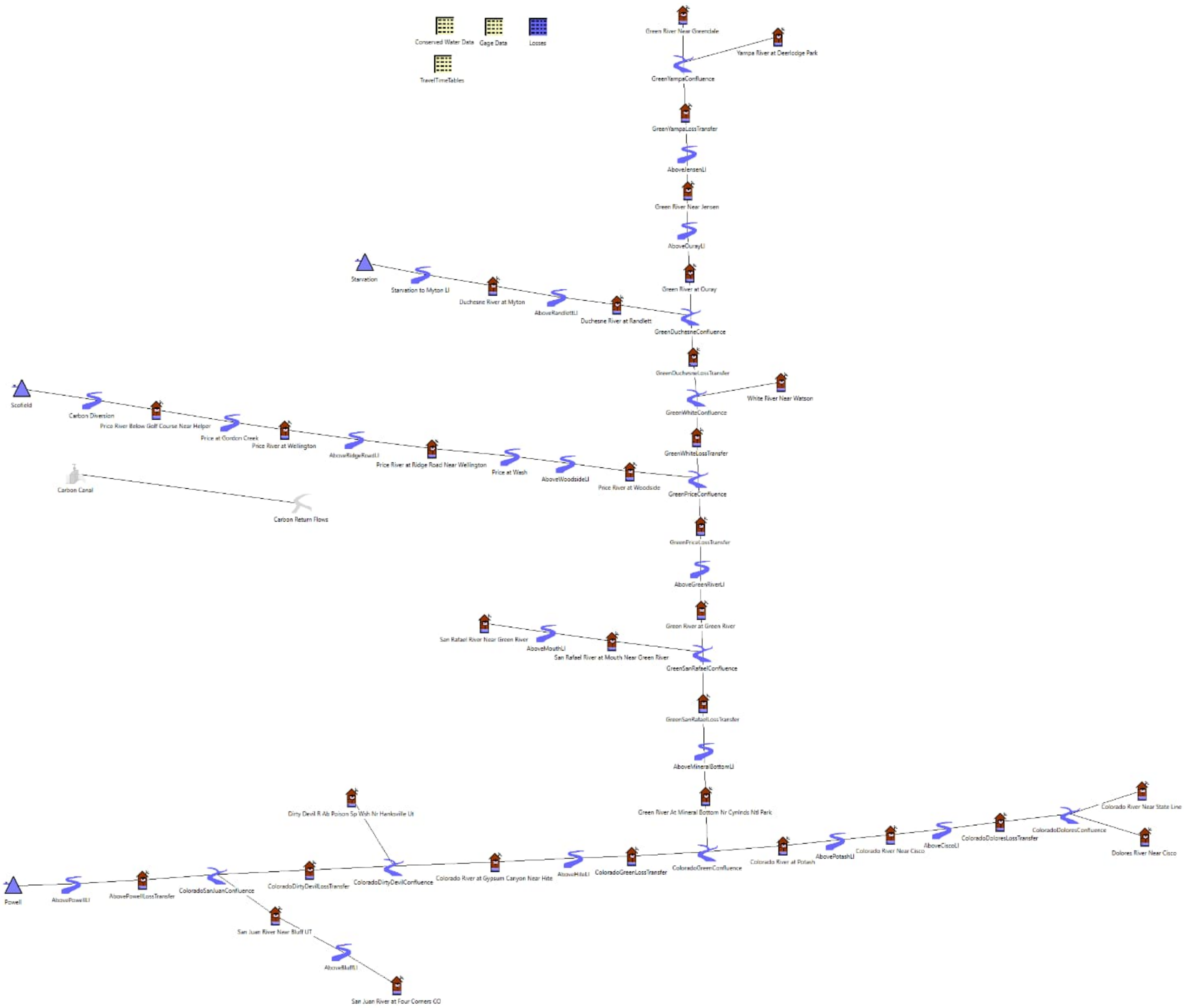

Figure 3-3. RiverWare Workspace of the Colorado River Basin Model Developed for Transit Loss Calculations

## 3.2.2. Reach Length and Travel Time

Reach length was computed in QGIS[6] as the distance between gages represented on Figure 3-3 with distances measured along the flowlines layer from the USGS National Hydrography Dataset (NHD).[7] To estimate travel time between reaches, the SciPy library in Python[8] was used to optimize a temporal shift in historical hourly flow data between upstream and downstream gages. To approximate travel time between RiverWare reaches with a simulated confluence at either the upstream or downstream reach boundary, travel time estimates were scaled from adjacent USGS gage locations based on distance from the simulated confluence gage.

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[6] https://qgis.org/
[7] https://www.usgs.gov/national-hydrography/national-hydrography-dataset
[8] https://scipy.org/

No rapid geomorphic change was assumed to have occurred for the reaches modeled with this method during the simulation period; therefore, distance between reaches was assumed to be constant and input directly to the RiverWare model. In the physical network of the RiverWare model, travel time was already accommodated by observed gage data. In the model's accounting framework, however, travel time was computed to simulate a temporal lag. Due to this and the model simulating at a daily timestep, a constant value for travel time through each reach was considered sufficient.

### 3.2.3. Loss Volume

The estimate of base loss volume is the most physically complex parameter required for this method. A series of assumptions were required to quantify a relationship between flow and loss volume through each reach in the RiverWare model. First, bank storage impacts of CCU water on system water were assumed to have resulted in a net-zero flow volume change over the simulation period of a single WY. The volume of water that flows into bank storage was assumed to return to the main channel downstream within the WY. Additionally, riparian ET losses were assumed a sufficient proxy for total volume of loss through a length of reach when the goal was to develop a relationship between flow rate and loss volume for incremental analysis. Other processes, such as infiltration and seepage into groundwater, were assumed negligible in magnitude compared with ET. Surface evaporation was assumed included in the ET. Regardless, this concept of incremental transit loss estimation allowed for flexibility in these assumptions should better data become available in the future.

As a proxy for total incremental transit loss through a river reach, monthly ET volume was quantified using riparian area. First, historical ET data were queried from OpenET; OpenET provides monthly historical ET data using an ensemble of six different ET models at a 30-meter spatial resolution (Melton et al. 2021). A recent study indicates the SSEBop model of ET is the most accurate for estimating ET of wetland and riparian areas (Volk et al. 2024); therefore, ET estimates from the SSEBop model were used. Riparian area was computed for the modeled reaches using the Colorado River riparian vegetation corridor extent polygon, CO-RIP (Woodward et al. 2018). With these geospatial data inputs, the OpenET data were summarized using riparian areas to yield a monthly time-series of ET volume for each modeled reach from January 2000 through December 2024.

The monthly time-series of ET volume for the region between modeled reaches described above served as the dependent variable for a regression model where monthly average flow volume and seasonality (parameterized as a sine curve) were independent variables. Analysis showed, in any given month, ET volume was predicted well by the previous month's average volumetric flow and seasonality. This regression model was used to extrapolate an estimated ET volume at regular intervals of flow for each modeled reach. Estimated ET volumes were used to produce a table of values associating volume of ET for discrete flow rates; therefore, application of this incremental transit loss method assumed that riparian ET volume was analogous to incremental transit loss. In RiverWare, one flow to loss volume lookup table for each modeled reach was included. This allowed the model to determine loss volume at any reach, interpolating linearly as necessary such that a value for incremental loss volume could be estimated at any given flow rate.

### 3.2.4. Calculation

Initially, transit loss was calculated as the loss with only system water in each river reach and termed "base loss" through the reach. Then, the transit loss was recalculated with the addition of CCU water which became "total loss" through the reach. Incremental loss was calculated by taking the difference between total loss and base loss (Equation 3). This incremental loss allowed for an accounting transfer from CCU water to system water.

$$IL = TL - BL \qquad \text{Equation 3}$$

Where:

$IL$ = incremental loss (flow)
$TL$ = total loss (flow)
$BL$ = base loss (flow)

The base loss represented the transit loss that would occur if system water were the only water volume flowing through the modeled reach. In RiverWare, the base loss volume was the first value determined from the flow-to-loss volume lookup table, interpolated linearly as necessary. The flow for this determination was the system flow through the reach, and the result was a loss volume for the system water exclusively (which is represented by riparian ET) in the reach.

The total loss represented the transit loss estimated for the modeled reach when both system water and CCU water were present. Like base loss, this value was determined from the flow-to-loss volume lookup table in RiverWare, interpolated as necessary; however, the flow for this determination was the total flow including CCU water. The result was a total loss volume larger than that of the base loss volume.

The incremental loss represented the additional transit loss attributable to CCU water and was estimated as the difference between total loss and base loss. For each reach, incremental loss was equal to total loss minus base loss. The incremental loss volume for each reach, therefore, depended heavily on the flow-to-loss volume lookup table developed for each reach (Section 3.2.3). This incremental loss was the volume of water that RiverWare transfers from the CCU water volume to the system volume at the modeled reach.

After computing the physical incremental transit loss volume, this quantity was transferred from the CCU water volume to system water volume at the downstream location of each modeled reach (Figures 3-2 and 3-3). The physical amount of water in the river system remained unchanged, including all the physical gains and losses within each reach. The incremental transit loss was applied as an accounting adjustment, a paper transfer, so that system water was not penalized for additional transit losses associated with CCU water.

In RiverWare, the accounting transfer occurred where the corresponding travel time was applied at each reach, ensuring that the paper transfer aligned with real-time flow data at network gages. The modified volumes of system water and CCU water became the inflow to the next downstream river reach, and the process was iterated until the downstream destination (that is, Lake Powell) was reached.

## 3.3 Incremental Evaporation

CCU water stored in a reservoir along with system water had an incremental impact on the reservoir's total evaporation due to the additional volume that would have otherwise been absent. This impact could be quantified and removed from the CCU water volume so that the reservoir's system water is not improperly incurred and increased evaporation loss caused by the presence of CCU water. Parameters required for this incremental evaporation reduction were total reservoir evaporation, total surface area of the reservoir with both CCU water and system water, and surface area of the reservoir with system water only (determined using the volume of CCU water).

### 3.3.1. Incremental Evaporation Parameters

Total reservoir evaporation, if not available through direct measurement, was computed based on the evaporation coefficients for the reservoir and reservoir total surface area. The total surface area of the reservoir with both CCU water and system water was determined using the reservoir's storage along with its elevation-volume table (EVT) and elevation-area table (EAT), which associate reservoir pool elevation to volume and area, respectively. These are typically available for most reservoirs from bathymetry or other studies. Finally, the surface area of the reservoir with system water only was determined using the total storage minus the CCU volume along with the EVT and EAT.

### 3.3.2. Calculation

The calculation process for incremental evaporation loss was much like that of transit loss through a river reach; in this case, the incremental evaporation was determined by the difference in the reservoir's surface area and associated surface evaporation with and without the addition of CCU water volume.

First, a base surface area was estimated as the surface area of the reservoir with only system water present. This was determined by a series of lookups from the EVT and EAT with the reservoir's storage reduced by the CCU water volume. Values between rows in the EVT or EAT were linearly interpolated.

Next, a total surface area was estimated as the surface area of the reservoir with system water and CCU water present. Similar to the base surface area estimation, this was determined using lookups from the EVT and EAT of the reservoir. The incremental increase in surface area was then equal to the total surface area minus the base surface area. From these variables, incremental evaporative loss was calculated using Equation 4:

$$EL_{Conserved} = E_{Reservoir} \times \frac{SA_{Incremental}}{SA_{Total}} \qquad \text{Equation 4}$$

Where:

$EL_{Conserved}$ = loss of CCU water due to evaporation (AF)
$E_{Reservoir}$ = reservoir evaporation (AF)
$SA_{Incremental}$ = incremental increase in reservoir surface area due to CCU water (AF)
$SA_{Total}$ = total surface area for the reservoir (AF)

In this method, losses over shorter periods of time could be aggregated to a total volume over the period during which CCU water is physically stored in the reservoir. This allowed accounting for changes over shorter periods of time (for example, daily) such as CCU water arriving in Lake Powell over time. This volume could then be transferred from the CCU water to the system water at whatever time is desired (for example, end of each day) since the volume is consistently being tracked. This method could be applied to a scenario where water flows into Lake Powell from an upstream project, water is stored in upstream reservoirs as a result of forbearance, or any other scenario where CCU water is stored in a reservoir and evaporative losses need to be accounted for.

# 4 RESULTS

CCU water generated by UT DMPP pilot projects during WY 2025 is water Utah will seek credit for as defined in the Provisional Accounting MOU. Of the four UT DMPP projects, only the Temporary Fallowing pilot projects delivered water downstream to Lake Powell in WY 2025. Water enrolled in the Temporary Fallowing – SE Tributary Group pilot project (Section 4.1) consists of both direct flow and storage water. Under the Temporary Fallowing – SE Tributary Group pilot project, all direct-flow water was delivered and released downstream to Lake Powell, while only a portion of the enrolled storage water was delivered and released downstream. The remaining storage water enrolled for this Temporary Fallowing pilot project was stored in Scofield Reservoir and is being delivered downstream during the non-irrigation season (December through February) of WY 2026 along with the water enrolled in the Storage Forbearance – Price River pilot project (Section 4.4).

Water for the Temporary Fallowing – E Tributary pilot project (Section 4.2) was delivered downstream to Lake Powell. Water delivered to the Storage Forbearance –Duchesne River pilot project (Section 4.5) was temporarily stored in Starvation Reservoir and is being released during the non-irrigation season (November through February) of WY 2026. Tables 4-1 through 4-7 summarize the total water delivered to the UT DMPP during WY 2025 for each UT DMPP pilot project.

## 4.1 Temporary Fallowing – SE Tributary Group

UT DMPP full and partial season temporary fallowing activities in the SE Tributary region received natural flow water that may have otherwise been used on participating fields between March 24 and June 8. The irrigation company diverted water for operations and irrigation purposes. Shareholders enrolled in the UT DMPP could have used water for irrigation on participating fields but did not by virtue of being enrolled in the UT DMPP for 2025.

From March 24 through June 8 CCU water was estimated based on a daily maximum for fallowing shares. The post-season estimates of the CCU water that would have been delivered but for the conservation activities (Total Credit on Figure 4-1) resulted in 914 AF over that time period. The volume of CCU water realized between June 9 and September 30 was nearly all released from Scofield Reservoir storage shares (Figure 4-2 in red). However, over 6 days at the end of August (August 26 through 31), the CCU water realized was based off natural flow due to significant rainfall increasing flow in Price River. From June 8 to September 30, the UT DMPP CCU volume accumulated was 1,235 AF. These two periods account for the total CCU received at Point A which amounts to 2,149 AF. This volume of CCU water (2,149 AF; Table 4-1) was then tracked through the system and reduced by incremental transit loss amounts until arriving in Lake Powell.

Table 4-1. Estimated Total Conserved Consumptive Use Volume of Utah Demand Management Pilot Program Water Generated during Water Year 2025 from Canal Releases for Temporary Fallowing – SE Tributary Group Pilot Project

| Project Name | Date | Total UT DMPP CCU Water |
|---|---|---|
| Temporary Fallowing – SE Tributary Group – Flow (Natural and Released) | March 24, 2025, through September 30, 2025 | 2,149 AF |

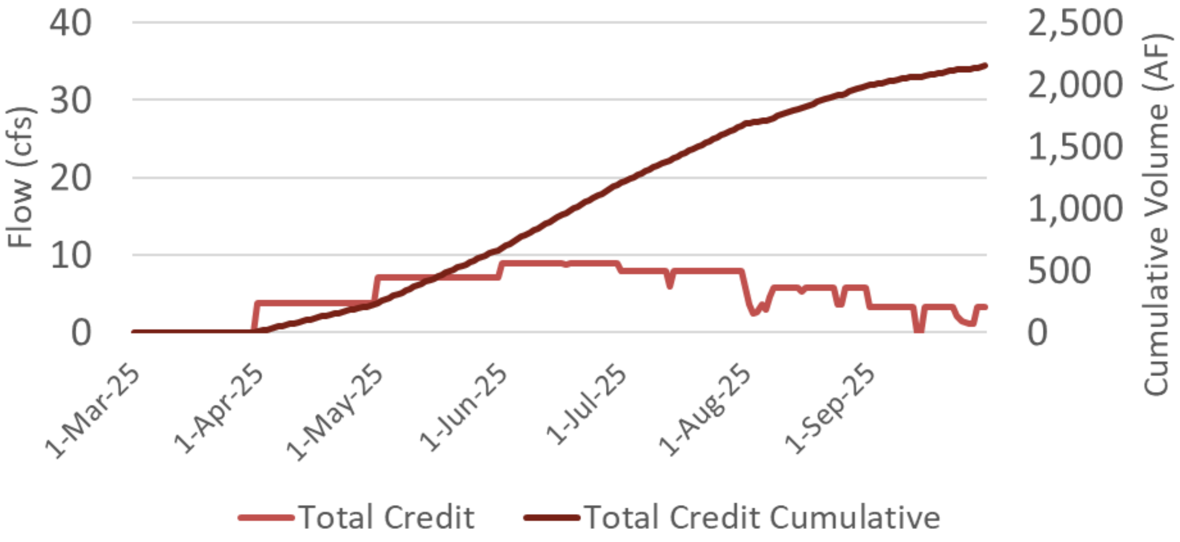

Figure 4-1. Time Series of Post-Season Conserved Consumptive Use Volume Generated (Daily and Cumulative) in Temporary Fallowing – SE Tributary Group Pilot Project

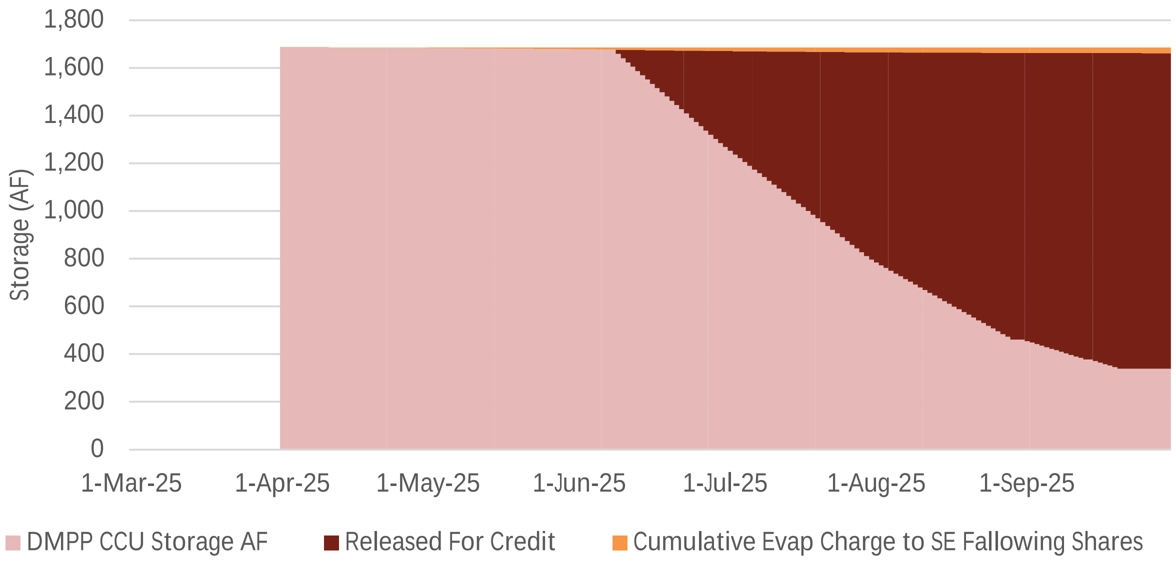

Figure 4-2. Volume of Shares Stored in Scofield Reservoir, Evaporation Reduction, and Volume Released for Direct Flow Credit for the Temporary Fallowing – SE Tributary Group Pilot Project

*Note: The volume released corresponds to a portion of the accumulated credit on Figure 4-1 starting June 9, 2025.*

## 4.2 Temporary Fallowing – E Tributary

Partial season temporary fallowing took place on two subgroups of fields (Brush Creek and Green River) between July 1, 2025, and September 30, 2025, to yield CCU water that is accounted for in the Temporary Fallowing – E Tributary pilot project. The first group of fields is irrigated with water from Brush Creek, a tributary to the Green River below the Green River Near Jensen, UT USGS Gage.

