ArkDSS Memorandum
Final

To: Bill Tyner and Kelley Thompson, Colorado Division of Water Resources

From: Wilson Water Group

Subject: Task 2.1 – Basin Operations
Fryingpan-Arkansas Project Facilities and Related Operations

Date: April 2019

INTRODUCTION

One of the Task 2.1 objectives is to:

> *Develop and document an understanding of the operations of key water use facilities in the basin in order to accurately represent the use and operations in the water rights allocation modeling. This understanding will be developed through interviews with DWR personnel, operators of large canal and reservoir systems, and representatives of federal facilities.*

Key water use facilities include diversion structures, transmountain diversions, reservoirs, and reservoir systems.

- Diversion structures include structures that received Fryingpan-Arkansas Project (Project) and/or store other water in Reclamation facilities.
- Transmountain diversions include those structures that transport non-native water from another basin into the Arkansas River basin for storage in Reclamation facilities.
- Reservoirs include Project reservoirs and other reservoirs that interact with Project operations.

This memo covers the East Slope Fryingpan-Arkansas Project facilities and how they are operated for project use and non-project use. Related operations for the Winter Water Storage Program (WWSP) and the Voluntary Flow Management Program (VFMP) are also included. The information provided in this memorandum was developed from publicly accessible sources, and information provided by, and discussions with, representatives from Reclamation, SECWCD, and the Division of Water Resources (DWR).

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Two primary meetings were held as follows:

- November 29, 2017 meeting with Reclamation at the Pueblo Reservoir Field Office. The objectives of the meeting were "*to discuss and document day-to-day operation of the Fryingpan-Arkansas project, their accounting of water in the project's reservoirs, and their interactions with the Southeastern Colorado Water Conservancy District and the Division 2 office…Discuss with Reclamation staff their efforts to develop a RiverWare model for the Fryingpan-Arkansas project.*" The following people attended the meeting:
  - Roy Vaughan, Terry Dawson, and Shane Hayden, US Bureau of Reclamation
  - John Van Oort, DWR, River Operations Coordinator
  - Bill Tyner, DWR, Assistant Division 2 Engineer
  - Kelley Thompson, DWR, Lead Modeler
  - Erin Wilson and Lisa Brown, Wilson Water Group
- January 20, 2018 meeting with Southeastern Colorado Water Conservancy District (SECWCD). The objectives of the meeting were to discuss the interaction between SECWCD and Reclamation, and understand the water allocation process. The following people attended the meeting:
  - Garrett Markus, SECWCD Engineer
  - Erin Wilson and Lisa Brown, Wilson Water Group

The information provided in this memorandum was developed from publicly accessible sources, and information provided by, and discussions with, representatives from Reclamation, SECWCD, and DWR. Information in this memorandum is believed to be accurate. However, this information should not be relied upon in any legal proceeding.

SYSTEM OVERVIEW

The Fryingpan-Arkansas Project is a Reclamation project that collects water on the West Slope of the Continental Divide, imports the water to the East Slope, and distributes the water to users in the Arkansas Basin. The project facilities include Ruedi Reservoir on the Fryingpan River; a series of collection points and tunnels throughout the headwaters of the Fryingpan River and Hunter Creek; Boustead Tunnel; Turquoise Reservoir on Lake Fork Creek; Twin Lakes Reservoir on Lake Creek; Mt. Elbert Conduit; Halfmoon Diversion; Mt. Elbert Forebay and Power Plant; Pueblo Reservoir on the Arkansas River; and the Fountain Valley Conduit. The West Slope facilities and operations will not be included in the ArkDSS model and therefore are excluded from this memo. Boustead Tunnel, the East Slope facilities and operations will be included in the ArkDSS model and are described in this memo.

Where to find more information:

- The West Slope facilities are represented in the Colorado River Decision Support System (CRDSS) and documented in the Upper Colorado River Surface Water Model User's Manual and Upper Colorado Basin Information Report.

The Fryingpan-Arkansas Project is authorized as a multi-purpose project. Water imported from the West Slope provides supplemental water for irrigation, municipal, domestic, and industrial uses, and is used for hydropower generation and incidental benefits for recreation, fish, and wildlife purposes. Pueblo Reservoir also is used for flood control purposes. When the Project was authorized, the projected average annual diversion of the West Slope collection system was 69,200 acre-feet. Since the Fryingpan-Arkansas Project began diverting water through Boustead Tunnel in 1972, the average annual diversion has been 52,698 acre-feet, with annual values ranging from around 3,300 in 1987 to near 110,000 acre-feet in 1984. Note that there are often discrepancies between diversions recorded at the Boustead Tunnel gage and diversions reported in Reclamation's Annual Operating Plans based on the individual collection systems[1]. These minor discrepancies are a result of the accuracy limitation of the flow measurements at each individual diversion.

Water is imported from the West Slope through Boustead Tunnel and released into Turquoise Reservoir. Turquoise Reservoir can release water directly to the Lake Fork Creek (tributary to the Arkansas River), or into the Mt. Elbert Power Conduit. Additional native water can be diverted into the Mt. Elbert Conduit by the Halfmoon Creek Diversion structure. The Mt. Elbert Conduit delivers water to the Mt. Elbert Forebay. Water is then run through the Mt. Elbert Pumped-Storage Power Plant and delivered to Twin Lakes Reservoir. When power prices are low, water from Twin Lakes can be pumped back to the Mt. Elbert Forebay. Twin Lake Reservoir can release water directly to Lake Creek, a tributary to the Arkansas River, or water can be released directly to the Otero Pump Station. Note that the Otero Pump Station is not a Reclamation facility; it is owned by Colorado Springs and Aurora.

The terminal Reclamation facility is Pueblo Reservoir. Water can be released from Pueblo Reservoir via the Arkansas River to meet downstream irrigation and municipal demands; by exchange to meet upstream project demands; and directly out of the reservoir through the south outlet works for the Fountain Valley Authority, Pueblo West Metropolitan District, and the Pueblo Board of Water Works. Beginning in 2016, water can also be delivered through the north outlet works through the Southern Delivery System. In addition, there is a direct irrigation delivery made from the reservoir to the Bessemer Ditch and releases from the fish hatchery outlet to the Pueblo Fish Hatchery.

The Project reservoirs provide a major benefit to both Project and non-Project water users. Other transmountain importers use Turquoise Reservoir and Twin Lakes to store non-Project West Slope water in their permanent space within Project facilities. Homestake Tunnel and Busk-Ivanhoe Tunnel import non-Project Colorado River basin water to Turquoise Reservoir.

[1] For example, the Boustead Tunnel Gage records show 3,300 acre-feet diverted through the Boustead Tunnel in 1987; however Reclamation Annual Operating Plan reported around 2,600 acre-feet in 1987.

The Twin Lakes Canal imports non-Project Colorado River basin water to Twin Lakes. Pueblo Reservoir also offers excess capacity contract storage space that is used as non-Project water storage by a significant number of water users. Overall, the Project facilities account for about 777,000 acre-feet of storage in the Arkansas Basin.

Where to find more information:

- Details on Homestake, Busk-Ivanhoe, and Twin Lakes Canal can be found in the Colorado Springs Utilities, Aurora, and Colorado Canal memos.
- Detailed description of project facilities is included in Reclamation's Annual Operating Plans.

Note that although Trinidad Reservoir is a Reclamation facility, it is operated by the Army Corps of Engineers. The reservoir accounting is done by the Division Office and the Purgatoire District.

Where to find more information:

- Trinidad Reservoir and the Purgatory River uses are documented in ArkDSS Water District 19 memorandum and the ArkDSS Purgatoire Water Conservancy District Operations memorandum.

PHYSICAL INFORMATION AND DATA AVAILABILITY

The Fryingpan-Arkansas Project facilities were constructed by Reclamation starting on the West Slope in 1964 and finishing on the East Slope in 1975. Reclamation generally has electronic daily records of reservoir content dating back to the start of project operations. The reservoirs' content data have been collected from Reclamation.

Reclamation periodically performs reservoir sedimentation studies to update the depth-capacity-surface area curves. Currently, a sedimentation study is being performed on Turquoise and Twin Lakes reservoirs. Pueblo Reservoir has an original, a 1993, and a 2012 curve. Reclamation measures the storage content of the reservoirs using pressure transducers.

When freezing temperatures are not problematic, Reclamation measures evaporation for Turquoise, Twin Lakes, and Pueblo Reservoir using pans. They have daily electronic records of pan evaporation back to October 1, 1996. During the winter months when the evaporation pan has been winterized, evaporation factors (shown below) are used to calculate evaporation at project reservoirs. Note that to find the monthly volume of evaporation in acre-feet, the factor in Table 1 is multiplied by the surface area of the reservoir, minus the ice cover.

Table 1: Reclamation Monthly Evaporation Factors

Month	Ruedi	Turquoise	Twin Lakes	Pueblo
OCT	0.0530	0.1217	0.1217	0.1366
NOV	0	0.0566	0.0566	0.0886
DEC	0	0.0171	0.0171	0.0735
JAN	0	0.0274	0.0274	0.07078
FEB	0	0.0497	0.0497	0.10592
MAR	0	0.0771	0.0771	0.1548
APR	0	0.1337	0.1337	0.1760
MAY	0.1470	0.2006	0.2006	---
JUN	0.3605	0.2554	0.2554	---
JUL	0.3244	0.2246	0.2246	---
AUG	0.2332	0.1766	0.1766	---
SEP	0.1419	0.1663	0.1663	---

The sixteen west slope collection diversions are gaged. Project water is brought through a series of tunnels then conveyed to the Arkansas River basin through Boustead Tunnel. Complete records are available in HydroBase (see details in the "Charles H. Boustead Tunnel" Section below). Non-Project water imported through the following tunnels can also be stored in Turquoise Reservoir. Homestake Tunnel has daily diversion records in HydroBase, from 1966 to present, with the month of July missing in 1977. Busk-Ivanhoe Tunnel has daily diversion records in HydroBase from 1948 to present, with missing information in 1953. Non-Project water imported through Twin Lakes Canal can be stored in Twin Lakes Reservoir. Twin Lake Canal has complete daily diversion records in HydroBase from 1935 to present.

Charles H. Boustead Tunnel

Boustead Tunnel conveys Project water from the West Slope collection system to the East Slope distribution system. Boustead Tunnel was drilled 10.5 feet high and 5.4 miles long. Water is gravity-fed through the 945 cfs capacity tunnel. The original capacity for Boustead Tunnel was 900 cfs. The Southeastern Colorado Water Conservancy District was awarded an additional 45 cfs if certain conditions are met. Boustead Tunnel water is delivered to Turquoise Reservoir.

Transmountain diversions are measured at the Boustead Gaging Station, located at the East Portal. The gage is maintained by the Colorado Division of Water Resources. When the project is in priority, this gage is used by Reclamation to determine the amount of imports. For the modeling effort, the Boustead Gaging Station values will be used to represent historical imports. The Boustead Gaging Station daily streamflow information is in HydroBase from October 1, 1971 to present, as shown in Figure 1. The record is complete, except for a few days in August 1979, which should, according to Reclamation, should be estimated to be zero for modeling purposes.

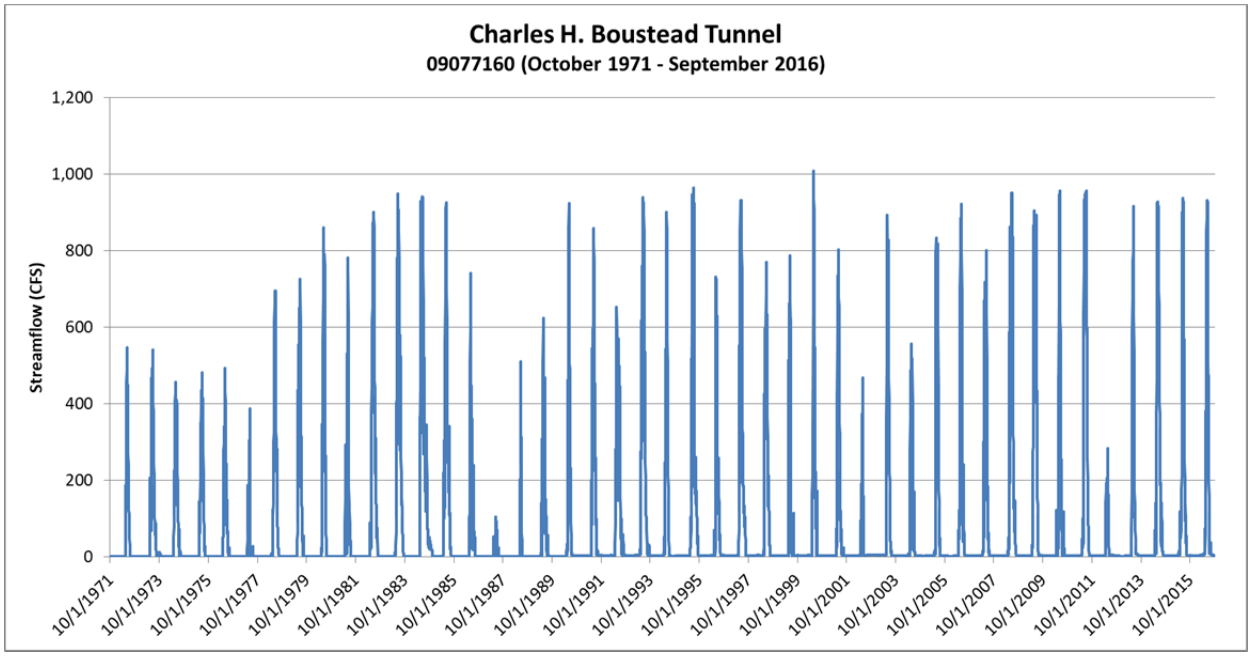

Figure 1: Gaged Flow through the Boustead Tunnel

Turquoise Reservoir

Turquoise Reservoir is located on Lake Fork Creek. The maximum reservoir capacity is 135,525 acre-feet, with a capacity of 129,398 acre-feet at the spillway crest. Multiple water users own storage in Turquoise Reservoir. Turquoise Reservoir was originally a 17,416 acre-foot reservoir owned by CF&I Steel Corporation. The reservoir was enlarged for the Fryingpan-Arkansas Project. As part of the agreement with Reclamation, CF&I retained an account in the reservoir equal to their original 17,416 acre-foot reservoir and could purchase an additional 10,000 acre-feet of storage capacity. The CF&I interests in Turquoise Reservoir have since been purchased by Colorado Springs Utilities, Aurora, and Pueblo Board of Water Works.

Reclamation provided daily total reservoir storage values from October 1, 1971 through November 30, 2015, shown in Figure 2. The record is complete, except for four days throughout the period. For the ArkDSS modeling effort, these values will be filled using linear interpolation.

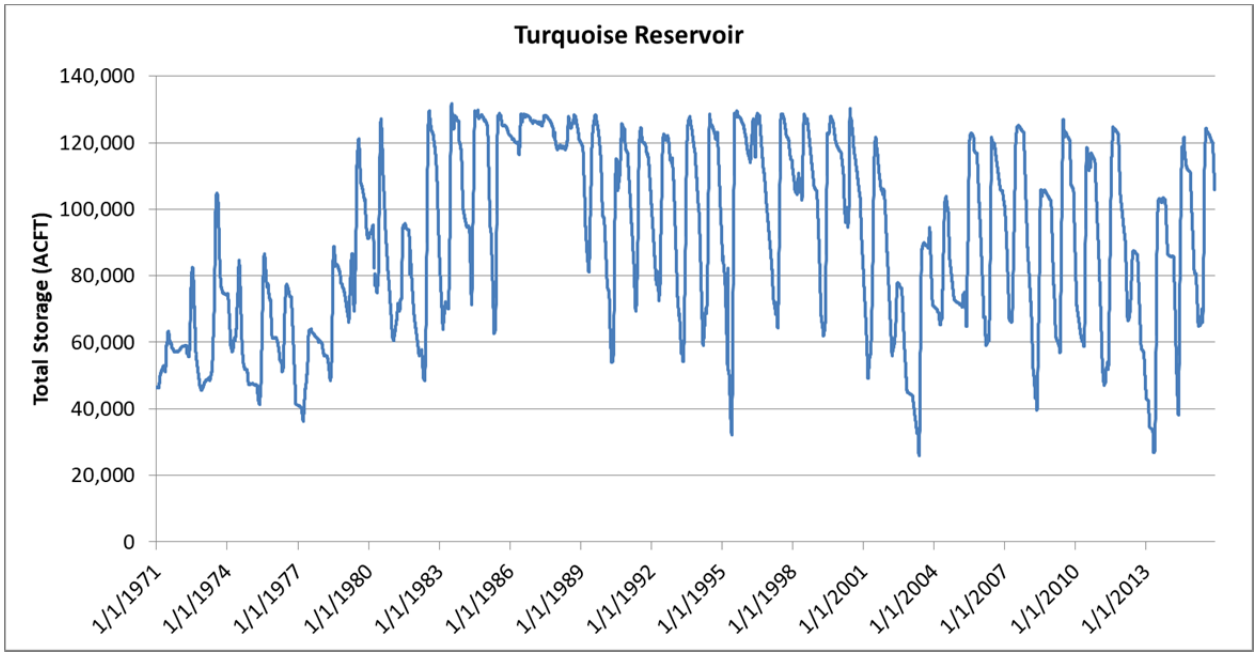

Figure 2: Turquoise Reservoir Daily Storage

In addition to receiving native water from Lake Fork Creek and transmountain water from Boustead Tunnel, Turquoise Reservoir also receives transmountain water from Homestake Tunnel and Busk-Ivanhoe Tunnel. These imports are used to fill the accounts owned by other entities. Table 2 shows the account information for Turquoise Reservoir.