Following are data used in computing the amount of CCU water from the Temporary Fallowing – E Tributary, Brush Creek subpilot project:

1. Post-season CCU estimates based on OpenET data
2. Measured flow at Brush Creek Near Jensen, UT USGS Gage 09263500 (downstream of pilot project)

Table 4-2 and Figure 4-3 show the UT DMPP estimates based on CCU and flows at the Brush Creek Near Jensen, UT USGS Gage. To calculate the CCU savings, the daily potential flow from post-season CCU estimates was compared with the daily flow at the Brush Creek Near Jensen, UT USGS Gage, and the minimum of these two flows was the CCU savings for that day. Based on this method, a total of 698 AF CCU was estimated for the Temporary Fallowing – E Tributary, Brush Creek subpilot project; however, with the low flows recorded from the Brush Creek Near Jensen, UT USGS Gage, only 461 AF of that possible CCU flow was credited. The difference between the post-season CCU estimate and the volume of water realized at the USGS Gage was due to hydrologic shortage in the Brush Creek basin and intervening diversions. East Park Reservoir, for instance, only filled to about 55% of average resulting in significant shortage in reservoir deliveries to shareholders.

Table 4-2. Estimated Volume of Conserved Consumptive Use Water Generated during Water Year 2025 from Temporary Fallowing – E Tributary, Brush Creek Subpilot Project

| Project Name | Date | Total UT DMPP CCU Water |
|---|---|---|
| Temporary Fallowing – E Tributary, Brush Creek | September 30, 2025 | 461 AF |

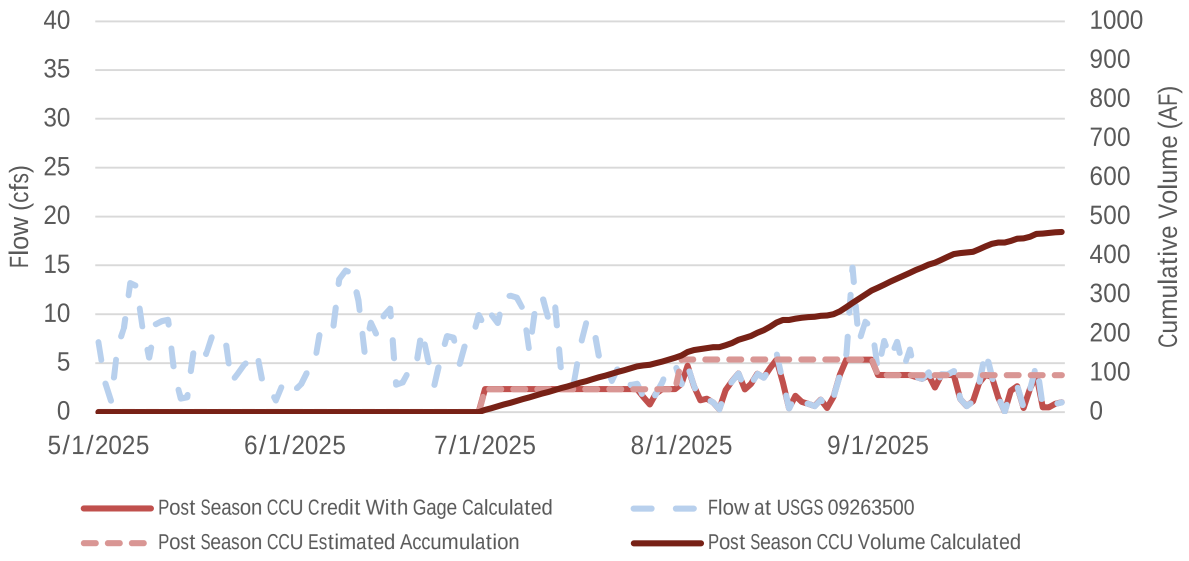

Figure 4-3. Time Series of Flow at Brush Creek near Jensen, Utah U.S. Geological Survey Gage 09263500, Potential Flow from OpenET-Based Conserved Consumptive Use, Final Daily Conserved Consumptive Use Limited by Either Gage or OpenET-Based Flow, and Cumulative Final Conserved Consumptive Use Volume

The fields of the Temporary Fallowing – E Tributary, Green River subpilot project are along the Green River above the Green River At Ouray, Utah USGS Gage 09272400. Those fields are associated with 2,530 AF of water rights as specified in the Fixed-Time Change Application with the Division of Water Rights. The fields were partially fallowed from July 1, 2025, through September 30, 2025. Winter wheat was irrigated prior to the July 1 fallowing start date. A conservative assumption was made that half of the available water right would have been used during the prefallowing period, leaving approximately 656 AF of diversion water available to be used for UT DMPP. Post-season CCU estimates were used to estimate CCU water flow and volume for the July 1, 2025, to September 30, 2025, period. Those results are presented in Table 4-3 and on Figure 4-4.

Table 4-3. Estimated Volume of Conserved Consumptive Use Water Generated in WY 2025 from Temporary Fallowing – E Tributary, Green River Subpilot Project

| Project Name | Date | Total UT DMPP CCU Water |
|---|---|---|
| Temporary Fallowing – E Tributary, Green River | September 30, 2025 | 299 AF |

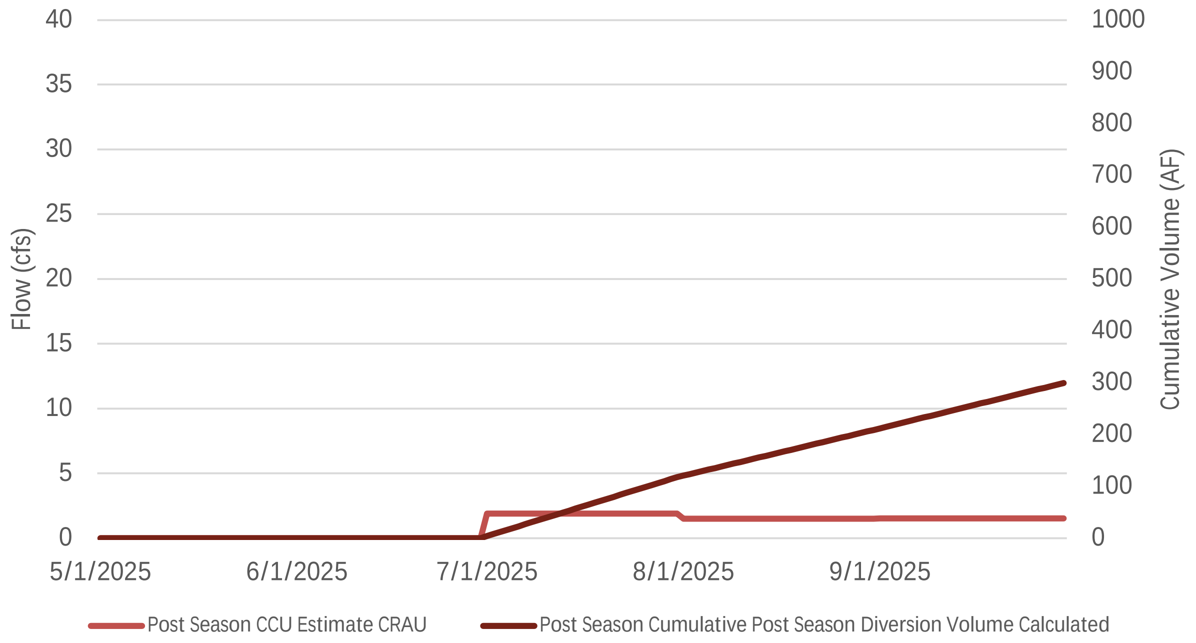

Figure 4-4. Time Series of Potential Green River Utah Demand Management Pilot Program Conserved Consumptive Use Volume Generated Using Conserved Consumptive Use and Cumulative Volumes

## 4.3 Transit Loss

As described in Section 3.2, UT DMPP CCU water will incur a reduction in volume as it travels from its source location (pilot project Point A's) to its storage destination (that is, Lake Powell). If the Temporary Fallowing – SE Tributary Group and E Tributary fields were aggregated together as one total UT DMPP temporary fallowing volume flowing to Lake Powell, then the total amount of flow considered for reduction by transit loss was 2,909 AF (Table 4-4). The reductions through the system over time start at the Green River at Ouray, Utah USGS Gage and end with storage in Lake Powell. Note that, after the UT DMPP water enters Lake Powell, it is reduced by incremental reservoir evaporation as described in Section 3.3. Table 4-4 shows the initial aggregate flow and volume after reductions at major gages in the system. The transit loss volume and percent, evaporative loss volume and percent, and total loss volume and percent are also shown. Figure 4-5 shows a time series of the aggregate CCU water flow and the flow as it incurs incremental loss through the system. Ultimately, the SE Tributary Group and E Tributary pilot projects incurred a transit loss reduction of 183 AF and an evaporative loss of 17 AF to result in 2726 AF delivered to Lake Powell by the end of WY 2025.

Table 4-4. Initial Aggregate Utah Demand Management Pilot Program Conserved Consumptive Use Water and Transit Loss Reductions at Gages through System Traveling To and Stored in Lake Powell

| Metric | UT DMPP CCU at Point A | Total Volume at Green River | Total Volume at Green River at Mineral Bottom | Total Volume at Colorado River at Gypsum Creek | Total Volume Lake Powell (Point B) |
|---|---|---|---|---|---|
| September 30, 2025 | 2,909 AF | 2,783 AF | 2,772 AF | 2,744 AF | 2,726 AF |
| Volume difference | 0 | 126 AF | 137 AF | 165 AF | 183 AF |
| Transit loss |  | 4.33% | 4.72% | 5.69% | 5.71% |
| Total evaporative loss |  |  |  |  | 17 AF |
| Total loss, transit and storage at Lake Powell |  | 4.33% | 4.72% | 5.69% | 6.30% |
| Evaporative loss |  |  |  |  | 0.60% |

*Note: Evaporative loss is also incurred once the water reaches Lake Powell and is shown.*

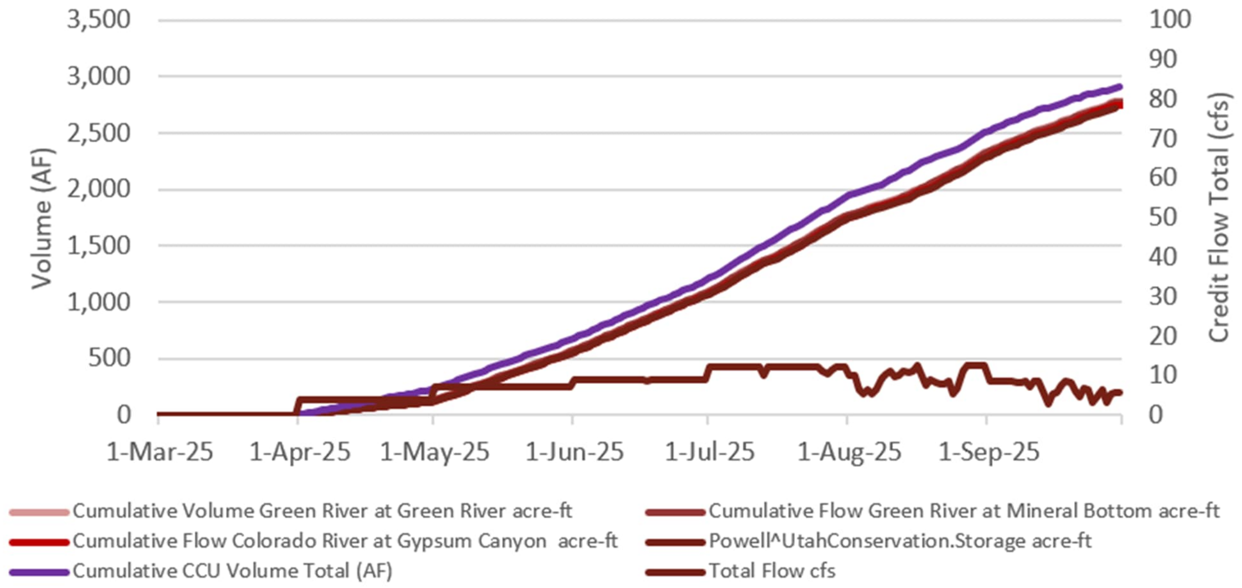

Figure 4-5. Time Series of Total Utah Demand Management Pilot Program Conserved Consumptive Use from Temporary Fallowing (SE Tributary Group and E Tributary pilot projects) Flow, Cumulative Volume, and Flow after Incurring Incremental Transit Loss

## 4.4 Storage Forbearance – Price River

Shares of water that were enrolled into the Storage Forbearance – Price River pilot project are from shareholders in the reservoir water company that typically lease their Scofield Reservoir shares to other irrigators but instead leased them to UT DMPP. Scofield Reservoir shares that were not delivered during the irrigation season as part of the Temporary Fallowing – SE Tributary Group pilot project are also managed together with Storage Forbearance – Price River UT DMPP water in Scofield Reservoir (Section 4.1). Table 4-5 and Figure 4-6 show the volumes committed from reservoir shares as well as the evaporation charge in Scofield Reservoir. Release of this water will occur in early WY 2026 (December through February).

Table 4-5. Estimated Volume of Water Stored in Scofield Reservoir during Water Year 2025 and Associated Evaporation Reduction Volume and Percent for Storage Forbearance – Price River Pilot Project

| Project Name | Total UT DMPP Enrolled Water | Total UT DMPP Storage on September 30, 2025 | Total Evaporation Reduction | Loss |
|---|---|---|---|---|
| Storage Forbearance – Price River | 2,152 AF | 2,108 AF | 44 AF | 2.06% |

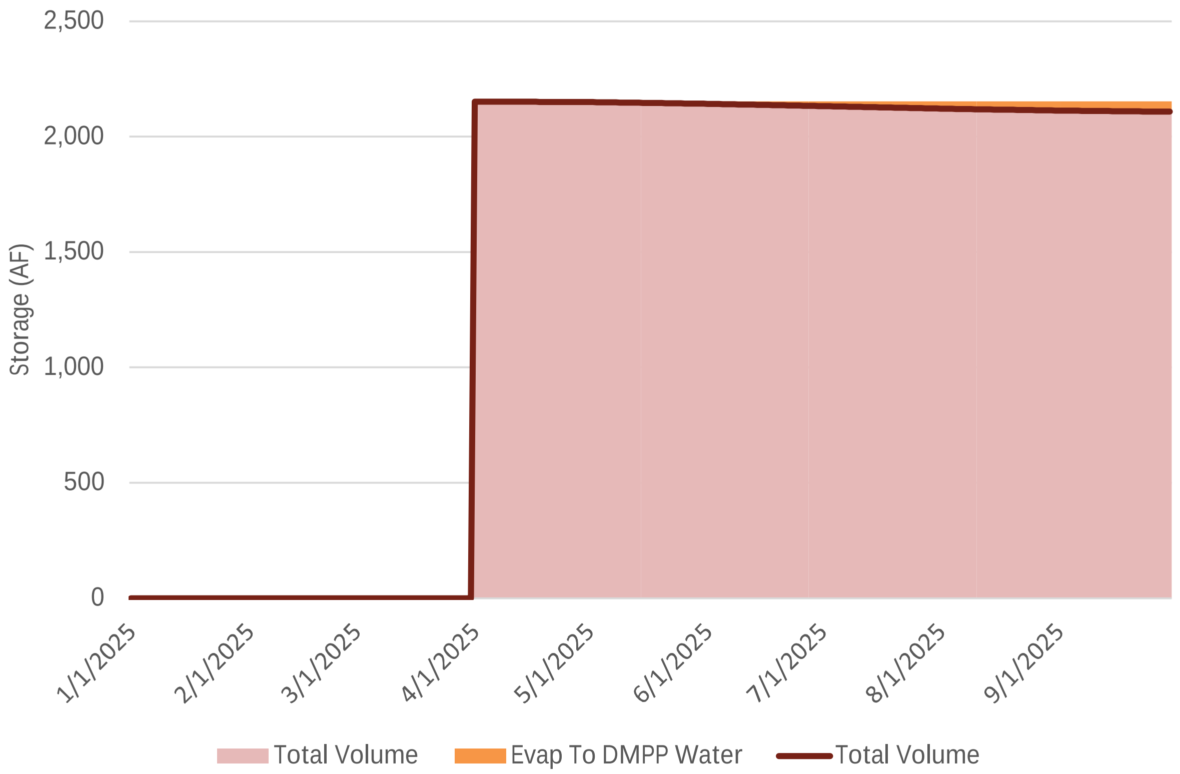

Figure 4-6. Time Series of the Volume in Scofield Reservoir, Including Storage Forbearance Reservoir Shares and Temporary Fallowing Reservoir Shares Not Released during the Irrigation Season

All reservoir shares that were part of the Temporary Fallowing – SE Tributary Group pilot project were stored in Scofield Reservoir until June 8. Starting on June 9, a portion of these shares were released for credit to UT DMPP through the irrigation season, and the remaining portion continued to be stored in Scofield Reservoir until after the irrigation season. Table 4-6 includes the volume committed from the Temporary Fallowing – SE Tributary Group pilot project combined with the volume committed from the Storage Forbearance – Price River pilot project, as well as the evaporation charge in Scofield Reservoir in total. Figure 4-7 includes the volumes in Scofield Reservoir from each of the two pilot projects as well as the evaporation charge for each in Scofield Reservoir over time.