Table 2: Turquoise Reservoir Account Information

Account name and owner	**Account capacity (acre-feet)**
Fryingpan-Arkansas Project (Reclamation)	63,062
CF&I – Colorado Springs Utilities	17,416
Homestake – Colorado Springs Utilities	15,000
Homestake – Aurora	15,000
CF&I – Aurora	5,000
CF&I – Pueblo Board of Water Works	5,000
Dead/Inactive - Fryingpan-Arkansas Project	8,920

Turquoise Reservoir can release water to Lake Fork Creek or the Mt. Elbert Conduit. Releases to Lake Fork Creek are measured at DWR gage Lake Fork Creek below Sugar Loaf Dam near Leadville (Gage ID 07082500 or LFCBSLCO). The reservoir has a minimum bypass requirement of 3 cfs (estimated average native inflow) between November 15th and March 15th, and 15 cfs, or native inflow, whichever is less for the remainder of the year. Inflow to the reservoir is computed by Reclamation using a mass-balance calculation. To estimate native inflow, Reclamation used the DWR administrative streamflow gage “Lake Fork Creek above Turquoise”

(LKCTURCO), which is operated seasonally. Reclamation doubles the gaged flow to estimate the total native inflow.

Reclamation's preferred operation is to send as much water as possible to the Mt. Elbert Conduit for two reasons: 1) maximizes power production and 2) avoids localized flooding downstream of Turquoise Reservoir on Lake Fork Creek. Reclamation may utilize water called for by other entities from Turquoise Reservoir for power production. As of March 2001, Aurora, Colorado Springs, Pueblo Board of Water Works, SECWCD and Reclamation reached an agreement with Lake County to minimize the possibility of a release to Lake Fork Creek above 400 cfs. Lake Fork Creek has a limited conveyance capacity and flows above 400 cfs may cause localized flooding and river crossing difficulty.

Mt Elbert Conduit, Halfmoon Creek Diversion, and Mt. Elbert Power Facilities

Mt. Elbert Conduit; Halfmoon Creek Diversion; and Mt. Elbert Forebay, Power Plant and Pump-back system operate to generate hydropower and distribute water from Turquoise Reservoir to Twin Lakes. Hydropower operations are a secondary benefit of project water delivery.

Mt. Elbert Conduit is 10.7 miles long and has a maximum capacity of 400 cfs, with a normal operating capacity of 350 cfs. The primary intake is from Turquoise Reservoir. A private contractor runs the Sugarloaf hydropower plant, which generates power with releases to the conduit. There is a bypass around the Sugarloaf plant that can also connect Turquoise Reservoir and the Mt. Elbert Conduit. When the conduit is not at capacity, additional native Arkansas River water can be diverted from Halfmoon Creek via the Halfmoon Creek Diversion. There is a 7 cfs bypass requirement at the Halfmoon Creek Diversion. Diverted water from Halfmoon Creek is used for non-consumptive hydropower generation. It is released from Twin Lakes Reservoir and returned back to the Arkansas River via Lake Creek. When the native Arkansas River water rights are in priority, water diverted from Halfmoon Creek can be stored in Project Reservoirs. For more details on water rights, see the "Water Rights and Accounting" section below. The conduit is also used to supply water to the Leadville Fish Hatchery. The fish hatchery normally needs 5.4 cfs from the conduit. The Mt. Elbert Conduit terminates at the Mt. Elbert Forebay.

Reclamation tracks the Mt. Elbert Conduit flows closely. They record the total daily conduit flows by water source. Additionally, they measure the flow through the Sugarloaf plant, the Sugarloaf bypass, diversions to the fish hatchery, and diversions from Halfmoon.

The Mt. Elbert Forebay is an 11,143 acre-foot reservoir. The reservoir is not used for long-term storage, but used to re-regulate water delivered by the Mt. Elbert Conduit and for short-term storage of water delivered by the pump-back station. Reclamation provided daily total reservoir storage values from September 25, 1996 through November 30, 2015. As shown in Figure 3, the record is complete.

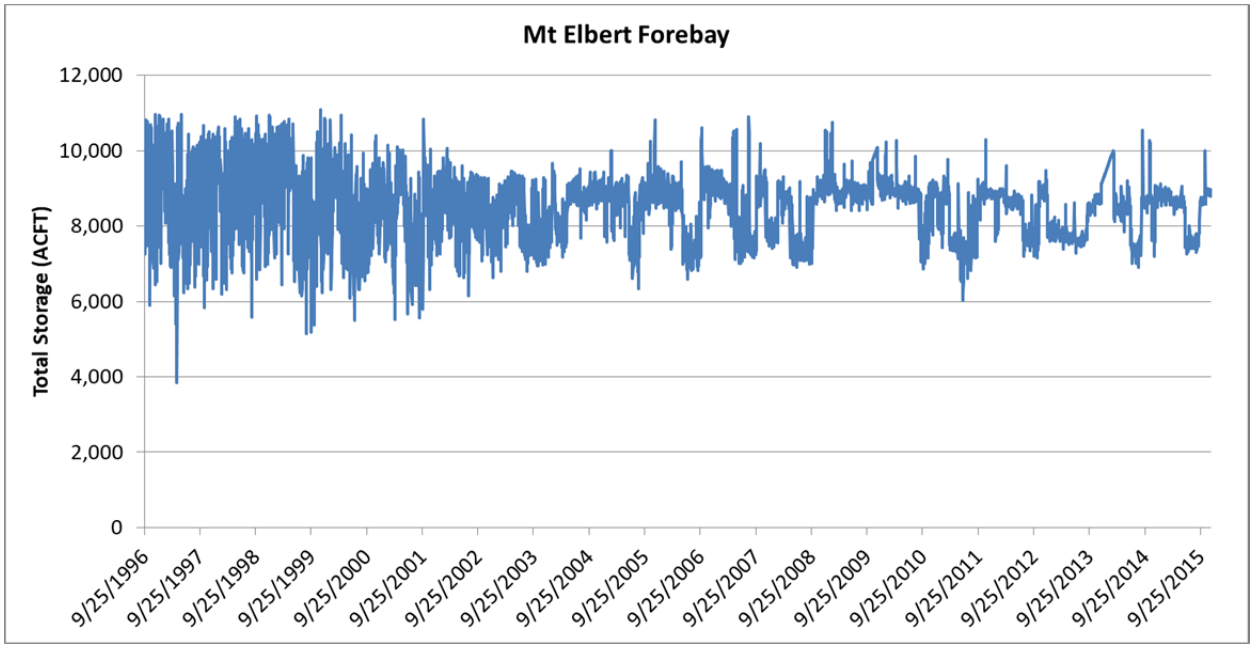

Figure 3: Mt. Elbert Forebay Daily Storage

The Mt. Elbert Power Plant is a pump-storage hydropower generation facility. Water from the Mt. Elbert Forebay is dropped 445 feet through two turbines, each with a generating capacity of 100 megawatts. There is no bypass around the turbines, so the hydropower plant maintenance schedule is a critical component of Project operations. The power plant delivers water to Twin Lakes Reservoir, which serves as the afterbay. For the pump-back, the turbines can be reversed and water from Twin Lakes pumped back up to the Mt. Elbert Forebay.

The power plant and pump-back operation is scheduled by the Western Area Power Association (WAPA), in close coordination with Reclamation. On a day-to-day basis, Reclamation informs WAPA of water delivery orders. WAPA schedules the water deliveries and the pump-back operations. The pump-back operation happens most nights, when power prices are low. The system is very reactive and can help balance the power grid. Reclamation operates Twin Lakes so there is enough space to serve as the afterbay for power operations, and that the reservoir elevation does not drop below the pump-back intake.

Twin Lakes Reservoir

Twin Lakes Reservoir is located on Lake Creek. It serves multiple purposes, including water storage for the Fryingpan-Arkansas Project, the afterbay for the Mt. Elbert Power Plant, and storage for other entities. The reservoir has a maximum storage capacity of 147,500 acre-feet and standard operational limit of 140,855 acre-feet. Twin Lakes Reservoir was original constructed by the Twin Lakes Reservoir and Canal Company (TLRCC) and was enlarged as part of the Project.

Reclamation provided daily total reservoir storage values from January 1, 1981 through November 30, 2015, as shown in Figure 4. The record is missing October 1, 1983 through September 30, 1986 and occasional days throughout the period.

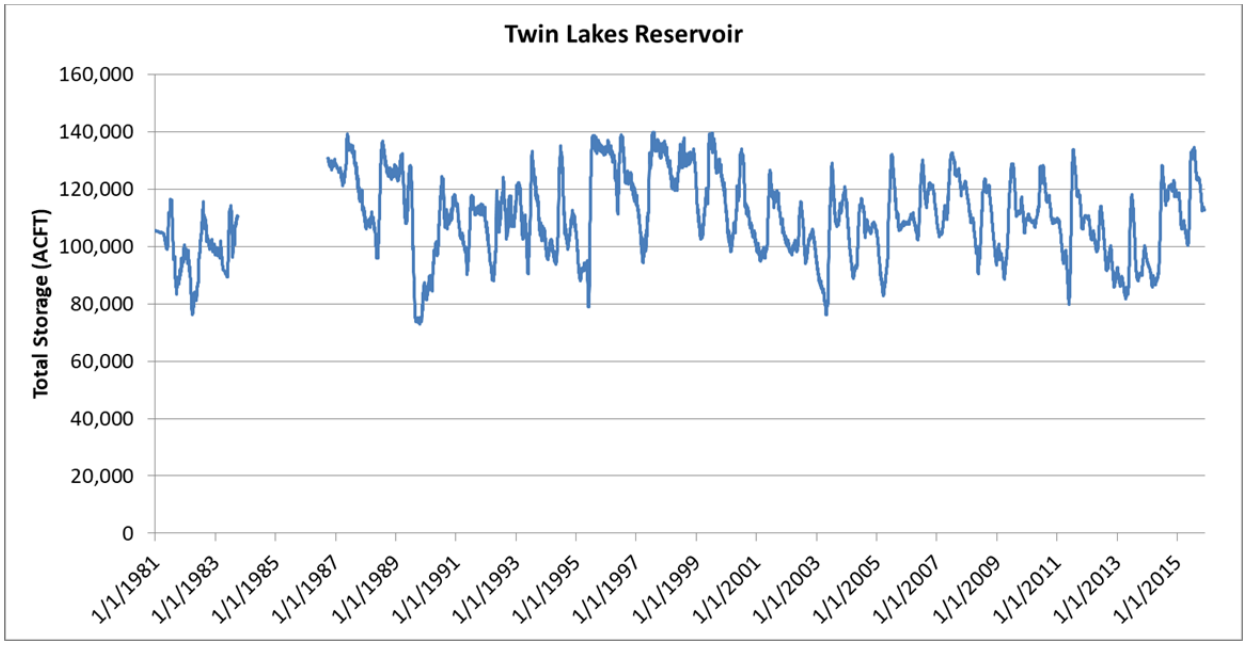

Figure 4: Twin Lakes Reservoir Daily Storage

In addition to the account distribution shown in the Table 3, the suggested minimum reservoir content needed to maintain Power Plant operations is 76,908 acre-feet. This means that if TLRCC has no water in storage, Reclamation must maintain 13,584 acre-feet of Project water in Twin Lakes Reservoir. Reclamation has the flexibility to store Project water beyond their account maximum if TLRCC does not need the space. However, other users may not impinge on Reclamation's storage space. At its highest levels, the combined Mt. Elbert Forebay and Twin Lakes storage must be less than 144,182 acre-feet to maintain power production.

Table 3: Twin Lakes Reservoir Account Information

Account name and owner	Account capacity (acre-feet)
Fryingpan-Arkansas Project (usable Project space)	12,967
Twin Lakes Canal Company	54,452
Fryingpan-Arkansas Project (Inactive Pool)	9,614
Dead Pool	63,324

The TLRCC ownership shares, as of March 2018, are provided in Table 4.

Table 4: Twin Lakes Reservoir and Canal Company Account Information

Account	Shares	Percent of Ownership
Colorado Springs Utilities	27,119.67	54.569%
Pueblo Board of Water Works	11,476.16	23.143%
Pueblo West Metro District	5,906.75	11.911%
Aurora	2,488.48	5.018%
Colorado Canal Agricultural	252.73	.51%
Miscellaneous	1287.545	2.596%
Woodland Park	184.97	0.373%
XCEL	750	1.512%
Upper Arkansas Water Conservancy District	121	0.2
Total	49,589.965	100%

The Otero Pipeline has an intake at the outlet works of Twin Lakes Reservoir. This facility is not owned or operated by Reclamation; it is used to distribute water to Colorado Springs and Aurora. The reservoir can also release to Lake Creek. There is a minimum bypass requirement of 15 cfs or native inflow, whichever is less, as measured by the Lake Creek below Twin Lakes Reservoir (LAKBTLCO) gage. The minimum bypass can be met with native water, Project water, or stored account water. In dry years, it can be an operational challenge to maintain the 15 cfs.

Pueblo Reservoir

Pueblo Reservoir, located on the mainstem Arkansas River, is the terminal storage facility for the Project. Pueblo Reservoir also provides flood control and flat-water recreational benefits. It has a total capacity of 481,444 acre-feet and a standard operational limit of 256,949 acre-feet. In the "Operation" section below, Pueblo Reservoir operations are discussed in more detail. Pueblo Reservoir can release water via the spillway, spillway outlet works, river outlet works, fish hatchery outlet works, south outlet works, Bessemer Ditch outlet works, and north outlet works. The original headgate of the Bessemer Ditch was inundated by the reservoir and the Bessemer Ditch outlet works releases directly into the ditch. Pueblo accounting is more complex than Turquoise and Twin Lakes Reservoirs. The larger reservoir operating accounts are shown in Table 5. Additional information on account storage is described below in the "Water Rights and Accounting" section.

Table 5: Pueblo Reservoir Operating Account Information

Account name	Top of Account Elevation (feet)	Account capacity (acre-feet)
Surcharge	4919.0	131,504
Flood Control	4898.7	26,991
Active Conservation (usable Project space)	4893.8	228,828
Joint Use	4880.49	66,000
Inactive Pool	4796.7	25,792
Dead Pool	4764.0	2,329

Reclamation provided daily total reservoir storage from January 1, 1975 through November 30, 2015, shown in Figure 5. The record is complete, except for June 11, 2013 through July 8, 2013 and occasional days in 2015. The missing values should be filled with linear interpolation.

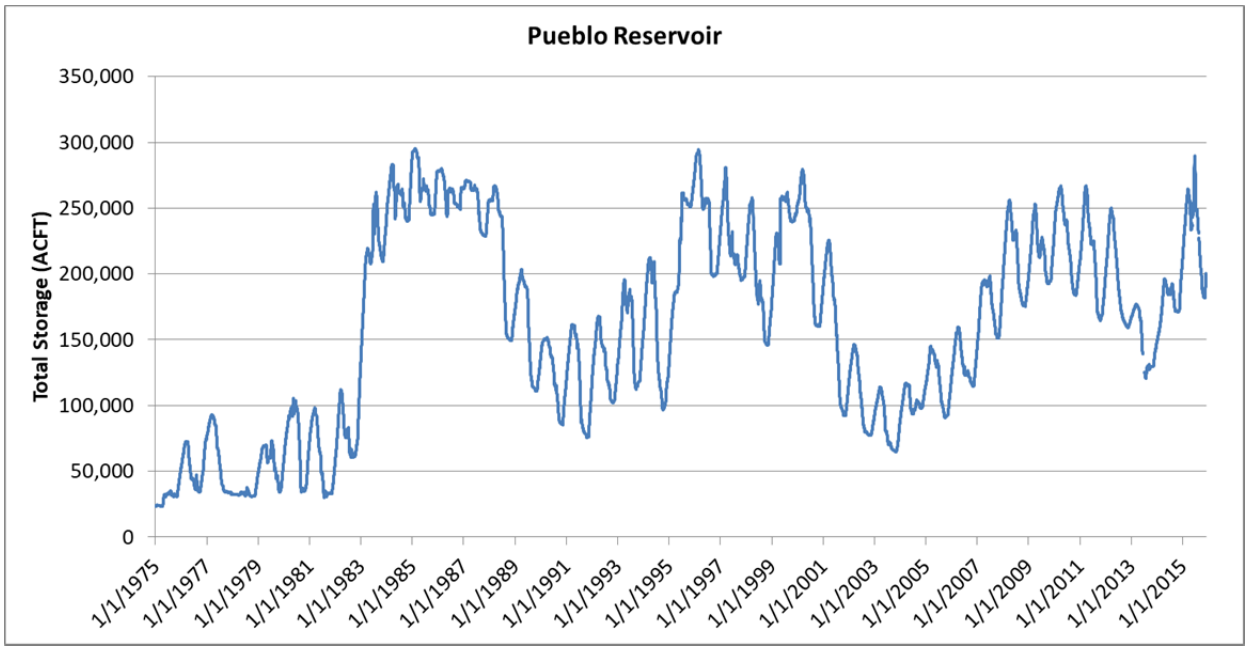

Figure 5: Pueblo Reservoir Daily Storage

Where to find more information:

- The Fountain Valley Conduit and Southern Delivery Systems are documented in the ArkDSS Water District 10 memorandum and the ArkDSS Colorado Springs Utilities Operations memorandum.
- Additional information on Pueblo Board of Water Works is documented in the ArkDSS Pueblo Board of Water Works Operations memorandum.
- Additional information on Pueblo West is documented in the ArkDSS Pueblo West Operations memorandum.