Table 4-6. Estimated Volume of Water Stored during Water Year 2025 and Associated Evaporation Reduction Volume and Percent for the Temporary Fallowing – SE Tributary Group Pilot Project

| Project Name | Date | Total UT DMPP Storage | Total Evaporation Reduction | Loss |
|---|---|---|---|---|
| Temporary Fallowing – SE Tributary Group – Storage (not released) | September 30, 2025 | 353 AF | 24 AF | 6.45% |

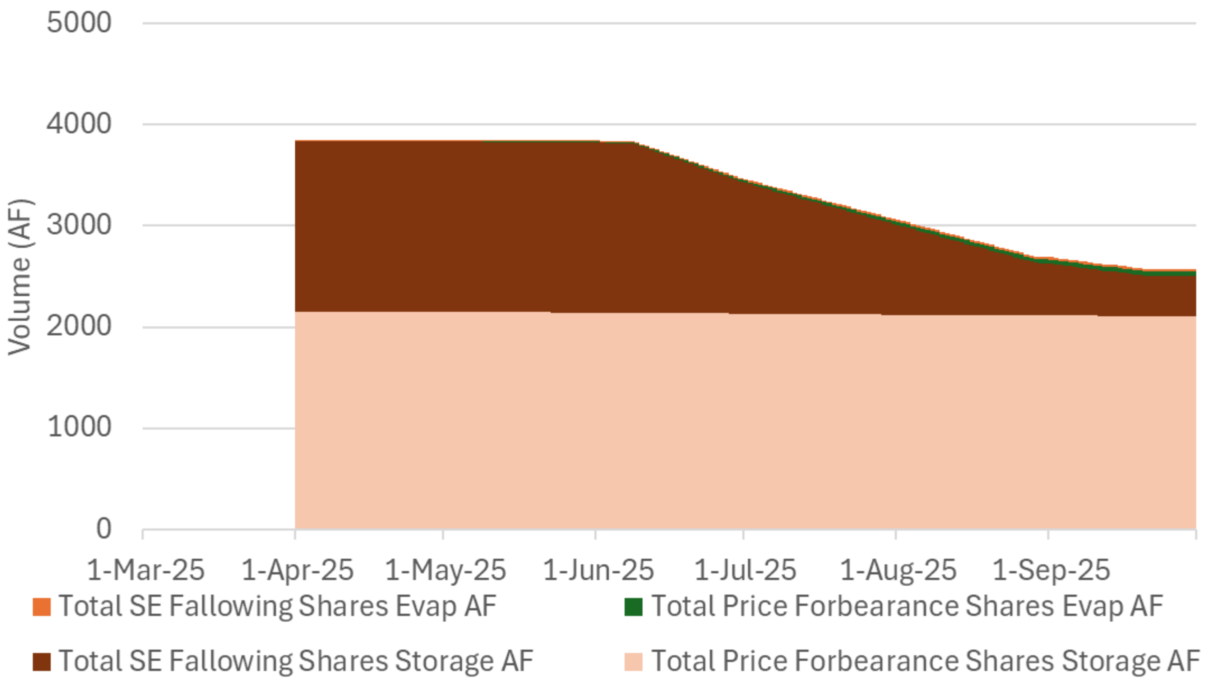

Figure 4-7. Time Series of Total Volume in Scofield Reservoir and Evaporation Charge

## 4.5 Storage Forbearance – Duchesne River

The Storage Forbearance – Duchesne River pilot project was implemented by reducing transbasin diversions when water right priority allowed and instead storing that water in Starvation Reservoir for release in early WY 2026 (November through February). While this pilot project was seeking to divert up to 4,500 AF from the Wolf Creek and Twin Creek sources based on prospective water right yield, hydrology is a limiting factor that influences the timing and availability of water year to year. This water right was regulated off on June 9th which is about a month earlier than usual. Therefore, under the Provisional Accounting MOU, the amount available to claim will vary each year depending on hydrology and seasonal effects on timing. Due to hydrologic shortages during WY 2025, the participating water right was only in priority April 5 through June 8, 2025, and again September 10 through September 30 (for this report), 2025. The associated volumes and evaporation reduction are included in Table 4-7 and on Figure 4-8.

Table 4-7. Estimated Volume of Utah Demand Management Pilot Program Water Generated during Water Year 2025 and Associated Evaporation Reduction Volume and Percent for Storage Forbearance – Duchesne River Pilot Project

| Project Name | Date | Total UT DMPP Storage | Total Evaporation Reduction | Loss |
|---|---|---|---|---|
| Storage Forbearance – Duchesne River | September 30, 2025 | 955 AF | 27 AF | 2.76% |

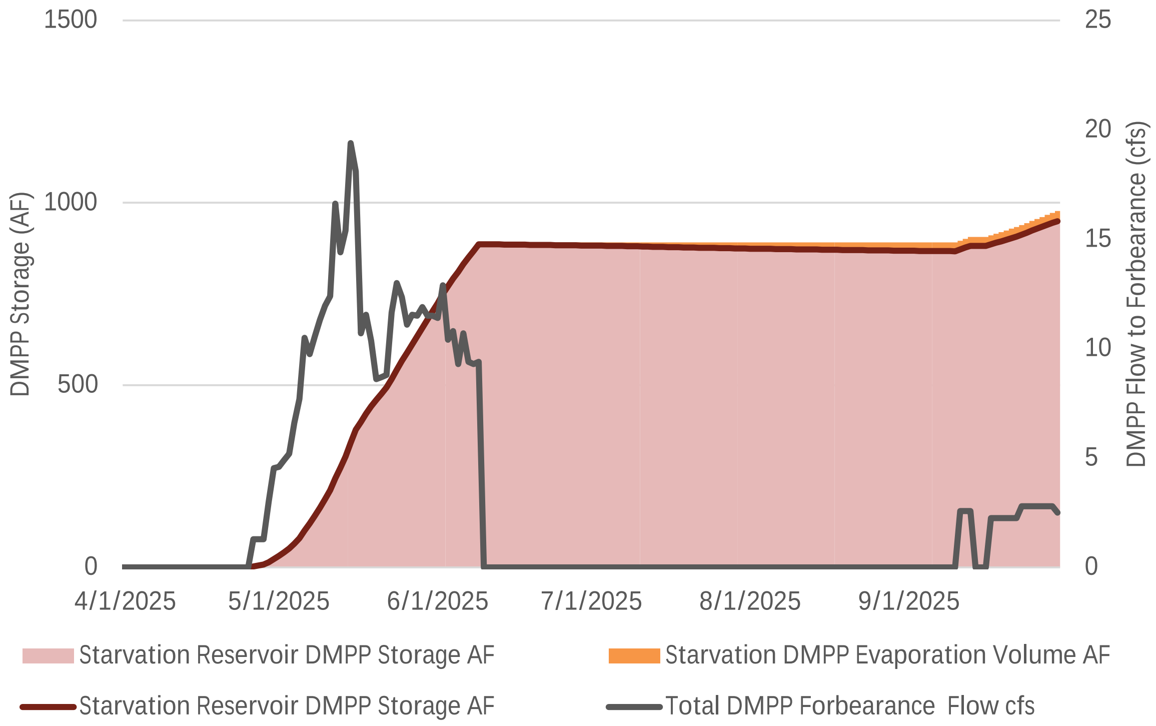

Figure 4-8. Time Series of the Volume in Starvation Reservoir, Daily Volume Generated, and Evaporation Incurred

# 5 DISCUSSION

This section examines key findings and lessons learned from the UT DMPP implementation during WY 2025. Section 5.1 reviews changes in methodology for estimating CCU and how these updates improved alignment with program requirements; Section 5.2 compares pre-season and post-season results, highlighting variability across fields and factors influencing differences; and Section 5.3 addresses reporting challenges under the Provisional Accounting MOU, including additional requirements and data availability issues. Together, these sections provide insights into methodological refinements, performance outcomes, and operational considerations for future program cycles.

## 5.1 Methodology Changes in Estimating Conserved Consumptive Use

UT DMPP methods have evolved over time to improve accuracy and align with program requirements. As shown in Table 2-1, two versions of pre-season DRP estimates were produced using the *Estimated Depletion Reduction Calculation Methodology* (Appendix A):

- Version 2: Total depletion calculated on a growing-season basis using DAYMET precipitation
- Version 2.1: Total depletion based on the sum of monthly depletion using PRISM precipitation

The difference between these two estimates is less than 10 percent, which meets UT DMPP data quality objectives and falls within the margin of error for both approaches.

When version 2 was developed, the Provisional Accounting MOU between UCRC and Reclamation was not yet in place; therefore, methods were designed to estimate pre-season DRP and post-season CCU for the UT DMPP implementation period (typically through October 31), which is consistent with Utah's irrigation season.

In August 2025, UT DMPP overhauled the methodology to comply with the MOU requirement for WY 2025 reporting rather than the full irrigation season. Key changes included the following:

- Converting monthly depletion depth (inches) to volume (AF) by applying field size and summing monthly volumes for enrolled months.
- Linking WY depletion volumes to field boundaries to create a field-scale depletion model based on historical look-back data.
- Using PRISM precipitation data instead of DAYMET. Provisional PRISM data are available within 24 hours of collection and are typically finalized about 6 months later, whereas DAYMET data are posted only once per year, up to 6 months after the end of the calendar year. Therefore, continuing to rely on DAYMET precipitation would not comply with UCRC reporting timelines under the Provisional Accounting MOU.

In version 2.2, post-season CCU calculations use ET only (rather than full depletion), assuming effective precipitation and carry-over soil moisture remain constant under irrigated and non-irrigated conditions for the year of implementation.

## 5.2 Pre-season vs. Post-season Results

Across all temporarily fallowed fields enrolled in UT DMPP, post-season CCU was approximately 30 percent lower than pre-season DRP estimates. However, for some individual fields and applicants, differences exceeded 80 percent with the largest discrepancies observed in partially fallowed fields (Table 5-1).

Table 5-1. Differences between Pre-season and Post-season Results for Temporary Fallowing Projects

| Project Name | Full or Partial Season Fallow | Estimated Pre-Season DRP WY 2025, April through September, v2.1 (AF) | Post-WY 2025 CCU, v2.2 (AF) | Relative Difference between DRP and CCU (percent) |
|---|---|---|---|---|
| DMPP25_17b | Partial | 1176 | 698 | -51.0 |
| DMPP25_17a | Partial | 506 | 213 | -81.3 |
| DMPP25_17c | Partial | 150 | 86 | -54.5 |
| DMPP25_9 | Full | 974 | 665 | -37.7 |
| DMPP25_14 | Full | 245 | 284 | 14.7 |
| DMPP25_18 | Full | 439 | 498 | 12.6 |
| DMPP25_16 | Full | 232 | 214 | -8.2 |
| DMPP25_10 | Full and partial | 317 | 191 | -49.8 |
| DMPP25_24 | Full | 156 | 177 | 12.4 |
| DMPP25_8 | Full | 59 | 69 | 16.8 |
| DMPP25_19 | Full | 109 | 125 | 13.6 |
| UT DMPP Total | N/A | 4,363 | 3,220 | -30 |

For partial-season fallowing, UT DMPP anticipates updating the pre-season DRP methodology to better approximate carry-over soil moisture at the start of the fallow period, reflecting irrigated conditions by assuming a full soil water column prior to fallowing. Post-season estimates of partial-season fallowed fields known to have been well-watered until the fallow start date showed higher than expected water consumption, suggesting that a full soil water column at the outset of partial season fallowing does need to be assumed. This change to the methods would likely result in a lower pre-season DRP estimate, closer to the post-season CCU estimates observed.

For full-season fallowing, differences between pre- and post-season estimates are expected. Pre-season DRP represents a typical-year estimate based on historical conditions, while post-season CCU reflects actual hydrology during the pilot year. Variability is primarily driven by differences between the pilot year and the 7-year look-back period.

In WY 2025, reference ET was similar to median look-back years, but precipitation was lower (NOAA 2025), likely reducing post-season CCU compared with pre-season DRP.

Following are additional factors contributing to differences:

- Use of PRISM precipitation for post-season CCU instead of DAYMET (due to data availability)
- Monthly timestep for post-season CCU versus seasonal or annual timestep for pre-season DRP, affecting soil moisture accounting
- Uncertainty in depletion estimates, particularly for OpenET data at smaller field sizes and shorter timesteps (Volk et al. 2024)

Together, these factors likely amplified differences beyond hydrologic variability.

UT DMPP plans further analysis to identify additional drivers of variability, including the following:

- Field size: Does size influence agreement between pre- and post-season estimates?
- Water portfolio: How were fields typically irrigated (high-flow shares vs. reservoir shares)? Did this vary across the 7-year historical period, affecting hydrologic availability under irrigated conditions?
- Subirrigation: What part does groundwater play in approximating CCU associated with a conservation activity? How can UT DMPP methods better account for this moving forward?

## 5.3 Provisional Accounting Reporting Deadline Challenges

The Provisional Accounting MOU requires reporting within 60 days after the end of the WY. For WY 2025, UT DMPP was unable to meet this deadline due to the following factors:

- Additional requirements identified: During collaboration with UCRC, UT DMPP learned that daily depletion reduction estimates were needed to support transit loss modeling. Additionally, the pre-season estimates were based on a full irrigation season (including October), requiring a complete overhaul of source code to accomplish the following:
    - Produce monthly field-scale estimates
    - Generate daily depletion reduction estimates
    - Exclude October from the report

  These additional requirements required a full revision of pre-season methods to produce WY-based estimates rather than irrigation season estimates to comply with the Provisional Accounting MOU. UT DMPP staff were unable to complete this overhaul and deliver Project Cycle 2 estimates within the same timeframe. The methods revision required more than 150 hours of coding, QA/QC, and integration into the SQL database to maintain consistency across Project Cycle 2 and Provisional Accounting models.
- Incomplete applicant records: Applicant records detailing water movement through the canal were not available until early December 2025, and the records provided at that time were incomplete, requiring further clarification and discussion.