OPERATIONAL INFORMATION

This section discusses the daily, seasonal, and annual operations of the Fryingpan-Arkansas Project, including which entities are responsible for different decisions. Reservoir water rights and accounting procedures are also discussed.

The Fryingpan-Arkansas Project facilities store and deliver water to a significant amount of users within the basin. The primary purpose is to provide water to project participants, and the manner in which water is delivered gives Reclamation flexibility to support the Voluntary Flow Management Program. The large storage capacity in Pueblo Reservoir also allows for flexibility in storing Project and non-Project water, in addition to supporting the Winter Water Storage Program. Table 6 shows the typical order of operations and responsible parties throughout the year.

Table 6: Fryingpan-Arkansas Project Annual Operations and Responsible Entities

Date	Action	Responsible Entities
Year Round	Water users request storage releases through the Division Office, which then coordinates with Reclamation to operate releases from the three Project reservoirs.	Division Office and Reclamation
Year Round	Administration of native water direct and storage rights.	Division Office
Year Round	Reservoir storage accounting.	Reclamation
Year Round	Diversion accounting.	Division Office
March 15	Project Water application is mailed to project participants. Current Year's Winter Water Storage Period begins (November 15 through March 14)	SECWCD
April 15	Pueblo Reservoir Joint Use Pool must be evacuated, or Reclamation must seek an extension from Army Corps of Engineers.	Reclamation
End of April/ early May	West Slope collection system opens and imports through Boustead Tunnel begin.	Reclamation
May 1	Carryover Winter Water Storage evacuated.	Water users and Division Office
May 1	Forecast issued for available Project water for the year.	Reclamation
3rd week of May	Project water is allocated to project participants.	SECWCD
July 1	VFMP recreational flow targets begin.	SECWCD, CPW, Chaffee County, Arkansas River Outfitters Association, Trout Unlimited
August 15	VFMP recreational flow targets ends.	
November 15	WWSP begins.	Water users and Division Office
Winter	Reclamation draws down upper reservoirs to create ~60,000 acre-feet of available storage space.	Reclamation
Winter	VFMP fishery flow targets (around 250 cfs) begin.	SECWCD, CPW, Chaffee County, Arkansas River Outfitters Association, Trout Unlimited

Project Allocation

While Reclamation operates and maintains the project facilities, Southeastern Colorado Water Conservancy District (SECWCD) is responsible for repaying their reimbursable project costs and allocating Project water to Project participants. On a day-to-day basis, there is limited interaction between SECWCD and Reclamation. SECWCD and Reclamation primarily interact to discuss allocation at the beginning of the irrigation season. Project water can be used to extinction. Therefore, SECWCD makes an allocation based on project water availability and requests from project participants.

The general allocation process is as follows:

1. Reclamation issues the May 1st forecast, which estimates how much water will be imported from the West Slope.
2. SECWCD compiles the First Use and Second Use allocation requests from project participants.
3. SECWCD sets the allocation amount depending on the May 1st forecast, the current amount of unallocated Project water stored on the East Slope, and allocation requests. Only 80 percent of the allocation is made available to project participants at this time.
4. Once the May 1st forecast imports have been realized, SECWCD makes the remaining 20 percent of the allocation available to project participants.

This following discusses the details of each step.

Forecast Process

Forecasting for the Project is critical to Reclamation's operations. They use forecasts of runoff on the West Slope to predict their ability to import water and forecasts on the East Slope to predict Project operations. Reclamation generally provides forecasts on the first of each month, but these are for informational purposes. The key forecast is issued on May 1st for total imports from the West Slope. In recent years, the May 1st forecast has been within 10% of the actual run-off volume. For the West Slope runoff, Reclamation uses four SNOTEL sites located in the West Slope collection system basin. Reclamation is currently building a new forecast model and plans on increasing their snowpack data collection efforts beginning in 2018.

One of the key components to the forecast is predicting when the West Slope Collection system can be opened in the spring. The diversion points are located high in the watershed in remote places with difficult access. Reclamation balances getting the collection system operational as soon as possible, with the risk of heavy snow forcing them to reopen collection system access roads.

First Use Allocation Process

As discussed above, Project water can be used to extinction. SECWCD sets First Use Allocation based on Reclamation's forecast of imports on May 1st, the unallocated Project water stored in Project Reservoirs. Once the allocation is set, SECWCD determines the volume of water

available to each entity. SECWCD will only make 80 percent of the allocation available at the beginning of the irrigation season. SECWCD will then inform Reclamation of each entity's allocation when the entity has paid SECWCD and Reclamation will make the water available. Once the forecasted imports have been achieved, SECWCD will make the remaining 20 percent of the allocation available. In years when the Project yield is significantly more than forecasted SECWCD will offer a second allocation. In years when the Project yield is less than forecasted, SECWCD may not provide the remaining 20 percent of the allocation.

The process for deciding how much Project water each entity receives is done in several steps. Every year, SECWCD sends out a Project water application form via certified mail on March 15th. At that time, each entity puts in a Project water request. This is the maximum amount of water that SECWCD will assign to the entity, but there are many years when the total requests are greater than the allocation, so SECWCD has to limit the amount of Project water that is assigned. Agricultural users general request more water than is available.

There is a set percent of total Project water that gets allocated to municipal users and to agricultural users. Originally, it was 51 percent to municipal users and 49 percent to agricultural users. These percentages have shifted based on the principle of "Not Previously Allocated Non Irrigation Water" (NPANIW). Under NPANIW, when a ditch that received Project water is sold to a municipal user, the ditch's average Project allocation also is transferred to the municipal user. The Project water can never be used for agriculture again. Currently, 3.7 percent of the original agricultural distribution has been transferred to municipal users, so the ratios are now 54.7 percent municipal users and 45.3 percent agricultural users.

To determine the maximum percent of the allocation cap for each ditch, SECWCD is governed by the Reclamation Reform Act (RRA). The RRA lays out the procedure for determining eligible acres to receive project water. SECWCD starts in September to determine the eligible acres and distributes the allocation on a pro-rata basis. To determine eligible acres, land ownership and leasing on an individual farm level is needed. This starts with an accounting of the shareholders for all ditches in the SECWCD. Each person that has more than 240 acres throughout the Arkansas Valley must fill out a form describing their land ownership and leasing. The eligible acres are then aggregated by ditch company.

For municipal entities, the Project has a total storage cap of 159,000 acre-feet. This cap includes current year municipal allocation and municipal carry-over storage. SECWCD also is charged with distributing water throughout their district boundaries to municipal users. Therefore, they have established the following four sectors and related caps:

- East of Pueblo = 37,400 acre-feet
- West of Pueblo = 12,400 acre-feet
- Pueblo = 31,200 acre-feet
- Fountain Valley Authority = 78,000 acre-feet

Each Project municipal entity also has an individual cap. However, entities inside a sector can share the sector's allocation and storage. For example, if a municipal entity from East of Pueblo does not elect to take their maximum Project allocation, then that unused allocation is first made available to other East of Pueblo municipal entities. If there is still extra allocation, it is made available to all municipal users, and then it is made available to agriculture.

Second Use Allocation

As discussed above, the first use of Project water is for direct use. The return flows generated by first use of the water are also allocated. Return flows from Project Water use can be tracked and used to extinction. SECWCD generally leases the irrigation return flows to augmentation providers. Municipal users track their own return flows and use or lease them.