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# APPENDIX A: ESTIMATED DEPLETION REDUCTION CALCULATION METHODOLOGY REPORT, VERSION 2.2

# Estimated Depletion Reduction Calculation Methodology Report

Document No.: 251001233012_d88d63a3
Version: 2.2

Colorado River Authority of Utah
Management and Technical Consulting for Utah Demand Management Pilot Program
December 17, 2025

Jacobs

# Estimated Depletion Reduction Calculation Methodology Report

| | | | |
|---|---|---|---|
| **Client name:** | Colorado River Authority of Utah | | |
| **Project name:** | Management and Technical Consulting for Utah Demand Management Pilot Program | | |
| **Document no.:** | 251001233012_d88d63a3 | **Project no.:** | WXYB8600 |
| **Version:** | 2.2 | **Project manager:** | Calah Worthen |
| **Date:** | December 17, 2025 | **Prepared by:** | Jacobs Engineering Group, Inc. |
| **File name:** | Estimated Depletion Reduction Calculation Methodology_v2.2 | | |

## Document History and Status

| Version | Date | Description | Author | Reviewed/Approved |
|---|---|---|---|---|
| 1 | 2/7/2025 | Version sent to the Authority for review | Drew Stock,<br>Calah Worthen | Scott Morrison |
| 1.1 | 2/27/2025 | Responded to client comments (received 2/14); added *Discussion* section; reformatted into the Jacobs report; cleared redlines | Drew Stock,<br>Calah Worthen | Scott Morrison |
| 2 | 10/7/2025 | Added methodology for multiple irrigation periods; added QA/QC section; added discussion on soil moisture calculation coefficients, median vs. average summary statistic, and look-back period; discussed post-season depletion and daily estimates used for provisional accounting; revised to 2026 irrigation-season timelines | Drew Stock,<br>Jen Knapp,<br>Burdette Barker | Lily Bosworth,<br>Calah Worthen |
| 2.1 | 11/19/2025 | Revised monthly carry-over soil moisture calculation to include a maximum limit based on crop rooting depth and available water capacity. Revised annual calculation to be the sum of the monthly depletion estimates. | Eric Holmstead | Drew Stock |
| 2.2 | 12/19/2025 | Revised end-of-season conserved consumptive use calculation and updated variable names for readability. | Drew Stock | Lily Bosworth |

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# Acronyms and Abbreviations

| | |
|---|---|
| $\Delta D$ | depletion change from irrigated to fallowed condition |
| API | Application Programming Interface |
| Authority | Colorado River Authority of Utah |
| AWC | available water capacity |
| AWS | available water storage |
| CCU | conserved consumptive use |
| DMPP | Utah Demand Management Pilot Program |
| $D_{after}$ | depletion from area when DMPP is implemented |
| DRO | depletion reduction opportunity |
| eeMETRIC | Google Earth Engine Implementation of the Mapping Evapotranspiration at High Resolution with Internalized Calibration |
| ET | evapotranspiration |
| $ET_a$ | actual evapotranspiration |
| $ET_{mon}$ | monthly crop evapotranspiration |
| $ET_{o,after}$ | short-reference evapotranspiration for the after DMPP participation period |
| $ET_{o,preseason}$ | short-reference evapotranspiration for depletion reduction opportunity period |
| $ET_{prev\ mon}$ | previous month monthly crop evapotranspiration |
| $ET_{win}$ | winter or nongrowing season evapotranspiration |
| FSA | Farm Service Agency |
| Jacobs | Jacobs Engineering Group Inc. |
| LEPA | low-elevation precision application |
| LESA | low-elevation spray application |
| MESA | mid-elevation sprinkler application |
| NOAA | National Oceanic and Atmospheric Administration |
| NRCS | Natural Resource Conservation Service |
| $P_{eff}$ | effective precipitation |
| $P_{eff,\ mon}$ | monthly effective precipitation |
| $P_{eff,\ prev\ mon}$ | previous month monthly effective precipitation |
| $P_{mon}$ | monthly precipitation |

| | |
|---|---|
| PRISM | Parameter elevation Regression on Independent Slopes Model |
| $P_{win}$ | winter or nongrowing season precipitation |
| QA/QC | quality assurance and quality control |
| Reclamation | United States Bureau of Reclamation |
| RZ | crop rooting depth |
| SCPP | System Conservation Pilot Program |
| SDI | subsurface drip irrigation |
| SF | soil water storage factor |
| $SM_{co}$ | carry-over soil moisture |
| $SM_{co,\ mon}$ | monthly carry-over soil moisture |
| $SM_{co,\ prev\ mon}$ | monthly carry-over soil moisture at start of previous month |
| SSURGO | Soil Survey Geographic Database |
| UCRB | Upper Colorado River Basin |
| UCRC | Upper Colorado River Commission |
| Upper Division States | Colorado, New Mexico, Utah, and Wyoming |
| USU | Utah State University |
| water year | October 1 through September 30 (designated by calendar year in which it ends) |

# 1. Introduction

The Colorado River Authority of Utah (the Authority), in accordance with the Authority's *Colorado River Management Plan* (Authority 2022), is implementing an intrastate Utah Demand Management Pilot Program (DMPP) to begin during irrigation season 2025 (April 1 through October 31). The purpose of the DMPP is to identify opportunities and challenges associated with developing a full-scale, long-term agricultural demand management program in Utah. Specifically, the DMPP seeks to implement projects that achieve water conservation through reduced water depletion. Coordinating with the Utah Division of Water Rights to distribute and account for the reduced water depletion through a change application process on the subject water right(s) will help the Authority test demand management and maintain 1922 Colorado River Compact compliance.

In March 2024, the Authority hired Jacobs Engineering Group Inc. (Jacobs) and its subconsultant partners to assist in developing, administering, designing, and implementing the DMPP. This report summarizes the depletion reduction calculation methodologies used by Jacobs and its subconsultants for three types of eligible projects under the DMPP (temporary fallowing, irrigation system conversion, and storage forbearance).

This report specifies the assumptions and data sources used to support depletion reduction estimates for projects being implemented during the DMPP's project cycle 2, season 2026. This report, submitted as Version 2, builds upon Version 1, which summarized the methodology used in the DMPP's project cycle 1, beginning at irrigation season 2025. The methodology presented in this report will be used by the Authority to estimate post-season conserved consumptive use (CCU) for individual DMPP projects in project cycles 1 (2025-2026) and 2 (2026) and support provisional accounting for the Upper Colorado River Commission (UCRC) at the end of the 2025 and 2026 water years. Version 1.1 of this memo was used to calculate preseason depletion reduction opportunity (DRO) for project cycle 1.

# 2. Data Sources

Table 2-1 summarizes data sources used to calculate depletion reduction estimates for the DMPP’s project cycle 2, which includes projects scheduled for implementation in 2026. These data sources directly support calculations and methods described in this report. Additional references are provided throughout this report.

**Table 2-1. Summary of Key Data Sources Used in Depletion Reduction Calculations**

| Data Source | Timescale | Usage | Reference | Additional Notes |
|---|---|---|---|---|
| eeMETRIC (version 2.3 or latest version available through OpenET API) | Monthly gridded $ET_a$ depths were obtained from OpenET API; underlying data are available at the daily timescale. | All $ET_a$ values are estimates from OpenET's eeMETRIC model, not potential ET estimates. Monthly eeMETRIC data are used to derive $ET_a$ inputs used in **Equations 1**, **2**, and **3**. The following forms of ET are used in this report:<br>▪ $ET_a$: Actual or growing season[a]<br>▪ $ET_{win}$: Nongrowing or winter season[a]<br>▪ $ET_{mon}$: Monthly ET | Melton et al. (2021) | OpenET provides satellite-based estimates of the total amount of water that is transferred from land surface to atmosphere through ET; it also provides the mean $ET_a$ depth within each agricultural field boundary at the monthly timescale. OpenET uses area-weighted average of grid cells when aggregating polygon data (OpenET 2025a). |
| SSURGO | SSURGO soils data were downloaded annually and assumed constant throughout the entire, up to 7-year, look-back period. | AWS or its byproducts are used in **Equations 2**, **3**, and **4**. | NRCS (2024) | The variable *aws0150wta* in the SSURGO soils database represents the maximum amount of plant-available water a soil can hold in the top 59 inches (150 centimeters). This is the maximum depth AWS is reported in in the SSURGO database. When multiple soil classifications were found in the same agricultural field boundary, then the area-weighted AWS was used. |
| Hill et al. 1989 Depletion Equation | Irrigation-season data were used. | The equation to calculate annual depletion in inches (**Equation 1**) is from Hill et al. (1989); annual depletion (inches) is calculated as ET (during growing season), minus nongrowing season $SM_{co}$ at start of irrigation season, minus $P_{eff}$ (growing season). | Hill et al. (1989) | N/A |

| Data Source | Timescale | Usage | Reference | Additional Notes |
|---|---|---|---|---|
| Literature | Crop rooting depths were adjusted annually throughout the historical look-back period based on crops grown each year, for up to 7 years; if multiple crops with differing rooting depths were planted in same agricultural field during a single year, then average crop rooting depth was used. | **Equation 2** uses crop rooting depths (RZ) to calculate $SM_{co}$. | Crop rooting depths are based on Jacobs (2024a) in the Colorado River Basin; assumptions are based on CCC (2024), Sertse et al. (2019), Dharmasri et al. (1993), Allen et al. (2015), St. John et al. (2017), Pleasant (2023), and Franzen et al. (2005). | DMPP applicants provide crop names for entire look-back period. If a record of historical crop types is unavailable, then alfalfa is assumed due to its prevalence in Utah (UDWRe 2024). |
| FSA | Agricultural field boundaries were held constant throughout the look-back period. | Agricultural field boundaries summarize $ET_a$, AWS, precipitation, and acreages; depletion estimates are completed at the field-scale. | N/A | Geospatial layers showing agricultural field boundaries were obtained from the FSA by DMPP applicants. |
| PRISM Climate Group, Oregon State University | Monthly gridded precipitation depths were obtained from PRISM; underlying data are available at daily timescale. | The following precipitation data are used in **Equations 1**, **2**, and **3**.<br>▪ $P_{eff}$: Estimate of the portion of precipitation that supports plant growth during irrigation season<br>▪ $P_{mon}$: Monthly precipitation<br>▪ $P_{win}$: Winter or nongrowing season precipitation | PRISM Climate Group (2025) | PRISM Climate Group provides localized, $P_{mon}$. The gridded monthly results are used to derive $P_{eff}$, $P_{mon}$, $P_{win}$. Esri's zonal statistics tool (Esri 2024) was used to find the mean precipitation depth within each agricultural field boundary each month using the gridded precipitation data. |

[a] Growing season is March 1 to October 31, and the nongrowing season is November 1 to March 31.

API = Application Programming Interface
AWS = available water storage
CCU = conserved consumptive use
DDMP = Utah Demand Management Pilot Program
DRO = depletion reduction opportunity
eeMETRIC = Google Earth Engine Implementation of the Mapping Evapotranspiration at High Resolution with Internalized Calibration
ET = evapotranspiration
$ET_a$ = actual evapotranspiration
$ET_{win}$ = nongrowing (winter) season evapotranspiration
$ET_{mon}$ = monthly crop evapotranspiration
FSA = Farm Service Agency
Irrigation season = March 1 through October 31
NRCS = Natural Resource Conservation Service
$P_{mon}$ = monthly precipitation
$P_{win}$ = nongrowing season precipitation
$P_{eff}$ = effective precipitation
PRISM = Parameter elevation Regression on Independent Slopes Model
$SM_{co}$ = carry-over soil moisture
SSURGO = Soil Survey Geographic Database
Water year = Oct 1 through September 30 designated by the calendar year in which it ends

# 3. Methodology

This section describes the methodology used to estimate depletion, DROs, and potential diversion savings associated with implementing DMPP-eligible project types, specifically fallowing, irrigation system conversions, and storage forbearance projects. For the DMPP, depletion is the net removal of water from either the water source or hydrologic system. In theory, depletion from irrigation is the difference in consumptive water use between the irrigated condition and what would have occurred in the nonirrigated condition (Barker pers. comm. 2025a). DRO, for the DMPP, is defined as the volumetric increase in water estimated to remain in the system due to forgoing irrigation, converting to a higher efficiency irrigation system, or forgoing use of stored water. The terms depletion and CCU are used interchangeably in this report. DRO is used to describe preseason depletion saving potential, and CCU is used to describe end-of-season actual depletion savings.

## 3.1 Preseason Estimates

Depletion volumes are heavily influenced by the hydrologic condition of a given year. Because DRO estimates are derived in late fall for the following irrigation season, before most snowfall of a given water year, the hydrologic condition of the enrolled irrigation season is largely unknown. As a result, to determine preseason depletion estimates, this analysis looks back at a series of historical data to estimate DRO as a typical historical depletion volume. Preseason DRO estimates are based on the median annual depletion volume of a designated look-back period, typically the most recent 7 years. The following subsections outline the rationale for selecting the look-back period and describe the methods used to calculate both depletion and DRO volumes. Sample DRO estimates for both full and partial-season fallowing cases of a single field are provided in Appendix A.

### 3.1.1 Historical Depletion at the Field Scale

#### 3.1.1.1 Estimating Depletion for Fallowing Projects and Provisional Accounting

**Equation 1** provides the monthly depletion calculation at the field scale, based on the annual methodology presented by Hill et al. (1989). The eeMETRIC model (Melton et al. 2021) helps to determine actual evapotranspiration ($ET_a$) in this methodology, consistent with UCRC (2022). Monthly $ET_a$ values are mean values within each field boundary using gridded $ET_a$ data. Carry-over soil moisture ($SM_{co}$) and effective precipitation ($P_{eff}$) are computed as shown in **Equations 2a/2c** and **3**, respectively.

$$\text{Depletion (inches)} = ET_{mon} - SM_{co,\,mon} - P_{eff} \qquad \textbf{Equation 1}$$

Where:

$ET_{mon}$ = monthly OpenET eeMETRIC actual evapotranspiration (inches) (Melton et al. 2021)
$P_{eff}$ = monthly effective precipitation (inches)
$SM_{co,\,mon}$ = carry-over soil moisture at start of the month (inches)

For each field, the monthly depletion depth (inches) is converted to a volume in acre-feet by converting inches to feet and multiplying the depth by the field size in acres; monthly depletion volumes for any month the respective field is enrolled in the program within the irrigation season are summed; the resulting water year depletions are joined with the field boundary to create a field-scale depletion model, identifying the historical depletion volume based on the look-back period for each field included in DMPP applications. Winter $SM_{co}$ for each field is calculated using winter/nongrowing season $ET_a$ data (Melton et al. 2021), winter/nongrowing season precipitation data (PRISM Climate Group 2025), available water storage (AWS) for soil depth 0 to 59 inches (0 to 150 centimeters) (NRCS 2024), and crop rooting depths (provided in **Table 3-1**). Winter/nongrowing season precipitation and $ET_a$ values are calculated by summing the monthly values for each parameter over the nongrowing season.

**Table 3-1. Crop Rooting Depths**

| Crop | Rooting Depth (inches) |
|---|---|
| Alfalfa | 54 |
| Apples | 42 |
| Apricots | 42 |
| Barley | 36 |
| Beans | 24 |
| Berries | 36 |
| Canola | 36 |
| Cherries | 42 |
| Corn | 36 |
| Durum wheat | 36 |
| Field crop unspecified | 36 |
| Flaxseed | 35 |
| Grain/seeds unspecified | 36 |
| Grapes | 36 |
| Grass hay | 24 |
| Horticulture | 24 |
| Idle pasture | 39 |
| Melon | 60 |
| Mustard | 47 |
| Oats | 36 |
| Onion | 30 |
| Orchard unspecified | 42 |
| Pasture | 39 |
| Peaches | 42 |
| Potato | 30 |
| Pumpkins | 60 |
| Rye | 36 |
| Safflower | 60 |
| Sorghum | 36 |
| Soybeans | 24 |
| Spring wheat | 36 |
| Squash | 24 |
| Sugar beets | 48 |
| Sunflower | 48 |
| Triticale | 36 |
| Turfgrass ag | 24 |
| Vegetables | 24 |
| Watermelons | 60 |
| Winter wheat | 36 |

Note: Crop rooting depths are based on Jacobs (2024a) and assumptions based on the CCC (2024), Sertse et al. (2019), Dharmasri et al. (1993), Allen et al. (2015), St. John et al. (2017), Pleasant (2023), and Franzen et al. (2005).

**Equation 2a** provides the $SM_{co}$ calculation, consistent with Hill et al. (1989). However, $ET_{win}$ is taken to be all $ET_a$ during the winter months instead of only ET from the actively growing crop as done in Hill et al. (1989). This is an implicit assumption by Hill et al. that ET during the winter was small and is also a result of the limitation of the available modeling methods at the time, which were intended only for the crop while it was growing. The use of full winter $ET_a$ in the present analysis will result in less $SM_{co}$ than the equivalent Hill et al. data would have under some conditions but we do not believe there is sufficient justification for subsequently adjusting the assumed 67% $P_{eff}$ in **Equation 2a**. Section 5.3 discusses the use of **Equation 2a**, which is the method currently applied by the Authority, and introduces **Equation 2b** as a potential alternative approach. Available water capacity (AWC) was computed as the ratio of the AWS and maximum soil depth of 59 inches (NRCS 2024). In **Equation 1**, winter $SM_{co}$ is applied as $SM_{co,\ mon}$ in March of each year. $SM_{co}$ values for subsequent months are calculated according to **Equation 2c**.

$$SM_{co} = minimum(0.67 * (P_{win} - 1.25 * ET_{win}), 0.75 * RZ * AWC) \qquad \textbf{Equation 2a}$$

Where:

$SM_{co}$ = winter/nongrowing season carry-over soil moisture at start of irrigation season (inches)
$P_{win}$ = winter/nongrowing season precipitation (inches)
$ET_{win}$ = winter/nongrowing season evapotranspiration (inches)
RZ = crop rooting depth (inches) from Table 3-1
AWC = soil available water capacity (inch per inch)

For the first month of the irrigation season, $SM_{co}$ is calculated per **Equation 2a**. For subsequent months, monthly $SM_{co}$ ($SM_{co,\ mon}$) is calculated according to **Equation 2c** and expected to decrease over time. $SM_{co,\ mon}$ cannot fall below zero or exceed 0.75 * RZ * AWC, even in cases of high $P_{eff}$. Monthly effective precipitation ($P_{eff,\ mon}$) is calculated according to **Equation 3.**

$$SM_{co,\ mon} = MIN(MAX(SM_{co,\ prev\ mon} - ET_{prev\ mon} + P_{eff,\ prev\ mon}, 0), 0.75 * RZ * AWC) \qquad \textbf{Equation 2c}$$

Where:

$SM_{co,\ mon}$ = carry-over soil moisture at start of month excluding March (inches)
$SM_{co,\ prev\ mon}$ = carry-over soil moisture at start of previous month (inches)
$ET_{prev\ mon}$ = previous month monthly crop evapotranspiration (inches)
$P_{eff,\ prev\ mon}$ = previous month monthly effective precipitation (inches)
RZ = crop rooting depth (inches) from Table 3-1
AWC = soil available water capacity (inch per inch)

$P_{eff}$ is an estimate of the portion of precipitation that supports plant growth during the irrigation season. $P_{eff}$ is calculated monthly using methodology shown in **Equation 3**, consistent with the United States Department of Agriculture (USDA 1970). Total monthly precipitation ($P_{mon}$) was obtained from PRISM Climate Group (2025), and total monthly crop evapotranspiration ($ET_{mon}$) is assumed to be $ET_a$ obtained from OpenET (2025a). Monthly $P_{eff}$, calculated from **Equation 3**, is used to calculate depletion using **Equation 1**.

$$P_{eff} = SF(0.70917 P_{mon}^{0.82416} - 0.11556)(10^{0.02426 ET_{mon}}) \qquad \textbf{Equation 3}$$

Where:

$P_{eff}$ = monthly effective precipitation (inches)
SF = soil water storage factor
$P_{mon}$ = monthly precipitation (inches)
$ET_{mon}$ = monthly crop evapotranspiration (inches)

The soil water storage factor (SF) is defined by **Equation 4**, consistent with USDA (1970), which states the following: "the term D was generally calculated as 40 to 60 percent of the available soil water capacity in the crop root zone, depending on the irrigation management practices used." Original **Equations 3** and **5** were developed before sprinkler irrigation was common. For surface irrigation, best practice then—and, in many cases, now—is to deplete the soil to about 50 percent AWS and then refill to field capacity. This practice, however, is not reasonable for most sprinkler systems, especially center pivots, where water application typically occurs before water depletion from the soil reaches 50 percent AWS. A value of 40 percent of AWS strikes a balance between surface and sprinkler irrigation management practices and was used in this methodology (Barker pers. comm. 2025a). SSURGO AWS data (NRCS 2024) were obtained to support quantification of usable water storage (D in **Equation 4**) and is summarized as an area-weighted average within each DMPP applicant field boundary. Thus, the soil water SF was calculated at the field scale.

$$SF = 0.531747 + 0.295164D - 0.057697D^2 + 0.003804D^3 \qquad \textbf{Equation 4}$$

Where:

SF = soil water storage factor
D = usable soil water storage (inches)

The underlying depletion estimation methodology in this report (Hill 1989) is for use at the irrigation-season scale. While similar procedures can be used to estimate monthly depletion, the results of the depletion estimation methodology herein are considered accurate to the irrigation-season level because numerous short-term variables skew the estimates that tend to average out over a full season, such as heavy rainstorms and wind. However, monthly depletion estimates help to calculate DROs for partial-season fallowing projects and estimate daily scale CCU for provisional accounting (Section 3.2.3).