Currently, the Division Office tracks the agricultural return flows. For irrigation return flows, it is assumed that 40 percent of the river headgate diversions return to the river. SECWCD only takes credit for return flows from the ditches that are in the H-I model, because the H-I model has defined URF zones. About 97 percent of the agricultural Project water is delivered to ditches in the H-I model. After ArkDSS, SECWCD is planning on using the defined URFs to track return flows for the remaining ditches.

To allocate the return flows, SECWCD tracks the eligible acres under the three regional augmentation suppliers; Colorado Water Protection and Development Association (CWCPA), Lower Arkansas Water Management Association (LAWMA), and Arkansas Groundwater Users Association (AGUA). For example, if 43,000 acre-feet has been allocated as first use to agricultural users, this generates 17,200 acre-feet of return flows that SECWCD then allocates to the augmentation supplier based on their eligible acres.

During the irrigation season, the return flows are calculated by the Division office using the Groundwater Accounting Model (GWAM). SECWCD works with the Division office to initialize the model with First Use allocations to help the model best predict where return flows will be generated. At the end of the irrigation season, SECWCD reviews the actual Project water diversions with the Division office.

Where to find more information:

- For details on augmentation plans, augmentation demands and supply, the GWAM model, and return flow calculations, refer to the ArkDSS Lower Arkansas Water Conservancy District Operations memorandum.

The process of setting First Use and Second Use Allocation is completed by the 3rd week of May. The allocation is approved by the SECWCD Board at their June meeting.

Reclamation Operating Principals and Physical Restrictions

Reclamation is governed by the Project operating principals. A distilled version of the variables that Reclamation considers on a day-to-day basis to operate the Project is discussed below. In general, Reclamation has weekly meetings to discuss operations with stakeholders.

Reclamation operates Turquoise Reservoir such that the possibility of needing to release more than 400 cfs to Lake Fork Creek cfs is minimized. This operational constraint can be a major challenge if both of the Mt. Elbert Power Plant turbines are down. As mentioned above, there is no bypass for the power plant, so the Mt. Elbert Conduit cannot be used when both turbines are out. Reclamation works closely with WAPA to coordinate the turbine maintenance schedule. For Twin Lakes Reservoir, Reclamation operates to minimize the possibility of releases to Lake Creek exceeding 1,600 cfs.

Starting around November 15, Reclamation begins to draw down the Project water stored in Twin Lakes and Turquoise Reservoirs in order to have 60,000 acre-feet of storage capacity available between the two reservoirs by May 1. Generally, Reclamation prefers to have the majority of the space available in Turquoise Reservoir because of the outflow capacity limitations. Reclamation attempts to make consistent releases from November 15 to May 1; but often make adjustments during the snowfall season based on the import forecast. The goal of this operation is to have enough Project water moved to Pueblo Reservoir so that Reclamation does not have to move stored water or transbasin water from the upper reservoirs during the peak spring runoff. Under high flow conditions, a High Water Advisement can be issued and the rafting companies cannot run the river.

Reclamation is sensitive to the conditions of the natural fishery in the Arkansas River. They try to keep their releases from the upper reservoirs to a minimum during the Caddisfly hatch, which generally occurs around the first two weeks in May.

During the summer, Reclamation tries to keep Turquoise Reservoir at a level that can support the boat ramp and other flat water recreational activities. The boat ramp becomes inaccessible when storage drops below 65,233 acre-feet.

During low flow conditions, Reclamation balances releases from Pueblo Reservoir to the fishery and to the river channel. The fishery and the river channel both depend on releases from Pueblo Reservoir.

Twin Lakes Exchange

The Twin Lakes Exchange is an agreement between TLRCC and SECWCD to preserve stream flows and fishery values in the Roaring Fork River above Aspen Colorado's West Slope. Reclamation is responsible for accounting for this exchange. As discussed in the "Physical Structures" section, Twin Lakes Reservoir was originally built by the TLRCC to store water that was diverted by the TLRCC from the West Slope. The exchange allows TLRCC to forego diverting 3,000 acre-feet/year of senior water rights from the Roaring Fork drainage in

exchange for receiving an equivalent amount of water that the Project diverts and conveys through Project facilities from the south forks of Hunter Creek to Twin Lakes Reservoir.

Winter Water Storage Program

The Winter Water Storage Program (WWSP) allows irrigators to store water in reservoirs during the winter that, historically, they would have diverted from the river in order to increase the soil moisture of their fields. During the irrigation season, the irrigators then release their winter water from storage to supplement direct flow right diversions. This program was one of the purposes of the Project, and requires Reclamation cooperation since Pueblo Reservoir is one of the WWSP reservoirs. WWSP was decreed in 1987 in case 84CW179 and has been further refined over time through agreements with the participants.

In general, WWSP operates by participants foregoing diversion of their direct flow rights from November 15 through March 1. An equivalent volume of foregone diversions is placed into storage in the following reservoirs:

- Pueblo Reservoir
- Lake Meredith
- Lake Henry
- Holbrook Reservoir and Dye Reservoir
- Adobe Creek Reservoir and Horse Creek Reservoir
- Great Plains Reservoirs
- John Martin Reservoir

Winter water is stored under a March 1, 1910 water right, which is fairly junior in the basin. This allows non-participants in the WWSP to divert under their direct rights. The WWSP is subject to the Kansas-Colorado compact, which has implications to accounting at John Martin Reservoir.

Where to find more information:

- John Martin Reservoir operations are documented in the ArkDSS Water District 67 memorandum.

The total yield from the WWSP is divided between participants using the formula shown in Table 7, which was decreed in 84CW179 and amended to include Otero Canal:

Table 7: Distribution of WWSP Yield to Participants

Participant	First 100,000 ac-ft (%)	Next 3,106 ac-ft (ac-ft)	> than 103,106 ac-ft (%)
Bessemer Canal	6.297		5.2475
Highline Canal	8.457		7.0475
Oxford Canal	2.040		1.7000
Catlin	9.300		7.7500
Las Animas Consolidated Canal	2.799		2.3325
Otero Canal	0.699		0.5825
Riverside - West Pueblo	0.408		0.3400
Colorado, Henry and Lake Meredith	11.137		12.8025
Holbrook Canal	8.876	356	10.5375
Fort Lyon Canal	38.157		38.1600
Amity Canal	11.830	2,750	13.5000

Pueblo Reservoir specifically begins storing winter water on November 15. Releases from Pueblo Reservoir during the winter water storage period are typically less than 100 cfs as called for by Colorado DWR. Winter water can also be carried over in Pueblo Reservoir for one year. On May 1 of the following year, participants with Carryover Winter Water lose dominion and control, and the water is released from Pueblo Reservoir and treated as native Arkansas River water.

One of the unique features of Pueblo Reservoir is the Joint Use Pool. This is a 66,000 acre-foot storage space that can only be used for storage from November 15 to April 15. However, winter water carryover storage has to be evacuated by May 1. Unused Project agricultural water reverts to SECWCD on May 1. The two weeks between April 15 and May 1 can be difficult for water users to manage. On rare occasions, Reclamation has been able to get a two week extension on the Joint Use Pool from the U.S. Army Corps of Engineers, but this extension is not guaranteed and Reclamation and other water users cannot depend on it in the future.

Voluntary Flow Management Program

Another special operation that Fryingpan-Arkansas Project helps support is the Voluntary Flow Management Program (VFMP). The goals of the VFMP are to keep water in the Arkansas River year-round to protect the fishery and to enhance the recreational boating experience in the summer. These goals are accomplished by releasing water from the upper reservoirs and storing the water in Pueblo Reservoir until it is needed by water users. SECWCD is a participant and other entities can also volunteer to have their water be part of the program. To support the VFMP, Reclamation, with approval by SECWCD, sets aside 10,000 acre-feet of stored Project water to release from July 1 through August 15 and tries to balance their operations based on the imports and releases of other entities. In dry years, it may not be possible for Reclamation

to set aside 10,000 acre-feet. In some years, more than 10,000 acre-feet has been set aside for the VFMP with SECWCD's approval.

Reclamation works closely with the VFMP participants to decide when to release the 10,000 acre-feet and how quickly to release the water. The VFMP participants will send in their water release request to Reclamation on Thursday for releases for the next week. Any additional evaporation caused by storing the water in Pueblo instead of the upper reservoirs is paid for by the Colorado Parks and Wildlife and the rafting association.

During the winter, the VFMP goal is for river flow to be at a consistent rate of about 250 cfs. During this time, Reclamation is moving water from the upper reservoirs to Pueblo in order to make room for storing imports during the spring run-off. Reclamation works with the VFMP to hold the releases as constant as possible.