### 3.1.2 Fallowing Projects

After annual DROs are calculated, or monthly depletion estimates for all months enrolled in DMPP calculated are summed by year, field-scale DRO are estimated for fallowing and irrigation system conversion projects. To obtain a single annual DRO estimate per field, the median of a typically 7-year look-back period (refer to Table 3-2) is used. The look-back period excludes years when applicants fallowed their fields as part of participation in a conservation program (currently only the System Conservation Pilot Program [SCPP] is considered).

**Table 3-2. Look-Back Periods**

| Condition | Look-Back Period |
|---|---|
| Default look-back period | 2018 through 2024 |
| 1-year conservation program participation | 2017 through 2024 excluding SCPP year (for example, 2017 through 2023 if field enrolled in SCPP in 2024, 2017 through 2022 and 2024 if field enrolled in SCPP in 2023) |
| 2-year conservation program participation | 2016 through 2024 excluding SCPP years (for example, 2016 through 2022 if field enrolled in SCPP in 2023 through 2024, 2016 and 2019 through 2024 if field enrolled in SCPP in 2017 through 2018) |
| 3+-year conservation program participation | 2016 through 2024 excluding SCPP years[a] |

[a] This condition will result in a look-back period shorter than the recommended 7 years. SCPP was implemented in 2015 through 2018 and 2023 through 2024 (Authority 2025), so a minimum of 4 years of data would be used for any DRO estimate.

### 3.1.3 Irrigation System Conversions

For irrigation system conversions, historical depletion estimates are calculated at the field scale using the methodology presented in Section 3.1.1. DROs for irrigation system conversions are then estimated by multiplying the historical depletion estimate by a theoretical percentage change in depletion, based on the existing and proposed irrigation system. Depletion change percentages, based on studies in the Colorado River Basin (Jacobs 2024b) and Great Salt Lake Basin (USU et al. 2025), are listed in Table 3-3, with the underlying assumptions detailed in Table 3-4. To help align individual DMPP participants with these assumptions, particularly those related to reductions in irrigated acreage, additional field verification steps and coordination with applicants is recommended.

Table 3-3. Estimated Depletion Change Percentages for Irrigation System Conversions

| Pre-Demand Management Pilot Program Irrigation System | Post- Demand Management Pilot Program Irrigation System | Depletion Change (percent) |
|---|---|---|
| Basin/border | Pivot/lateral MESA | 0 |
| | Pivot/lateral LEPA | -2 |
| | Pivot/lateral LESA | -5 |
| | SDI | -18 |
| Pivot/lateral MESA | Pivot/lateral LEPA | -1 |
| | Pivot/lateral LESA | -4 |
| | SDI | -29 |
| Wheel line, hand line, solid set | Pivot/lateral MESA | -16 |
| | Pivot/lateral LEPA | -17 |
| | Pivot/lateral LESA | -20 |
| | SDI | -29 |

Sources: Jacobs 2024b; USU et al. 2025.

LEPA = low-elevation precision application
LESA = low-elevation spray application
MESA = mid-elevation sprinkler application
SDI = subsurface drip irrigation

Table 3-4. Irrigation System Conversion Assumptions

| From | To | Assumptions |
|---|---|---|
| Basin/border | Pivot/linear MESA | ▪ 21% reduction in irrigation area[a]<br>▪ 10% yield improvement[b]<br>▪ Change in area and yield linearly related to crop ET[c]<br>▪ 12% cap of MESA wind drift and evaporation losses[d] |
| | Pivot/linear LEPA | ▪ 21% reduction in irrigation area[a]<br>▪ 10% yield improvement[b]<br>▪ Change in area and yield linearly related to crop ET[c]<br>▪ 12% cap of LEPA wind drift and evaporation losses[d] |
| | Pivot/linear LESA | ▪ 21% reduction in irrigation area[a]<br>▪ 10% yield improvement[b]<br>▪ Change in area and yield linearly related to crop ET[c] |
| | SDI | ▪ Field production held constant[e]<br>▪ 25% yield improvement[f]<br>▪ 22% water productivity (ton per crop ET in) improvement[f] |

| From | To | Assumptions |
|---|---|---|
| Pivot/linear MESA | Pivot/linear LEPA | ▪ 12% cap of LEPA wind drift and evaporation losses[d]<br>▪ No change in geometry or yield |
| | Pivot/linear LESA | ▪ No change in geometry or yield |
| | SDI | ▪ Constant field production[e]<br>▪ 15% yield improvement[g]<br>▪ 22% water productivity (ton per crop ET in) improvement[h] |
| Wheel line, hand line, solid set | Pivot/linear MESA | ▪ 21% reduction in irrigation area[a]<br>▪ 7% yield improvement[b]<br>▪ Change in area and yield linearly related to crop ET[c]<br>▪ 12% cap of MESA wind drift and evaporation losses[d] |
| | Pivot/linear LEPA | ▪ 21% reduction in irrigation area[a]<br>▪ 7% yield improvement[b]<br>▪ Change in area and yield linearly related to crop ET[c]<br>▪ 12% cap of LEPA wind drift and evaporation losses[d] |
| | Pivot/linear LESA | ▪ 21% reduction in irrigation area[a]<br>▪ 7% yield improvement[b]<br>▪ Change in area and yield linearly related to crop ET[c] |
| | SDI | ▪ Constant field production[e]<br>▪ 22% yield improvement[g]<br>▪ 22% water productivity (ton per crop ET in) improvement[h] |

Sources: Jacobs 2024b; USU et al. 2025.

[a] When applying a circular or semicircular irrigation pattern to a square field, the field corners fall outside of the irrigated area. Field corners represent 21% of the starting area and are not assumed to be irrigated following conversion to center pivot.
[b] Assumption based upon yield data included in O'Brien et al. (2000), Ehlig and Hagemann (1980), and Sanden et al. (2011).
[c] Assumption is supported by Lamm (2016).
[d] Assumption is per Jacobs (2024b).
[e] This likely program assumption supports the producer and maximizes the reduction in depletion. Production may be controlled by a reduction in irrigated area that offers a reduction in irrigation system costs.
[f] Assumption is per Montazar (2020).
[g] Difference of notes [f] and [b].
[h] Assumption based on gravity (surface)-to-SDI conversion in Montazar (2020) and supported by deficit irrigation results in Lamm (2016).

### 3.1.4 Storage Forbearance Projects

Depletion reduction volumes associated with reservoir storage forbearance applications[1] are estimated using same method applied in SCPP (UCRC 2024). Estimated volumes of water released from storage (acre-feet) is multiplied by combined efficiency factor to account for both conveyance and irrigation losses (**Equation 5**). Conveyance and irrigation efficiency factors are both estimated at 80 percent (20-percent loss was assumed for each), with a combined efficiency factor of 64 percent (Bosworth pers. comm. 2025).

$$\text{Depletion reduction (acre-feet)} = \\ \text{Reservoir release volume (acre} - \text{feet)} * \text{conveyance efficiency} * \text{irrigation efficiency}$$

**Equation 5**

Where:

Conveyance efficiency = 80 percent (Bosworth pers. comm. 2025)
Irrigation efficiency = 80 percent (Bosworth pers. comm. 2025)

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[1] Evaluations of the recommended depletion reduction methodology are ongoing for those applications involving both fallowing and storage forbearance projects. Sufficient information is not yet available to support those estimates.

## 3.2 End-of-Season Estimates

End-of-season depletion estimates typically require comparison with an irrigated condition or reference field to quantify changes in depletion resulting from DMPP activity. While DROs are calculated during preseason analysis using a historical look-back period, growing conditions during the DMPP season may differ from those in the look-back years. Factors such as weather, water supply, irrigation management, and crop type can vary year to year, thus, accounting for all potential differences is not feasible. Additionally, one objective of the DMPP water conservation quantification methods is to develop a method that is as automated, therefore, broadly applicable and reproducible, as reasonably possible. To that end, a scaling approach was employed. In this context, a scaling approach refers to a method used to adjust preseason DROs so that they better reflect the actual conditions during the DMPP activity year. Because the DRO is based on historical data from a look-back period, they may not accurately represent the specific environmental and management conditions of the current year. The scaling approach helps bridge that gap by applying a correction factor—in this case, the ratio of reference ET between the DMPP year and the look-back period.

### 3.2.1 Fallowing Projects and Irrigation System Conversions

After the irrigation season ends, the depletion reduction resulting from the DMPP project (CCU) is calculated as the difference in ET between the irrigated and nonirrigated conditions for the same time period: DMPP activity year (**Equation 6**). The nonirrigated condition is available as the OpenET eeMETRIC ET value for the project fields on the DMPP activity year, and the irrigated condition for the DMPP activity year is estimated by using a scaling method based on a method suggested for the Upper Colorado River Basin (UCRB) by Allen and Torres (2018) and included as a potential method for use in Utah by Barker et al. (2025). The purpose of the scaling factor is to approximate the ET of the current year, as influenced by that year's specific weather at the project field if the field had been irrigated. Because this value does not exist due to DMPP participation, the preseason DRO is scaled to the DMPP activity year based on the ratio between the reference ET of the activity year and the reference ET of the median DRO year within the look-back period for each month of the DMPP activity. Here, short-reference ET is used because it is available through OpenET and supported by the work by others referenced above. Short-reference ET is the estimated ET rate in inches across the growing season from a short-canopy reference crop, such as grass.

ET is used in **Equation 6** rather than depletion as a simplification because $P_{eff}$ and $SM_{co}$ are assumed to remain the same regardless of an irrigated or nonirrigated condition. Thus, the end-of-season conserved consumptive use is approximately equal to the difference in ET between the nonirrigated and irrigated conditions for the same time period as follows:

$$\text{CCU} \approx \left(\frac{ET_{o,after}}{ET_{o,preseason}}\right) * ET_{preseason} - ET_{after} \qquad \textbf{Equation 6}$$

Where:

$CCU$ = conserved consumptive use due to fallowing (inches per month)
$ET_{after}$ = evapotranspiration from area when the DMPP is implemented (inches per month)
$ET_{preseason}$ = evapotranspiration for DRO period (inches per month)
$ET_{o,after}$ = short-reference evapotranspiration for after the DMPP participation period (inches)
$ET_{o,preseason}$ = short-reference evapotranspiration for DRO period (inches)

For each field, the monthly CCU depth (inches) is converted to a volume in acre-feet by converting inches to feet and multiplying the depth by the field size in acres; monthly CCU volumes for any month the respective field is enrolled in the program within the irrigation season are summed; the resulting water year CCUs are joined with the field boundary to create a field-scale CCU model, identifying the depletion savings for each field included in DMPP applications.

### 3.2.2 Storage Forbearance Projects

End-of-season depletion estimates of storage forbearance projects are equal to preseason estimates calculated according to **Equation 5**.

### 3.2.3 Provisional Accounting

The Upper Division States (Colorado, New Mexico, Utah, and Wyoming) acting through the UCRC entered into a Provisional Accounting Memorandum of Understanding (MOU) with the United States Bureau of Reclamation (Reclamation) in 2024. Under the UCRC-Reclamation Provisional Accounting MOU, participating entities are required to measure and record reductions in CCU resulting from qualifying activities, such as those contracted with the Authority through the DMPP. In addition, participants must account for transit losses between the location of the qualifying activity (Point A) and the storage reservoir (Point B), as well as evaporation losses occurring within the reservoir.

To support estimation of transit losses and storage losses, estimation of CCU on a daily timestep is required. Dailly CCU for fallowing projects can be derived by estimating monthly depletion per **Equation 1** and dividing the monthly depletion by the number of days per month (Barker pers comm. 2025b). The methodology used to calculate these daily depletion volumes for use in provisional accounting is most accurate at the irrigation-season level, so any results presented with these daily depletion volumes will have a high level of uncertainty at the subirrigation-season level. Although the irrigation season used in this analysis is March 1st through October 31st, under the UCRC-Reclamation Provisional Accounting MOU, CCU resulting from qualifying activities is reported by water year (October 1 through September 30).

## 3.3 Quantifying Diversion Savings

Diversion refers to the total volume of water withdrawn from a source for use, while depletion represents the portion of that water that is consumed and not returned to the system. For DMPP reporting, understanding both metrics is important: diversion helps characterize water use, while depletion is the key metric for quantifying CCU.

### 3.3.1 Preseason Depletion Reduction Opportunities and Enrollment Calculations

Preseason DRO estimates were used to determine the volume of water, needed for enrollment by DMPP participants to meet the estimated depletion reduction objective. These estimates were incorporated into **Equation 7**, which converts depletion volumes into diversion volumes using efficiency factors. To translate depletion into diversion, conveyance and irrigation efficiency factors were applied. Both were estimated at 80 percent, resulting in a combined efficiency factor of 64 percent (Bosworth pers. comm. 2025). This assumes a 20 percent loss for each component and reflects typical system performance in the region.

### 3.3.2 End-of-Season Diversion Reduction Estimates

End-of-season diversion reduction estimates are required to support UCRC-Reclamation provisional accounting, particularly for calculating transit losses. These estimates were derived by dividing the end-of-season depletion reduction volume by the combined efficiency factor as shown in **Equation 7**:

$$\text{Diversion reduction (acre} - \text{feet per year)} \ = \frac{\Delta D}{conveyance\ efficiency * irrigation\ efficiency} \qquad \textbf{Equation 7}$$

Where:

$\Delta D$ = Depletion change from *irrigated* to *fallowed* condition (acre-feet per year)
Conveyance efficiency = 80 percent (Bosworth pers. comm. 2025)
Irrigation efficiency = 80 percent (Bosworth pers. comm. 2025)

# 4. Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) is an integral part of any project and is best described as a set of activities and procedures designed to assure the reliability and accuracy of data and results. In this project, QA/QC is addressed by establishing qualitative and quantitative checks.

A spreadsheet tool was developed to support QA and verification of both input data and preseason DROs. The spreadsheet independently checked the input data sources by comparing the data used in the analysis with similar data sources. The spreadsheet tool also independently calculated depletion estimates and compared the results with the estimates calculated by the Python script. Data sources used for independent comparison are listed in Table 4-1. Post-season depletion estimate checks are currently being added to the QA/QC spreadsheet tool. Live updates to the tool and supporting documentation are available through a GitHub repository managed by Jacobs, with access provided at the Authority's discretion.

Comparing analysis inputs and results with independent data sources helped to verify accuracy and build confidence in the methodology; it also ensured that the data used and outcomes produced are consistent with other trusted sources, supporting transparency and reliability in DMPP reporting. Jacobs, in coordination with the Authority, will continuously improve upon the methods described in this report.

**Table 4-1. Summary of Key Data Sources Used in Depletion Reduction Calculations and Quality Assurance and Quality Control**

| Variable | Data Source Used in Analysis | Independent Data Source for Quality Assurance/ Quality Control |
|---|---|---|
| ET | eeMETRIC (version 2.3 or latest version available through OpenET API[a]) | eeMETRIC (latest version available through OpenET FARMS[b]) |
| Soil characteristic | SSURGO[c] | Web Soil Survey |
| Precipitation | PRISM Climate Group (2025)[d] | NOAA stations:<br>▪ USC00424342 Jensen, Utah<br>▪ USC00429368 Wellington 3 E, Utah |
| Crop rooting depth | Database referenced by Python script | Table 3-1 |
| Field boundary | Database referenced by Python script | FSA via applicant |

[a] Source: Melton et al. 2021.
[b] Source: OpenET 2025.
[c] Source: NRCS 2024.
[d] PRISM Climate Group 2025.

NOAA = National Oceanic and Atmospheric Administration

Table 4-2. describes each quality assurance indicator, applicable QA/QC component, how it is evaluated, and performance criteria goal. When DROs are calculated, the input data and calculations are thoroughly reviewed to evaluate precision, accuracy, repeatability, representativeness, and completeness of the results. As best practice, original data will never be edited or deleted. The data manager or QA/QC officer will conduct the review by applying data flags and associated comments in a series of new columns in the data. Flagged records should be retained in the project database but should not be included in subsequent data analysis and reporting efforts.

**Table 4-2. Quality Assurance Indicators**

| Quality Assurance Indicator | Quality Assurance/ Quality Control Component | Evaluation Criteria |
|---|---|---|
| **Precision:** Measure of agreement among repeated measurements of same property under identical, or substantially similar, conditions; random error. | Data source and equation comparison | Values within 25 to 50% of similar independent data source or calculation |
| **Accuracy:** Degree to which measurement result conforms to correct value or standard. | Confirmation of Python code calculations | Comparison of Python code and independent Excel calculations |
| **Comparability:** Measure of confidence that one dataset can be compared with another. | Data source comparison | Values within 25 to 50% range of similar independent data source |
| **Representativeness:** Degree to which data accurately and precisely represent population characteristic, parameter variations at sampling point, process condition, or environmental condition. | Identification and confirmation or correction of outlier values | Values within 25 to 50% range of similar independent data source or calculation |
| **Completeness:** Measure of amount of valid data obtained compared with amount of data expected to be obtained. | Data source evaluation | Identification of input data that are not available; inputs should cover entire 2016 through 2024 time period and participant field spatial geography |

Data review activities should consist of the following:

- Retrieve the most current input data for the independent QA/QC.
- Evaluate input data completeness and identify unavailable values; input values for field areas, crop rooting depths, and soil characteristics should be complete. Input values for $ET_a$ and precipitation may not be complete based on data available. When data are not available, fill data gaps of less than 1 month by linear regression, and fill data gaps exceeding 1 month using a similar data source or nearby field on a case-by-case basis.
- Review input data to ensure values are within expected ranges. Expected ranges for some data sources are listed below. Compare the input data used in the depletion reduction calculations with the independent input data sources to identify potential outliers, issues with unit conversions, or erroneous data values. Evaluate these records using best professional judgment if individual data points should be flagged in the dataset.
    - Precipitation: 0 to 6 inches per month
    - ET: 0 to 10 inches per month
    - AWS: 2 to 12 inches
    - Crop rooting depth: 24 to 60 inches
    - Agricultural field boundaries: flagged if any geographic dimension is less than 200 meters; agricultural fields with a smallest dimension of less than 100 to 200 meters may be suffering from a low $ET_a$ bias due to influence from adjacent nonirrigated fields. The Landsat thermal pixel is about 90 meters in width; therefore, fields with narrow edges could contain $ET_a$ values biased by nonirrigated areas (Melton pers. comm. 2025). If an agricultural field has a small field dimension, and the $ET_a$ value of the field appears to be less than the $ET_a$ values of neighboring fields by a margin of 15 percent or more, the field may be biased by nonirrigated grid cells. In this case, the monthly $ET_a$ depth values of the small-dimensioned field is overwritten with monthly $ET_a$ depth values of a neighboring field of similar crop types and irrigation method.

- Review the units reported in the depletion reduction calculations and independent input data and make any necessary unit conversions (for example, precipitation in millimeters to precipitation in inches).
- Review depletion reduction calculations by comparing results developed using the Python script with results using the QA/QC tool; ensure values are within expected ranges. Flag values that are not within range in the QA/QC tool. If a value is not within the expected range, then identify and note the reason for the difference in depletion reduction results and adjust and recalculate, as needed.

OpenET data undergo constant improvement and versioning updates, which may occur mid-season. Additionally, precipitation data through PRISM are provisional for 6 months prior to finalization. As applicant compensation is determined before the irrigation season begins and not revisited after agreements are signed, provisional data are used to determine compensation. At the end of the season, a different approach is used to determine depletion savings. As a result, provisional data are used in the preseason depletion savings calculation and will not be reevaluated at the end of the season. Jacobs uses the latest data that are available at the time.

# 5. Discussion

This section provides a detailed evaluation of the methods and assumptions used to estimate DROs under the DMPP; it also compares the DMPP approach with that of the SCPP, explains the rationale behind key methodological choices, and assesses the implications of those choices for consistency, accuracy, and future application. This section also highlights areas of uncertainty and outlines considerations for improving future analyses.

## 5.1 Methodology Differences between the Demand Management and System Conservation Pilot Programs

The DMPP methodology varies from SCPP methodology in several ways, and these differences are listed in Table 5-1.

**Table 5-1. Differences in Preseason Depletion Reduction Estimation Methodologies Used by the Demand Management and System Conservation Pilot Program**

| Demand Management Pilot Program | System Conservation Pilot Program |
|---|---|
| The baseline period was 7 years, based on professional judgment, which is considered to be a reasonable period to capture both wet and dry hydrologic conditions. Section 5.2 further explains why the 7-year baseline period was used in this analysis. | The baseline period was an 8-year span of 2016 through 2023 (Bosworth pers. comm. 2025). |
| Consumptive use from precipitation was calculated at the applicant field from $P_{eff}$ and winter $SM_{co}$. | Consumptive use from precipitation was estimated at a nearby nonirrigated area of the same general area and similar properties (for example, a reference field). Thus, the applicant field depletion was estimated as consumptive use of applicant field less the consumptive use of reference field. |
| The baseline depletion reduction estimate was calculated as the median of the baseline period. Median values are commonly used by the NRCS when dealing with hydrologic data to limit the bias of rare, yet abnormal, weather phenomena (USDA 2025). Section 5.2 explains how the median statistics were chosen for this analysis. | Baseline DRO was calculated as average value over baseline period. |
| For split-season fallowing alternatives, only remaining winter $SM_{co}$ was subtracted from the DRO estimate based on start of fallowing practices (early season or late season) and a comparison of ET and $SM_{co}$ values. | For split-season fallowing alternatives, fields planned for irrigation before the fallow period began, water stored in the soil zone due to irrigation before fallowing began was estimated, because the crop would continue consuming that water during fallowing. The estimated consumptive use from the soil storage was subtracted from the total CCU (UCRC 2024). |
| For end-of-season CCU estimates, the ratio of short-reference ET between the activity year and look-back period is applied to the preseason DRO estimate and difference between this value and end-of-season depletion estimate at the project field is the resultant end-of-season CCU estimate for the project field. | The consumptive use of the participating field is quantified similarly to the preseason depletion estimate as difference between consumptive use of applicant field minus consumptive use of similar nonirrigated field. A nearby irrigated field (reference field) is used to estimate consumptive use from irrigated supplies by subtracting the consumptive use from the nearby nonirrigated field. The end-of-season CCU is the difference between consumptive use of reference field and consumptive use of participating field. |

## 5.2 Summary Statistic Method and Look-Back Period Selection

The summary statistic method (median or mean) and look-back period were selected based on professional judgment. Using a look-back period of fewer than 3 years is unreasonable, as calculating a meaningful central tendency from fewer than three data points lacks statistical validity.

This section discusses the results of a simple statistical comparison used to evaluate both the look-back period and summary statistic method used to estimate DROs. Two look-back period options were considered:(1) 7-year look-back period as used for DMPP project cycles 1 and 2 and (2) 5-year look-back period used for an analysis in the Colorado River and Great Salt Lake Basins (Jacobs 2024b and USU et al. 2025, respectively). Similarly, two summary statistic methods were evaluated for selecting a representative DRO value from annual depletion estimates across the look-back period: (1) median used for DMPP project cycles 1 and 2 and (2) mean used in SCPP.

First, depletion was computed for areas within 30 fields throughout the UCRB in Utah for the years 2018 through 2024 (the most recent 7-year period). The selected areas were within at least 42 meters of the field boundaries to ensure that the shortwave Landsat pixels used in OpenET datasets were completely within the fields (42 meters is the length of the diagonal of a 30-meter by 30-meter pixel). However, for simplicity, precipitation was obtained from the gridMET dataset accessible through OpenET, and all fields were assumed to have a 48-inch-deep root zone with an AWC of 0.1 inch per inch.

A simple analysis of variance was performed using the 30 fields as replicate blocks, which were considered a random effect. The look-back period (7 years or 5 years) and the summary statistics method (mean or median) were treated as fixed effects in a two-by-two factorial analysis. The interaction between analysis period length and summary method was not significant. meaning that the main, or primary, effects of look-back period length and summary statistics method could be examined separately. No significant difference was found between using the mean or median to summarize the data; however, the difference between the 7- and 5-year periods was significant at the 5-percent probability level. Average depletion across all estimates when using the 5-year period was 31.2 inches per year, and the 7-year period resulted in an overall average estimate of 30.6 inches per year. This estimate is a difference of 0.5 inch per year (small discrepancies are because of rounding), which is less than 2-percent of the average 5-year value. This 0.5 inch is well within the uncertainty of ET, $P_{eff}$, and $SM_{co}$. The gridded weather datasets used for the $ET_a$ and precipitation data also have nontrivial uncertainties.

Further analysis is pending to compare the 5- and 7-year look-back periods as predictors for the prediction period. The present analysis was deemed sufficient based on timelines related to the project cycle 2 application evaluation period.

Given the small magnitude of the difference and the need for consistency across both project cycles 1 and 2, continuing to use a 7-year look-back period and median as the summary statistic method is supported; this approach aligns with previous DMPP project cycles and helps maintain clarity and comparability in reporting, especially during overlapping implementation periods.

## 5.3 Carry-Over Soil Moisture Calculation

Using e of **Equation 2a** to estimate $SM_{co}$ is based on professional judgment. In the formulation, Hill et al. (1989) assumes that 67-percent of $P_{win}$ is effective, although limited justification is provided for this assumption. The lower effectiveness rate compared with summer precipitation (80 percent) may reasonably reflect runoff losses associated with snowmelt. Hill et al. (1989) further adjusts $P_{win}$ by subtracting 125 percent of winter crop ET ($ET_a$). Crop ET was calculated only for the growing season, which sometimes extended into the defined winter period (beginning in October). For example, if the calculation season ended in September, but the crop continued growing into October, then 125 percent of October's $ET_a$ was subtracted from the winter precipitation. The factor of 1.25 corresponds to the inverse of the summer $P_{eff}$ rate (1 divided by 0.8) and was used to account for the portion of $P_{win}$ that would have been effective during the growing season, had it extended past September.

Rearranging the equation helps clarify how these assumptions are applied:

$$SM_{co} = \max\{0, \min[0.84(P_{Win} - 0.80ET_{WIN}), 0.75Z_rAWC]\}$$

**Equation 2b**

Where:

$SM_{co}$ = carry-over soil moisture
$P_{win}$ = winter precipitation
$ET_{win}$ = winter evapotranspiration
AWC = available water capacity

In this analysis, eeMETRIC $ET_a$ data from OpenET were used to estimate ET across the full calendar year. One caveat assumption is that the eeMETRIC model performs reasonably well over frozen surfaces (most $ET_a$ models are formulated only for nonfreezing conditions). Regardless, values of $ET_a$ are typically sufficiently small in the winter such that errors as much as 100 percent are still of acceptable magnitude from a hydrologic perspective.

By using the Hill et al. (1989) $SM_{co}$ equation and putting some confidence in the full $ET_{win}$ for the adjustment, less precipitation is assumed effective than was used in the Bear River Basin. Further, any precipitation not contributing to $ET_{win}$ is assumed to be 67 percent effective. Without any additional validation data, these assumptions are likely to be as justifiable as any other assumptions considering the uncertainties related with snowmelt hydrology.

The study area experiences conditions when $ET_{win}$ will exceed 80 percent of $P_{win}$ and the $SM_{CO}$ will be zero. In cases where offseason $P_{eff}$ is significant, $SM_{CO}$ is limited to not exceed 75 percent of the plant-available water in the rootzone. The assumption is that a crop could end the year with heavily depleted soil (2025 is a good example because irrigation water was typically shut off early). If sufficient precipitation occurs during the following winter, then $SM_{CO}$ should not be allowed to exceed what might feasibly be stored in the rootzone. The 75-percent multiplier is debatable, primarily because of the implicit assumption of filling the rootzone back up to field capacity by the end of the winter. Perhaps a value of 50 percent would be more conservative (from a $SM_{CO}$ standpoint); however, underestimating $SM_{CO}$ would overestimate potential conserved depletion, for which negative consequences from a basin standpoint are greater. Finally, based on the analyses, in some cases, all three paths of the $SM_{CO}$ equation would be triggered in different locations and years in the UCRB in Utah.

## 5.4 Future Considerations

The $P_{eff}$ calculation presented in **Equation 3** was developed by USDA in 1970. Since then, the Desert Research Institute, OpenET, and Barker et al. (2025) have evaluated different methods for estimating $P_{eff}$. Barker et al. (2025) suggest using the curve number method to estimate $P_{eff}$ at the daily timescale. This approach is likely more accurate than **Equation 3** because it is geographically specific, although the computational lift to shift from a monthly to a daily timescale creates a hurdle. Additionally, Desert Research Institute and OpenET are developing $P_{eff}$ raster data for the western United States, although the data are not currently available; these data could be used in the future to improve accuracy and reduce computations.

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# Appendix A
# Example Field Calculation

# Appendix A. Example Field Calculation

This appendix outlines the calculation of full-season and split-season fallowing for an example field totaling approximately 90 acres (shown on Figure A-1); the calculation methodology followed is outlined in the report to which the appendix is included.

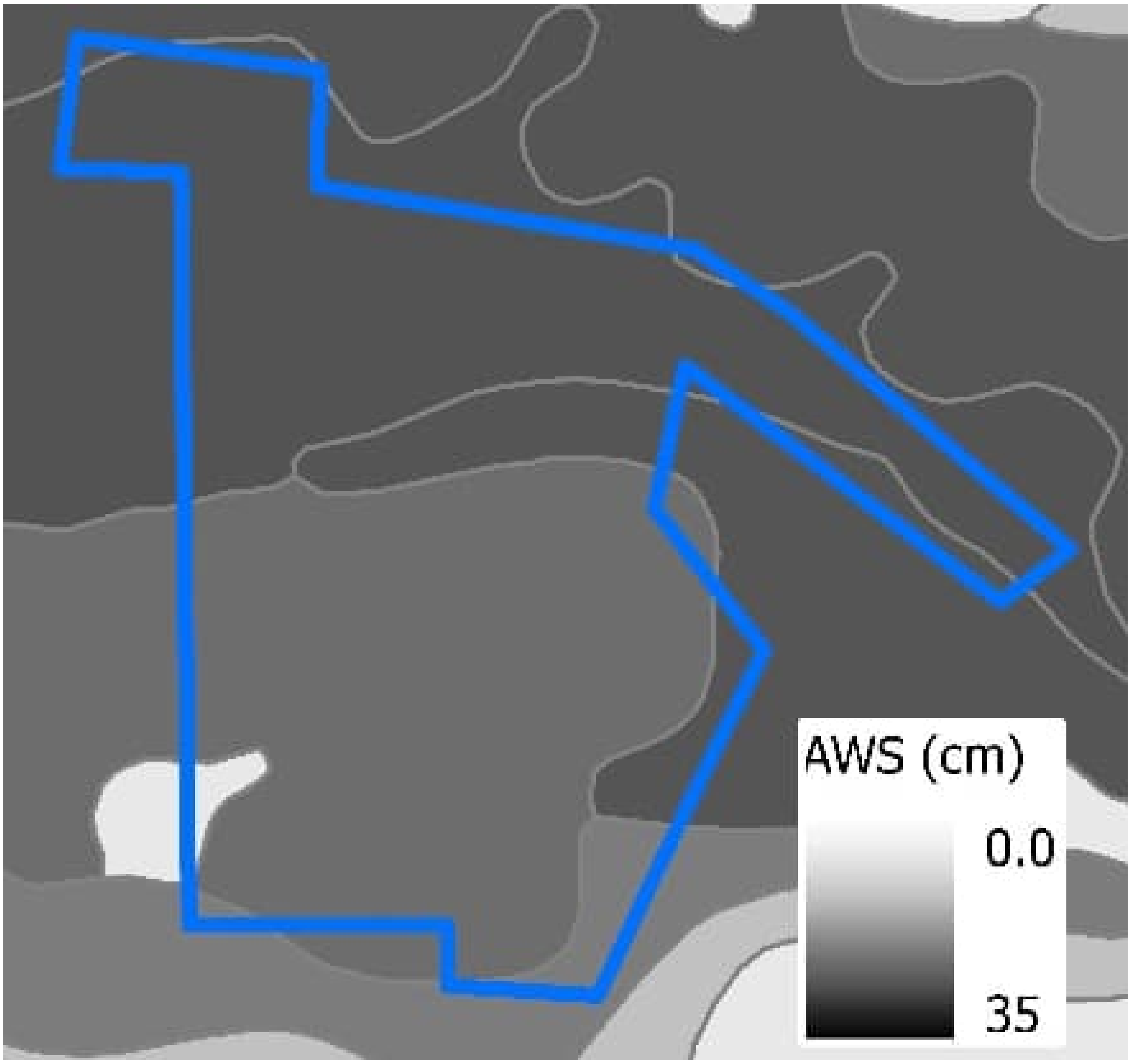
**Figure A-1. Example Field**

The calculation steps are as follows:

1. AWS in first 59 inches (150 centimeters) of soil is obtained from the *Web Soil Survey* (NRCS 2024). Using ArcPy tools in Python, the area-weighted average AWS is added as an attribute to field boundary layer. The area-weighted average AWS in first 59 inches (150 centimeters) of soil for example field is 9 inches (24 centimeters), as shown on Figure A-2 and summarized in Table A-1, where 2,138 acre-centimeters / 90 acres = 24 centimeters.
2. Usable soil water storage (D) was taken as 40 percent of the AWS. Therefore, D of the example field was 4 inches (40 percent of 9 inches, rounded to the nearest inch).
3. Soil water storage factor (SF) was then calculated based on **Equation 4**:

$$SF = 0.531747 + 0.295164*4 – 0.057697* 4^2 + 0.003804*4^3 = 1 \qquad \textbf{Equation A1}$$

**Figure A-2. Available Soil Water Storage**



*Source: NRCS 2024.*

**Table A-1. Available Water Storage for Example Field**

| Available Water Storage (centimeters) | Area (acres) | Available Water Storage x Area (acre-centimeters) |
|---|---|---|
| 22 | 42 | 930 |
| 21 | 3 | 59 |
| 26 | 34 | 886 |
| 6 | 1 | 5 |
| 26 | 10 | 258 |
| **TOTAL** | **90** | **2,138** |

4. Spatial mean of OpenET's eeMETRIC $ET_a$ and DAYMET precipitation data within each field boundary is obtained for each monthly timestep using zonal statistics in ArcPy. For July 2020, the example field received 0.2 inch of precipitation; this, ET was 5.3 inches. ET and precipitation summaries for the example field are presented in Effective precipitation (Peff) was calculated for every month of the growing season in the baseline period based on **Equation A2,** where SF of the example field equals 1 (from step 3 above):

$$\text{Peff} = 1 * (0.70917 P_{mon}^{0.82416} - 0.11556)(\ 100.02426ETc\mathbf{)} \qquad \textbf{Equation A2}$$

For July 2020, the calculation results were as follows:

$$\text{Peff} = 1 * (0.70917 * 0.2^{0.82416} - 0.11556)(10^{0.02426*5.3})\ = 0.1 \text{ inch}$$

Monthly Peff estimates are shown in Table A-4.