Pueblo Reservoir Flood Control Operations

Pueblo Reservoir was constructed with flood control as one of the authorized purposes. The active conservation pool is the maximum amount of storage that can be used from April 15th to November 14th for normal operations. The top of the conservation pool is 4880.38 feet. From November 15th to April 14th, the Joint Use pool can be used for conservation storage. The top of the Joint Use pool is at 4893.8 feet. Water that was stored in the Joint Use pool for water users must be evacuated by April 15th. The remainder of the reservoir storage is reserved for flood control operations.

Flood control operations for Pueblo Reservoir start when the Avondale gage reaches 6,000 cfs. Depending on pool elevation, the U.S. Army Corps of Engineers or DWR will call for releases from Pueblo Reservoir to hold the flow of the river at 6,000 cfs at the Avondale if possible. Releases from Pueblo Reservoir are reduced to accommodate the flow from tributaries between Pueblo Reservoir and the Avondale gage; however it is sometimes difficult to hold that level because flows are hard to predict. When Pueblo Reservoir storage levels reach the Flood Control Pool, the Army Corps of Engineers coordinates with Reclamation on reservoir operations. When necessary, the Army Corps of Engineers has made the decision to release water from Pueblo Reservoir at a rate higher than 6,000 cfs at the Avondale gage target to prevent an uncontrolled spill.

Water Rights

A significant portion of Project supply is diverted from the West Slope; but the Project also has native Arkansas River water rights. The Fryingpan-Arkansas Project water rights are held by SECWCD. Project water rights are decreed for all uses, including storage.. The majority of the water rights were originally decreed in water court case C.A. 5141 (Chaffee County). Pueblo Reservoir water originally decreed in water court case B-42135 (Pueblo County). One complication to the Project water rights it that Case C.A. 5141 provides for postponement of the water right administration date. The decree states that "As to water rights heretofore adjudicated in this District, priorities of irrigation granted by this decree shall be enforceable

only as of July 14, 1942, and priorities for purposes other than irrigation granted by this decree shall be enforceable only as of December 15, 1942." Case No. 80CW06 was a major updated to the original decrees. This case aligned conditional and absolute water rights with the structures that had been constructed, or were still planned. The case also applied the postponement of water right priority to the Mt. Elbert Forebay. The result of the postponement was to make the native Arkansas water rights junior to the Kansas Compact. Therefore, these rights come into priority when John Martin Reservoir is spilling and water is flowing past Garden City, Kansas.

Table 8 shows the Project absolute water rights in the Arkansas River basin.

Table 8: Fryingpan-Arkansas Project Absolute Water Rights – Arkansas River Basin

Water Right Location (WDID)	Source of Water	Absolute Decreed Amount
Turquoise Reservoir (1103500)	Lake Fork of Arkansas River and drainage tributary thereto above the dam which creates the reservoir, and water diverted under the District's west slope decrees	129,432 acre-feet
Twin Lakes Reservoir (1103503)	Lake Creek, Arkansas River and drainage tributary thereto through the Mt. Elbert Conduit and water diverted under the District's west slope decrees	139,750 acre-feet
Mt. Elbert Forebay (1103983)	Waters impounded by Twin Lakes Reservoir Enlargement, the Arkansas River and drainage tributary thereto through the Mt. Elbert Conduit, from Lake Creek, and water diverted under the District's west slope decrees	11,148 acre-feet & refill
Mt. Elbert Conduit (1101123)	Lake Fork of Arkansas River and drainage tributary thereto, and water diverted under the District's west slope decrees	370 cfs
Halfmoon Diversion Structure (1102057)	Halfmoon Creek	150 cfs
Pueblo Reservoir (1403526)	Arkansas River and drainage tributary thereto above the dam which creates the reservoir, and water diverted under the District's west slope decrees	357,678 acre-feet & refill

Accounting

This section discusses how the accounting responsibilities are divided between Reclamation and the Division Office. Detail on the specific accounting for Pueblo Reservoir is included in a sub-section below.

General Overview

Reclamation and the Division Office work together on a daily basis to account for the Fryingpan-Arkansas Project. In general, Reclamation has electronic copies of daily accounting forms dating back to 1997. Paper copies are available for earlier accounting records.

Reclamation tracks the reservoir account volumes. They send their accounting to the Division Office and the water users two to four times a week. The reports include each user account's inflow, outflow, evaporation, and total content. The Division Office reviews Reclamation's accounting. If either Reclamation or the Division Office finds discrepancies, they discuss and resolve the issues near real-time. Reclamation uses an Oracle Database to track the account contents.

The water users place their water orders from Turquoise and Twin Lakes directly with Reclamation and DWR. Water users place their water orders from their specific Pueblo Reservoir accounts with the River Coordinator at the Division Office. The River Coordinator applies the transit loss from the reservoir to the point of diversion and determines the total amount of release needed to supply the water user with their order at their headgate. The River Coordinator communicates the release request from the water user to Reclamation and will work directly with Reclamation's reservoir operators to make gate changes. Reclamation updates the account content based on the release request, inflow, and evaporation. Reclamation applies the daily evaporation based on the reservoir surface area. Project water is charged with evaporation before it is allocated to users. Other account types are charged with evaporation.

The Division Office records the amount of reservoir water diverted at the headgate as part of the diversion coding in HydroBase. They are currently working on developing the reservoir release classes for HydroBase, but they have not been fully implemented as of the date of this memorandum.

Each reservoir has an administration account, which is used by the Division Office and Reclamation to reconcile minor daily discrepancies so the reservoir storage balances. The administration account is needed because of the uncertainty in measuring inflow, outflow and evaporation. Generally, a positive number in the administration account represents native water that has been held in the reservoir out-of-priority. A negative number means that native water inflow was over-estimated and storage was released without a designated user. The Division Office and Reclamation try to keep the administration accounts at zero.

During the winter, the gage upstream of Twin Lakes freezes over. Reclamation uses reservoir storage levels and release data to determine the native inflow. Native inflow during this period is stored in the TLRCC account and accounting is performed on a weekly basis.

At the end of year, Reclamation will publish the Annual Operating Plan (AOP) for the Fryingpan-Arkansas Project. This document provides a summary of project operations and accounting.

Pueblo Reservoir Accounting

Pueblo Reservoir accounting requires the most diligence. Reclamation and the Division Office have accounts set up for all users of Project facilities. Each user may have water in one or more of the following general account categories:

- Current Year Project water allocation account
- Carryover Storage of Project water account
- Long-term excess capacity account
- Short-term excess capacity account
- WWSP account

Current Year Project water allocation account is active for all project participants that have been granted and paid for an allocation. It is used to deliver Project water to users downstream of Pueblo Reservoir. There is no restriction on the rate a user can request their Project water.

Carryover Storage of Project water is limited to municipal Project participants with defined municipal storage space in Pueblo Reservoir. Storage in Pueblo Reservoir has become more critical to municipal users as a protection against drought. May 1 is the start of the Project allocation year and any water remaining in the Current Year Project allocation for entities with defined municipal storage space in Pueblo Reservoir becomes Carryover Storage. There is no time limit to Carryover Storage of Project water, but there are volumetric limits. Municipal entities have a total cap of 159,000 acre-feet on Current Year Project allocation plus Carryover Storage of Project water. Each municipal entity is tracked in their individual Project accounts. As discussed in the Allocation section, each municipal entity has an individual capacity limit and is assigned to a sector, which has an overall sector capacity limit. Municipal entities in a sector can share Project space, so that if one entity goes over their individual capacity limit, they can borrow space from an entity that is not using their full capacity limit.

In addition to Project water, Pueblo Reservoir is also used to store non-project water. This is accomplished through Reclamation and SECWCD's Excess Capacity Contracting Program, informally referred to as "If and When" accounts. Long-term excess capacity accounts are Reclamation's preferred method of storing non-project water for entities. Long-term contracts offer the entity additional certainty in the amount of water they can store in Pueblo Reservoir. Long-term contracts are protected against spills from Pueblo Reservoir more than short-term contract. However, they require the entity to go through a NEPA process that will examine each water right that is going to be included in the contract, which can be costly and time-consuming. The large users in the basin generally hold long-term excess capacity contracts with

Reclamation. One example of a long-term excess capacity account is the SECWCD's Master Contract. SECWCD went through the NEPA process and negotiated with Reclamation to secure the contract. SECWCD administers the contract and has divided it up into sub-contracts with about 28 entities in the basin. Each entity has been assigned a maximum amount of storage they can purchase under the Master Contract. Other entities, including Pueblo Water, Aurora, and the Southern Delivery System water users also hold long-term excess capacity contracts.