5. Table A-2 and Table A-3, respectively.

6. Effective precipitation ($P_{eff}$) was calculated for every month of the growing season in the baseline period based on **Equation A2**, where SF of the example field equals 1 (from step 3 above):

$$P_{eff} = 1 * (0.70917 P_{mon}^{0.82416} - 0.11556)(10^{0.02426ET_c}) \qquad \textbf{Equation A2}$$

For July 2020, the calculation results were as follows:

$$P_{eff} = 1 * (0.70917 * 0.2^{0.82416} - 0.11556)(10^{0.02426*5.3})\ = 0.1 \text{ inch}$$

Monthly $P_{eff}$ estimates are shown in Table A-4.

**Table A-2. Evapotranspiration for Example Field, 2017 to 2023**

| Month | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| | (inches) | | | | | | |
| November[a] | 0.7 | 0.5 | 0.8 | 0.7 | 0.3 | 1.2 | 0.3 |
| December[a] | 0.2 | 0.4 | 0.1 | 0.3 | 0.2 | 0.7 | 0.0 |
| January | 0.0 | 0.3 | 0.2 | 0.0 | 0.3 | 0.1 | 0.0 |
| February | 0.1 | 0.3 | 0.3 | 0.5 | 0.1 | 0.3 | 0.2 |
| March | 0.5 | 0.5 | 0.5 | 0.5 | 0.2 | 1.0 | 0.8 |
| April | 1.7 | 1.9 | 3.0 | 1.9 | 0.9 | 1.6 | 2.1 |
| May | 2.5 | 3.1 | 4.4 | 5.1 | 2.2 | 3.0 | 3.8 |
| June | 5.2 | 1.9 | 5.1 | 5.7 | 4.2 | 3.2 | 5.4 |
| July | 3.3 | 2.5 | 4.3 | 5.3 | 3.3 | 2.3 | 6.7 |

| Month | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| | (inches) | | | | | | |
| August | 3.6 | 1.8 | 3.5 | 3.9 | 3.8 | 2.8 | 5.7 |
| September | 2.9 | 1.9 | 2.7 | 2.3 | 3.7 | 3.1 | 3.5 |
| October | 1.5 | 0.9 | 1.5 | 1.7 | 2.7 | 2.4 | 1.9 |
| **$ET_{win}$[b]** | **1** | **1.5** | **1.4** | **1.5** | **0.9** | **2.3** | **0.5** |
| **ET[c]** | **21.2** | **14.5** | **25** | **26.4** | **21** | **19.4** | **29.9** |

Source: OpenET 2024.

[a] November and December values shown are for previous calendar year
[b] Sum of ET from November 1 to February 28/29 (winter).
[c] Sum of ET from March 1 to October 31.

$ET_{win}$ = winter or nongrowing season evapotranspiration

### Table A-3. Precipitation for Example Field

| Month | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| | (inches) | | | | | | |
| November[a] | 0.3 | 0.1 | 0.8 | 1.7 | 0.7 | 0.2 | 0.2 |
| December[a] | 1.1 | 0.1 | 0.3 | 1.6 | 0.5 | 1.6 | 0.9 |
| January | 2.2 | 0.7 | 1.2 | 0.2 | 0.5 | 0.0 | 2.2 |
| February | 0.5 | 0.3 | 1.6 | 0.4 | 0.4 | 0.9 | 0.2 |
| March | 1.5 | 0.5 | 2.0 | 1.6 | 0.6 | 0.6 | 1.7 |
| April | 0.2 | 0.8 | 0.7 | 0.1 | 0.8 | 0.2 | 0.0 |
| May | 0.3 | 0.8 | 2.2 | 0.0 | 0.1 | 0.1 | 0.7 |
| June | 0.3 | 0.5 | 0.3 | 0.9 | 0.6 | 0.7 | 0.8 |
| July | 1.4 | 0.7 | 0.3 | 0.2 | 1.5 | 0.1 | 0.6 |
| August | 0.9 | 1.0 | 0.2 | 0.0 | 2.0 | 0.9 | 2.1 |
| September | 1.3 | 0.0 | 0.4 | 0.0 | 0.8 | 2.1 | 0.3 |
| October | 0.0 | 3.4 | 0.1 | 0.0 | 2.0 | 0.4 | 0.3 |
| **$P_{win}$[b]** | **4.1** | **1.2** | **3.9** | **3.9** | **2.1** | **2.7** | **3.5** |

Source: DAYMET 2024.

[a] November and December values shown are for previous calendar year.
[b] Sum of precipitation from November 1 to February 28/29 (winter).

### Table A-4. Effective Precipitation for Example Field

| Month | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| | (inches) | | | | | | |
| November[a] | 0.2 | 0.0 | 0.5 | 1.1 | 0.4 | 0.1 | 0.0 |
| December[a] | 0.7 | 0.0 | 0.2 | 1.0 | 0.3 | 1.0 | 0.6 |
| January | 1.3 | 0.4 | 0.8 | 0.1 | 0.3 | 0.0 | 1.3 |
| February | 0.3 | 0.2 | 0.9 | 0.2 | 0.2 | 0.5 | 0.0 |
| March | 0.9 | 0.3 | 1.2 | 1.0 | 0.4 | 0.4 | 1.0 |
| April | 0.1 | 0.5 | 0.5 | 0.0 | 0.5 | 0.1 | 0.0 |
| May | 0.1 | 0.6 | 1.6 | 0.0 | 0.0 | 0.0 | 0.5 |

| Month | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| | (inches) | | | | | | |
| June | 0.2 | 0.3 | 0.2 | 0.7 | 0.4 | 0.5 | 0.7 |
| July | 1.0 | 0.5 | 0.2 | 0.1 | 1.1 | 0.0 | 0.5 |
| August | 0.6 | 0.7 | 0.1 | 0.0 | 1.5 | 0.7 | 1.7 |
| September | 0.9 | 0.0 | 0.2 | 0.0 | 0.6 | 1.5 | 0.2 |
| October | 0.0 | 2.0 | 0.0 | 0.0 | 1.3 | 0.3 | 0.1 |

[a] November and December values shown are for previous calendar year.

7. Winter carry-over soil moisture ($SM_{co}$) was calculated according to Equation A3. The example field is a grass and alfalfa mix; therefore, the root zone depth for the entire field was assumed to be the average of the grass hay (24 inches) and alfalfa (54 inches) crop rooting depths, which equates to a rooting depth of 39 inches Effective precipitation ($P_{eff}$) was calculated for every month of the growing season in the baseline period based on **Equation A2**, where SF of the example field equals 1 (from step 3 above):

   $$P_{eff} = 1 * (0.70917 P_{mon}^{0.82416} - 0.11556)(10^{0.02426 ET_c}) \quad \textbf{Equation A2}$$

   For July 2020, the calculation results were as follows:

   $$P_{eff} = 1 * (0.70917 * 0.2^{0.82416} - 0.11556)(10^{0.02426 * 5.3}) = 0.1 \text{ inch}$$

   Monthly $P_{eff}$ estimates are shown in Table A-4.

8. Table A-2). Because the crop composition of the example field does not vary from 2017 through 2023, a single root depth value is used; however, root depth can vary by year if the crop composition varies between irrigation seasons. AWC is equal to the AWS in the first 59 inches of soil (0.16 inch per inch for the example field). Winter (November through March) precipitation and $ET_{win}$ values are summarized in Table A-3 and Effective precipitation ($P_{eff}$) was calculated for every month of the growing season in the baseline period based on **Equation A2**, where SF of the example field equals 1 (from step 3 above):

   $$P_{eff} = 1 * (0.70917 P_{mon}^{0.82416} - 0.11556)(10^{0.02426 ET_c}) \quad \textbf{Equation A2}$$

   For July 2020, the calculation results were as follows:

   $$P_{eff} = 1 * (0.70917 * 0.2^{0.82416} - 0.11556)(10^{0.02426 * 5.3}) = 0.1 \text{ inch}$$

   Monthly $P_{eff}$ estimates are shown in Table A-4.

9. Table A-2, respectively. For 2020 at the example field, the resulting $SM_{co}$ is as follows:

   $$SM_{co} = minimum\left(0.67 * (3.9\, inches - 1.25 * 1.5 \text{ inches}), 0.75 * 39\, inches * 0.16 \frac{inch}{inch}\right) = minimum\ (1.9, 4.6) = 1.9 \text{ inches.} \quad \textbf{Equation A3}$$

   The resulting winter $SM_{co}$ values for the example field are listed in the month of March in Table A-5. Monthly $SM_{co}$ values calculated according to Equation 2c are also included in Table A-5. An example calculation for the month of May 2020 is shown in **Equation A4**.

   $$SM_{co,\,mon} = MIN(MAX(1.9 - 1.9 + 0, 0), 0.75 * 39 * 0.16) = MIN(0, 4.6) = 0 \text{ inches} \quad \textbf{Equation A4}$$

**Table A-5. Monthly Carry-Over Soil Moisture for Example Field**

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| **Month** | **(inches)** | | | | | | |
| March | 1.9 | 0.0 | 1.4 | 1.4 | 0.7 | 0.0 | 1.9 |
| April | 2.3 | 0.0 | 2.1 | 1.9 | 0.9 | 0.0 | 2.1 |
| May | 0.7 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 |
| June | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| July | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| August | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| September | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

10. Monthly depletion was calculated at the field scale based on **Equation 2a**. To convert depletion from a depth to a volume, the depletion estimates were multiplied by the field area, which totaled 90 acres for the example field. Monthly depletion volumes for the irrigation season were summed up annually. Monthly and annual depletion estimates for the example field are shown in Table A-6. The depletion reduction opportunity (DRO) under the full-season fallowing alternative for this field was 114 acre-feet, which is the median value from the 7-year baseline period shown in Table A-6.

The approach for calculating the DRO of a split-season fallow closely followed the full-season fallow approach discussed previously with one key difference: depletion was calculated monthly. For this difference, winter $SM_{co}$ was depleted starting in April. After cumulative irrigation-season ET exceeds the sum of the cumulative irrigation-season $P_{eff}$ and winter $SM_{co}$, monthly depletion is equal to ET minus $P_{eff}$ only, and winter $SM_{co}$ is removed from the calculation. If applicants want to fallow their fields from June 15 to October 31, then their DRO for the year 2022 would be the sum of July through October and half of the June monthly depletion estimates (71 inches).

**Table A-6. Depletion Estimates for Example Field**

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| **Month** | **(inches)** | | | | | | |
| March | 0 | 2 | 0 | 0 | 0 | 5 | 0 |
| April | 0 | 11 | 3 | 0 | 0 | 11 | 0 |
| May | 13 | 19 | 21 | 38 | 13 | 23 | 25 |
| June | 38 | 12 | 37 | 38 | 29 | 20 | 35 |
| July | 17 | 15 | 31 | 39 | 17 | 17 | 47 |
| August | 23 | 8 | 26 | 29 | 17 | 16 | 30 |
| September | 15 | 14 | 19 | 17 | 23 | 12 | 25 |
| October | 11 | 0 | 11 | 13 | 11 | 16 | 14 |
| **Depletion[a]** | **116** | **80** | **147** | **174** | **109** | **119** | **175** |
| **6/15 through 10/31 Depletion** | **85** | **44** | **105** | **117** | **82** | **71** | **132** |

[a] Annual depletion equal to the sum of the monthly irrigation season depletion

[b] In this example, 2022 corresponded to the median depletion-value in the 7-year baseline period. So, the DRO for this field under the full-season fallowing alternative was approximately 119 acre-feet.

## A.1 References

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# Memo

Date: Thursday, October 30, 2025

To: Ali Effati, Colorado River Basin Bureau Chief

From: Ted Shannon (HDR)

Subject: Jicarilla Apache Nation Lease Water Accounting Estimation for Water Year 2025

## Executive Summary

This memorandum presents a comprehensive analysis of water losses associated with the Jicarilla Apache Nation ("JAN") lease, which releases up to 20,000 acre-feet annually from Navajo Reservoir. This lease agreement between the New Mexico Interstate Stream Commission ("NMISC"), JAN, and The Nature Conservancy is New Mexico's identified Qualifying Activity under the December 2024 Provisional Accounting MOU. Two releases occurred in Water Year 2025 ("WY25").

*Figure 1: Map showing the Accounting Reach between the Navajo Reservoir Outlet and the Piute Farms Wash*

### Objective

The study developed and applied a methodology to estimate carriage losses—water lost during transit due to evaporation and potential irrigation interference—along the more than 250-mile route from Navajo Reservoir to Lake Powell.

## Methodology

Losses were evaluated across nine San Juan River reaches using:

- Evaporative Losses: Estimated using OpenET data and high-resolution land use datasets.
- Irrigation Interference: Evaluated by comparing expected versus actual gaged flows.
- Reach Routing: Applied autocorrelation models to simulate travel time and flow attenuation.

Groundwater interactions and bank storage were evaluated but are difficult to measure directly. It is unclear whether apparent losses from groundwater interactions are permanent or if these translate into later baseflow gains and contribution to Lake Powell. The accounting therefore used evaporative losses as the primary transit loss and did not include groundwater interactions.

## Key Findings

Total losses ranged from 1% to 12% of released volume.

- Lowest loss (1%) occurred during the November 2024 release due to cooler temperatures and minimal evaporation.
- Highest loss (12%) occurred in July 2025, attributed to high temperatures and low precipitation.
- No irrigation interference was detected in any release.
- Loss per river mile ranged from less than 0.01% to 0.05%.
- Loss per transit day ranged from 0.04% to 0.61%.

The following table details losses and deliveries to Lake Powell for the release events:

| Release Dates | JAN Release Volume at Navajo Reservoir [acft] | Calculated JAN Volume at San Juan River below Piute Farms Wash [acft] | Loss Rates | | |
|---|---|---|---|---|---|
| | | | Total | Per River Mile | Per Transit Day |
| November 17 to December 3, 2024 | 10,991 | 10,892 | 1% | <0.01% | 0.04% |
| July 27 to August 7, 2025 | 10,161 | 8,921 | 12% | 0.05% | 0.61% |

The study confirms that a significant portion of JAN lease water reaches Lake Powell. Timing releases during cooler months and after the irrigation season can reduce losses. The methodology provides a replicable framework for future lease evaluations and supports transparent water accounting. The NMISC reserves the right to refine or revise loss calculations and methods as future data becomes available.

# JAN Lease Water Accounting Report for WY25

Under the lease agreement, the NMISC can lease 20,000 acre-feet/yr of JAN water stored in Navajo Reservoir ("reservoir") and place it in its Strategic Water Reserve by releasing that amount to the San Juan River. Two releases occurred in WY25. Table 1 lists those release events.

**Table 1. JAN Lease Water Events in WY25**

| Release Dates | Volume [acft] | Weather Conditions |
|---|---|---|
| November 17 to December 3, 2024 | 10,991 | Temperatures ranged from a low of 12°F to high of 68°F. Light rain on one day. Evaporation was less than 0.1 inches per day. |
| July 27 to August 7, 2025 | 10,161 | Temperatures ranged from a low of 52°F to high of 99°F. Light rain on two days. Evaporation ranged from 0.3 to 0.5 inches per day. |

Sources: Temperature information from the Farmington Agricultural Science Center weather station. Precipitation and evaporation from OpenET at Farmington.

Water released from Navajo Reservoir travels over 250 miles to reach the nearest bay of Lake Powell. This memorandum develops a framework and calculation method to estimate the degree of carriage losses. The method is then applied to the WY25 releases to provide the volume of original release water reaching Lake Powell.

### Carriage Loss Framework

A functional approach suggested by Pahl and Hasfurther (1985) was adopted to assess JAN carriage losses. These components are:

- **Evaporative:** A loss of water attributed to open water and near riparian vegetation.
- **Bank storage:** Rising river water surfaces could be driven into the riverbank and temporarily stored. This water reemerges as baseflow when river elevations decline.
- **Groundwater Influences**: Surface water can infiltrate into the aquifer via "losing" stream reaches. Alternatively, additional surface water may suppress base flow in "gaining" stream reaches.
- **Irrigation Interference**: It is possible that reservoir releases intended for Lake Powell could be diverted as part of ongoing irrigation operations. This could result in a portion consumed from crop evapotranspiration and irrigation inefficiencies.
- **Channel storage**: Potential losses increase over time during the transit journey. Reach routing evaluates the timing of the JAN release journey and assists in understanding relevant losses.

Studies of conveyance losses from reservoir releases noted that these losses are due to a variety of factors that are difficult to explicitly isolate. It is particularly challenging to quantify groundwater interactions and bank storage. It can be unclear whether these apparent losses are permanent or if they translate into later baseflow gains and contribution to Lake Powell. USGS (1996) groundwater modeling on the San Juan River found surface water "lost" in some reaches could return in gaining reaches. Precision Water Resources Engineering's (2018) RiverWare model also found losing and gaining reaches that varied based on river flow conditions.

For the JAN loss assessment, a San Juan River baseflow separation evaluation was conducted for a pulse reservoir release and a spring flood flow. This similarly found reaches where pulse flow was reduced and other reaches when the pulse flow had regained volume. The baseflow assessment could not determine if groundwater interactions and bank flow storage were permanent losses or represented longer term storage that eventually became baseflow.

Losses considered in this study are evaporative losses from open water and near riparian vegetation during transit. The OpenET dataset provides site-specific evaporation and precipitation conditions. Additionally, the evaluation determined potential inadvertent diversion into irrigation ditches. Typically, the JAN releases are coordinated to prevent this. Part of the JAN loss assessment is to show that no inadvertent irrigation interference occurred.

### Transit Reaches

The loss components were evaluated on nine San Juan River reaches, listed in Table 2. The reaches are defined based on the location of long-term USGS stream gages. Most of the reaches (A to F) occur within the irrigated areas, with an average reach length of 15 miles. Reaches in the lower San Juan River (G to I) have less water use and have an average length of 60 miles.

The USGS gage at the downstream-most reach, San Juan below the Piute Farms Wash (09379700), was recently reactivated by the USGS. The USGS conducted gage height data collection in water years 2023 and 2024. A rating curve based on three field measurements was available to estimate flows starting in 2025. While this gage has less data than the other locations, it likely will become more useful in future JAN releases. This gage is 60 river miles downstream of the Bluff gage and allows for accounting to within 11 river miles of the Zahn Bay of Lake Powell.

**Table 2. San Juan River Transit Reaches**

| Reach | Description (USGS Gage) | River Miles (Miles from Navajo Reservoir) | Travel Time from Navajo Reservoir |
|---|---|---|---|
| A | Navajo Outflow to Archuleta (09355500) | 6.9 | hours |
| B | Archuleta (09355500) to Bloomfield (09357000) | 31.0 | 0.4 days |
| C | Bloomfield (09357000) to Bolack Ranch (09357700) | 42.7 | 0.6 days |
| D | Bolack Ranch (09357700) to Farmington (09365000) | 47.8 | 0.6 days |
| E | Farmington (09365000) to Fruitland (09367540) | 60.5 | 0.7 days |
| F | Fruitland (09367540) to Shiprock (09368000) | 81.0 | 0.7 days |
| G | Shiprock (09368000) to Four Corners (09371010) | 115.4 | 1.0 days |
| H | Four Corners (09371010) to Bluff UT (09379500) | 194.2 | 2.0 days |
| I | Bluff UT (09379500) to Piute Farms Wash (09379700) | 254.5 | 2.7 days |

Notes: Travel time calculated from the Reach Routing section.

## Reach Routing

The JAN water is subject to different evaporation losses as it travels downstream. Reach routing was calculated using autocorrelation:

$$Qout(t) = Qin(t) * C_0 + Qin\,(t-1) * C_1 + Qin\,(t-2) * C_2 + Qin\,(t-3) * C_3$$

Where:

$Q_{in}(t)$ is the inflow at the upper portion of each reach on a specific day.

$Q_{in}(t-1)$ is the inflow at the upper portion from the previous day

$Q_{in}(t-2)$ is the inflow at the upper portion from two days previous

$Q_{in}(t-3)$ is the inflow at the upper portion from three days previous

$Q_{out}(t)$ is the outflow at the lower end of each reach on a specific day

$C_0$ to $C_3$ are unitless coefficients that describe travel time from the top to bottom of the reach.

A set of coefficients was calculated to describe the portion of flows from the upper portion of the reach that arrives at the lower portion over a period of four days. The coefficient $C_0$ is the portion of water that travels through the reach in a single day. The coefficient $C_1$ is the amount of water that takes a day to travel through the reach. The coefficients $C_2$ and $C_3$ are the portion of water that takes two and three days, respectively, to travel through the reach.

Calibration of the routing coefficients for Reaches A to H was done with the November 2024 JAN release. During this release the only diversions were a relatively constant flow through the Citizen's Ditch. Most tributaries were dry or had generally constant inflows. The Piute Farms Wash gage (Reach I) was not operational during November 2024. The spring flood flows in 2025 was used in reach routing estimation for Reach I.

Table 3 lists the routing coefficients. Figure 1 shows an example application of these coefficients in Reach I. The peak flows between Bluff to Piute Farms Wash were delayed by about 0.7 days and attenuated.

**Table 3. Reach Routing Coefficients**

| | Autocorrelation Reach Routing Coefficients [unitless] | | | |
|---|---|---|---|---|
| Reach | $C_0$ | $C_1$ | $C_2$ | $C_3$ |
| A | 0.961 | 0.039 | 0.000 | 0.000 |
| B | 0.605 | 0.395 | 0.000 | 0.000 |
| C | 0.764 | 0.236 | 0.000 | 0.000 |
| D | 1.000 | 0.000 | 0.000 | 0.000 |
| E | 0.879 | 0.029 | 0.076 | 0.017 |
| F | 0.899 | 0.101 | 0.000 | 0.000 |
| G | 0.589 | 0.411 | 0.000 | 0.000 |
| H | 0.048 | 0.748 | 0.099 | 0.105 |
| I | 0.267 | 0.733 | 0.000 | 0.000 |

Notes: Routing for Reaches A to H based on November 2024 releases. Routing for Reach I based on Spring 2025 flood flows.

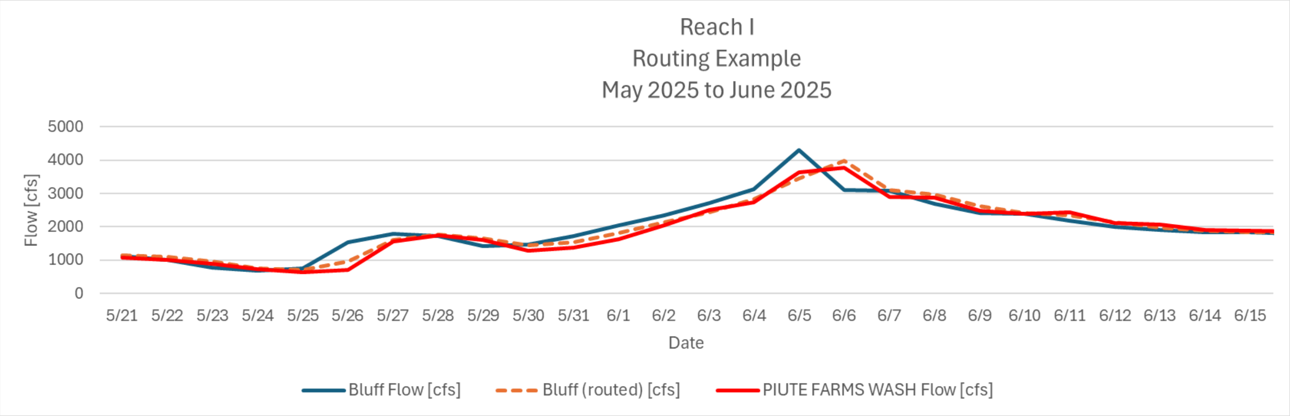

**Figure 2. Reach Routing Example**

## Evaporative Losses

Evaporation losses are calculated based on open water area within each reach and reach-specific evaporation rates. Three datasets of open water area (Table 4) were examined: a riparian assessment at low and high flow conditions conducted by the Biology Committee of the San Juan River Basin Recovery Implementation Program (“SJRIP”); detailed riparian delineations from New Mexico and Utah; and a recent 10-meter remote sensing Cropland Data land use product. To facilitate this comparison, the reach definition from the SJRIP Biology Committee was used as this data source was not available as a GIS dataset. The area units also are from the Biology Committee and are square meters of open water per river mile.

The 10-meter cropland data layer is often on the lower end of the comparisons, especially in the upper reaches. The San Juan River can become braided in these reaches, and the 10-meter resolution is often insufficient to identify these smaller channels. The New Mexico Riparian Habitat Map and Utah Water-Related Land Use product was selected as the source of open water area, both for its currentness and high-resolution. Table 5 shows the open water area from these products expressed in the analysis reaches.

**Table 4. Comparison of Open Water Areas**

| Reach (as defined in Holden et al, 1999) | Open Water Area [$m^2$ / mi] | | |
|---|---|---|---|
| | San Juan Biology Committee (Holden et al, 1999) | New Mexico Riparian Habitat Map Version 2.0 Plus (2020) and Utah DWRe Water Related Land Use (2021) | Cropland Data Layer Land Use (NASS 2024) |
| Reach 1 (RM 0-16)<br>Lake Powell | 114,291 to 152,314 | 224,338 | 162,018 |
| Reach 2 (RM 17-67) | 72,142 to 97,161 | 69,141 | 67,692 |
| Reach 3 (RM 68-105) | 113,314 to 199,049 | 121,940 | 130,388 |
| Reach 4 (RM 106-130) | 104,522 to 171,983 | 132,752 | 117,853 |
| Reach 5 (RM 131-154) | 107,422 to 206,925 | 117,183 | 103,848 |
| Reach 6 (RM 155-180) | 92,933 to 133,983 | 117,100 | 90,058 |
| Reach 7 (RM 181-213) | 77,043 to 102,519 | 107,208 | 71,853 |
| Reach 8 (RM 214-224)<br>Navajo Dam | 94,636 to 150,883 | 124,687 | 107,805 |

**Table 5. Reach Open Water Area**

| Reach | Description | Open Water Area [acres] | | |
|---|---|---|---|---|
| | | Total | New Mexico Riparian Habitat Map Version 2.0 Plus (2020) | UT DWRe Water Related Land Use (2021) |
| A | Navajo Outflow to Archuleta (09355500) | 224 | 224 | n/a |
| B | Archuleta (09355500) to Bloomfield (09357000) | 545 | 545 | n/a |
| C | Bloomfield (09357000) to Bolack Ranch (09357700) | 280 | 280 | n/a |
| D | Bolack Ranch (09357700) to Farmington (09365000) | 213 | 213 | n/a |
| E | Farmington (09365000) to Fruitland (09367540) | 380 | 380 | n/a |
| F | Fruitland (09367540) to Shiprock (09368000) | 529 | 529 | n/a |
| G | Shiprock (09368000) to Four Corners (09371010) | 987 | 795 | 192 |
| H | Four Corners (09371010) to Bluff UT (09379500) | 1,878 | n/a | 1,878 |
| I | Bluff UT (09379500) to Piute Farms Wash (09379700) | 1,419 | n/a | 1,419 |

The daily evapotranspiration rates during the JAN release operations were obtained from the OpenET eeMETRIC dataset. This dataset reflects both reach-specific temperatures, near riparian land uses, and precipitation. The 30-meter resolution of this product means that the open water evaporation estimate will also contain evapotranspiration of nearby riparian vegetation.

Currently, the OpenET website has limited capability to produce a custom export of data. Specific portions of reaches can be queried but entire reaches are difficult to consistently reproduce. An area-weighted centroid of each reach was determined in Table 6. These locations are generally half-way in each reach. Wider river portions in each reach may shift these locations. The centroid location is searched for in the OpenET website and a custom daily report exported.

**Table 6. Reach Centroid Locations**

| Reach | Latitude | Longitude |
|---|---|---|
| A | 36.808151 | -107.680008 |
| B | 36.697676 | -107.898383 |
| C | 36.69496 | -108.038007 |
| D | 36.708958 | -108.167931 |
| E | 36.721381 | -108.36168 |
| F | 36.744871 | -108.471623 |
| G | 36.891976 | -108.858666 |
| H | 37.277523 | -109.4436 |
| I | 37.292327 | -110.302139 |

## Irrigation Interference

Proving that irrigation did not inadvertently divert JAN water could be shown through ditch gaging. The New Mexico Office of the State Engineer operates a gaging network on each of the major ditches. If these diversions do not react to a JAN release (that is, diversions remain unchanged or only increase at a rate of tributary inflows), then it could be stated that JAN water remained in the San Juan River. Another method is to track the expected JAN volumes through each reach, after accounting for evaporation. At each reach, the USGS stream gage is compared to the expected volume. This later method was selected as it does not require ditch flow records, which may not always be available during JAN releases.

The process to assess irrigation interference is:

1. Start with known JAN releases from Navajo Reservoir
2. Route the releases to the next downstream reach, using the method in Section "Reach Routing"
3. Estimate evaporation losses. Multiply the OpenET rates for each transit day by the estimated open water area in the reach (Section "Evaporative Losses"). Apply the evaporation volume proportionally to the JAN surface flow volume and total gaged river volume.
4. Compare the calculated daily JAN surface flow to the reach gage flow:
    a. If the expected JAN surface flow is less than the gage flow, then assume no irrigation interference occurred.
    b. If the expected JAN surface flow is more than what is physically present at the gage, then assume some irrigation impacts occurred. The difference between expected JAN flow and actual flow is the magnitude of the impact, although this may subsequently be reduced by return flows in lower reaches.

## Total Carriage Losses

The evaporative losses were applied to the WY25 JAN releases (Table 7). The evaporation is generally higher in summer than in fall months, dependent on precipitation. There were no inadvertent irrigation diversions of the water. The minimum loss was for the November 17 to December 3, 2024 release with a total of 1% loss between the reservoir and Reach I, or less than 0.01% per river mile. This fall release had low evapotranspiration rates. Higher losses occur during summer months due to higher evaporation. The highest loss was 12%, or 0.05% per river mile, for the July 27 to August 7, 2025 release. Table 7. Summary of Losses of JAN Releases in WY25

| Release Dates | JAN Release Volume at Navajo Reservoir [acft] | Calculated JAN Volume at San Juan River below Piute Farms Wash [acft] | Loss Rates | | |
|---|---|---|---|---|---|
| | | | Total | Per River Mile | Per Transit Day |
| November 17 to December 3, 2024 | 10,991 | 10,892 | 1% | <0.01% | 0.04% |
| July 27 to August 7, 2025 | 10,161 | 8,921 | 12% | 0.05% | 0.61% |

Table 8 and Table 9 are a loss breakout by reach of each release event.

**Table 8. Estimated Losses of November 17-December 3, 2024 Release**

November 17 to December 3, 2024

| Item | | Value | |
|---|---|---|---|
| 1 | JAN Release from Navajo Reservoir | 10,991 | acft |
| 2 | Evaporation Losses | 99 | acft |
| | Reach A: Navajo Outflow to Archuleta | 9 | |
| | Reach B: Archuleta to Bloomfield | 22 | |
| | Reach C: Bloomfield to Bolack Ranch | 23 | |
| | Reach D: Bolack Ranch to Farmington | 2 | |
| | Reach E: Farmington to Fruitland | 3 | |
| | Reach F: Fruitland to Shiprock | 4 | |
| | Reach G: Shiprock to Four Corners | 3 | |
| | Reach H: Four Corners to Bluff UT | 20 | |
| | Reach I: Bluff UT to Piute Farms Wash | 12 | |
| 3 | Irrigation Interference Losses | 0 | acft |
| | Reach A: Navajo Outflow to Archuleta | 0 | |
| | Reach B: Archuleta to Bloomfield | 0 | |
| | Reach C: Bloomfield to Bolack Ranch | 0 | |
| | Reach D: Bolack Ranch to Farmington | 0 | |
| | Reach E: Farmington to Fruitland | 0 | |
| | Reach F: Fruitland to Shiprock | 0 | |
| | Reach G: Shiprock to Four Corners | 0 | |
| | Reach H: Four Corners to Bluff UT | 0 | |
| | Reach I: Bluff UT to Piute Farms Wash | n/a | |
| 4 | Total Losses | 99 | acft |
| 5 | Delivery to Lake Powell | 10,892 | acft |
| | As Percent of Navajo Release | 99% | |
| | Loss per River Mile (254.5 miles) | 0.004% | /Mile |
| | Loss per Transit Day (18 release days, 25 transit days) | 0.04% | /Day |

**Table 9. Estimated Losses of July 27-August 7, 2025 Release**

| July 27 to August 7, 2025 | | | |
|---|---|---|---|
| Item | | Value | |
| 1 | JAN Release from Navajo Reservoir | 10,161 | acft |
| 2 | Evaporation Losses | 1,240 | acft |
| | Reach A: Navajo Outflow to Archuleta | 21 | |
| | Reach B: Archuleta to Bloomfield | 65 | |
| | Reach C: Bloomfield to Bolack Ranch | 104 | |
| | Reach D: Bolack Ranch to Farmington | 32 | |
| | Reach E: Farmington to Fruitland | 53 | |
| | Reach F: Fruitland to Shiprock | 108 | |
| | Reach G: Shiprock to Four Corners | 113 | |
| | Reach H: Four Corners to Bluff UT | 422 | |
| | Reach I: Bluff UT to Piute Farms Wash | 321 | |
| 3 | Irrigation Interference Losses | 0 | acft |
| | Reach A: Navajo Outflow to Archuleta | 0 | |
| | Reach B: Archuleta to Bloomfield | 0 | |
| | Reach C: Bloomfield to Bolack Ranch | 0 | |
| | Reach D: Bolack Ranch to Farmington | 0 | |
| | Reach E: Farmington to Fruitland | 0 | |
| | Reach F: Fruitland to Shiprock | 0 | |
| | Reach G: Shiprock to Four Corners | 0 | |
| | Reach H: Four Corners to Bluff UT | 0 | |
| | Reach I: Bluff UT to Piute Farms Wash | n/a | |
| 4 | Total Losses | 1,240 | acft |
| 5 | Delivery to Lake Powell | 8,921 | acft |
| | As Percent of Navajo Release | 88% | |
| | Loss per River Mile (254.5 miles) | 0.05% | /Mile |
| | Loss per Transit Day (12 release days, 20 transit days) | 0.61% | /Day |

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