Short-term or annual excess capacity contacts are generally easier to execute than a long-term contract, but only offer storage on a year-to-year basis. Reclamation handles the applications for annual contracts. Entities have to fill out an application form every year. Part of the application is a NEPA questionnaire to see if the application will fit under Reclamation's "umbrella" NEPA permit. Holders of short-term excess capacity contracts will get two bills, one from Reclamation and one from SECWCD. For perspective, there were nine short-term excess-capacity contracts requested in 2018.

WWSP account tracks the amount of water that has been stored in Pueblo Reservoir during the current winter and the carryover from the previous winter. WWSP participants have separate accounts for their individual WWSP water.

Pueblo Reservoir Spill Procedure

Article 13(a) of the SECWCD/United States Contract defined criteria for evacuating water from Pueblo Reservoir. Whenever water is evacuated from Pueblo, Twin Lakes and Turquoise Reservoirs to meet the necessities of Project flood control, generation purposes, storage of trans-mountain Project water, or native Project water, and operational requirements; except as provided in Subarticle 13.(b) below, the water evacuated shall be charged in the following order:

1. Against water stored under contracts for if-and-when available storage space for entities which will use the water outside the District boundaries.
2. Against water stored under contract for if-and-when available storage space for entities which will use the water within the District boundaries.
3. Against any winter storage water in excess of 70,000 acre-feet.
4. Against water stored under contracts with municipal entities within the boundaries of the District, which water is neither Project water nor return flow from Project water and which is limited to 163,100 acre-feet, less any project water purchased and stored by municipal users. This evacuation will be charged pro rata against all water stored under such like contracts at the time of evacuation.
5. Against winter storage water not in excess of 70,000 acre-feet.
6. Against Project water accumulated from the Arkansas River and its tributaries.

Exchanges

Reclamation provides the opportunity for contract exchanges. Reclamation charges the water user a fee. For a Project Water Exchange, a contract holder can request that their non-Project water stored in Pueblo Reservoir be exchanged for Project water in Turquoise or Twin Lakes. Reclamation will re-color the contract holder's water in Pueblo to Project water and re-color Project water in one of the upper reservoirs as the contract holder's water. This occurs without changing the storage in either reservoir.

DWR approves requests for Administrative Exchanges. Reclamation operationally will store water in either Twin Lakes or Turquoise Reservoir and release from Pueblo Reservoir to satisfy the downstream calling right. The Division Office monitors Administrative Exchanges to ensure there is no injury to intervening structures.

One example of an exchange is Aurora can exchange their excess capacity water from Pueblo Reservoir up to Twin Lakes or Turquoise Reservoir in order to bring it through the Otero Pipeline. There needs to be exchange potential in the Arkansas River upstream of Pueblo Reservoir for this exchange to occur.

OTHER MODELING EFFORTS

The following provides a brief overview of other models of the Arkansas River Basin, both those that currently exist and two that are under development. It is important to note that the other models were or are being developed to meet a specific purpose; whereas the ArkDSS water resources planning model is intended to be used to investigate any "what-if" opportunities and operations contemplated in the future. To facilitate future investigations, the ArkDSS baseline model will represent current demands, water rights, and current operations as if they had been in place over a variable hydrologic period (1950 to current). What-if options can be implemented in the model and compared to the baseline simulation.

Reclamation RiverWare Models

A RiverWare model of the Arkansas River Basin is currently under development by Precision Engineering through a contract with Reclamation. The model's primary purpose is to provide a tool assessing impacts to rivers and reservoirs from changed operations. Unlike the ArkDSS planning model, representing Colorado Water Rights and associated administration is not the primary purpose.

As separate RiverWare model is also being developed by Reclamation contractors to represent the Purgatory River. It is unclear whether the two models will ultimately be linked or if they will be used separately for forecasting and optimizing operations. The RiverWare models were not available for the State of Colorado or Wilson Water Group review at the time of this memorandum. Based on discussions with Reclamation and Precision Engineering, there will likely be opportunity for coordination and joint model review during the ArkDSS development.

Reclamation is in the process of adding snow courses on the West Slope. They are creating a snowmelt forecasting model to use both existing Snotel sites and the new information to improve confidence in spring run-off forecast.

Hydrologic-Institutional Model

One important model for administration in the Arkansas River Basin is the Hydrologic-Institutional Model, referred to as the H-I Model. This model was developed during *Kansas v Colorado* litigation and is used to calculate the impact of groundwater pumping and replacement on streamflow at the Kansas-Colorado Stateline. The H-I model was developed in FORTRAN and specifically represents the hydrologic and institutional conditions for the Arkansas River surface water and groundwater from Pueblo Reservoir to the Stateline. This includes simulating surface water diversions, groundwater pumping, John Martin Reservoir operations, off-channel irrigation system reservoir, and groundwater replacement supplies. The H-I model is used to ensure that Colorado is in compliance with the Arkansas River Compact. It is not intended to be uses as a planning tool, nor does it represent the full Arkansas River Basin.

Southern Delivery System EIS Model

Recently, a model was developed to support the Southern Delivery System (SDS) pipeline Environmental Impact Statement (EIS). The SDS is a pipeline from Pueblo Dam to Colorado Springs, Fountain, Security, and Pueblo West. It was built with non-federal funding, but the National Environmental Policy Act (NEPA) process was required because of the nexus with a federal project. The Hydrologic Model was developed using MODSIM software, with custom operations written in PERL script. The Hydrologic Model included representation of the following stream segments and reservoirs:

- Lake Fork from Turquoise Reservoir to the Arkansas River
- Lake Creek from Twin Lakes Reservoir to the Arkansas River
- Upper Arkansas River - Lake Fork to Pueblo Reservoir
- Middle Arkansas River - Pueblo Reservoir to Fountain Creek
- Lower Arkansas River - Fountain Creek to Las Animas
- Fountain Creek Basin - Fountain Creek, Monument Creek, Williams Creek, and Jimmy Camp Creek
- Turquoise Reservoir and Twin Lakes
- Clear Creek Reservoir
- Pueblo Reservoir
- Lake Henry and Lake Meredith

Unlike the ArkDSS planning model, the purpose was to examine the impacts of the various alternatives considered as part of the EIS process to determine if they meet the project purpose and needs and to understand their impact on Reclamation facilities and operations. The model does not include the full Arkansas River basin demands, water rights, and operations.

Where to find more information:

- Amended Appendix C.1: Hydrologic - Institutional Model, Model Documentation, as amended August 2015
- Southern Delivery System Environmental Impact Statement: Hydrologic Model Documentation Report (November 2007) Prepared by MHW for the United States Bureau of Reclamation, Eastern Colorado Area Office.

MODELING CONSIDERATIONS

The following descriptions provide a framework for how Reclamation facilities are envisioned to be operated within the ArkDSS surface water allocation model. Refinements will likely be made during model development and calibration.

Modeling Considerations Based on Hydrology

- Transmountain water will be imported to the surface water model based on historical records.
- Movement of water between reservoirs will follow Reclamation standard operations as described above, including drawdown for spring runoff and imports, releases to Pueblo Reservoir to stage deliveries, and release through the VFMP reach.
- The initial ArkDSS surface water allocation model will be based on historical hydrology; therefore the overall Project allocation will be based on historical allocations.
- Percent of Project allocation to individual agricultural users will not vary year to year, but will represent recent typical percent allocations and/or typical percent allocations by decade.
- Percent of Project allocation to individual municipal users will be based on their sector's recent typical percent allocations, limited by available account space in Pueblo Reservoir.

Modeling Considerations Based on Standard Operations

- Individual accounts in Reclamation reservoirs will be included based on current user pools as reflected in Reclamation and Division 2 accounting databases described above.
- The WWSP operations in Pueblo Reservoir and other WWSP participating reservoirs, specifically WWSP filling period, user allocations, and carry-over policies, will be represented based on WWSP standard operations.
- Pueblo Reservoir flood control operations will follow Reclamation standard procedures.
- Pueblo Reservoir spill operations will follow Reclamation's draft spill sequence as described above.
- The Mt. Elbert Power Facilities will not specifically be represented in the daily surface water allocation model primarily because pump-back operations occur on a sub-daily basis. Hydropower operations will be considered a secondary benefit as the model delivers water to Twin Lakes via the Mt. Elbert Conduit.

Modeling Considerations Based on End Users

- Reclamation facilities do not have a single demand; demands for Project water and other water stored in the reservoirs will be represented at the final point of use.
- Storage in long-term and short-term excess capacity accounts will be based on individual user operations as documented in other Task 2 operating memoranda.
- Storage releases to demands and exchanges from Pueblo Reservoir to upstream Reclamation facilities will be driven by individual user demands as documented in other Task 2 operating memoranda.

Where to find more information:

- The final model representation of the FryArk facilities and associated operations will be documented in the Arkansas River Surface Water Model User's Manual.