

Appendix 3-B. PWRE Modeling Technical Memorandum

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Subject: Nebo Regional Water Project RiverWare Modeling, In Support of the NEBO RWP EA

For: Central Utah Water Conservancy District

By: Precision Water Resources Engineering

Please use the following document as a reference to understand the simulation of a Baseline scenario and Alternative scenario in support of the Nebo Regional Water Project Environmental Assessment.

The intended audience of this document is the Central Utah Water Conservancy District and their contractors and should not be considered in any way an Environmental Assessment. Material from this document may be used in support of the official Environmental Assessment.

For any questions, clarifications, or edits, please contact Tony Powell at tony@precisionwre.com.

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4 INTRODUCTION

Central Utah Water Conservancy District (District) asked Precision Water Resources Engineering (Precision) to evaluate a potential change to the operations along the Utah Lake System (ULS) in concert with infrastructure and users adjacent to and south of the Spanish Fork River. The potential operations change, also known as the Nebo Regional Water Project (NEBO RWP), would alter the way water is delivered to customers by taking advantage of new infrastructure and a new water treatment plant to supply a changed in water use type into the future. The Precision team simulated a baseline and an alternative scenario using a RiverWare© simulation model and compared the results in support of an Environmental Assessment (EA) for the NEBO RWP. This document covers model inputs, assumptions, rule logic and comparison of the two scenarios.

Inputs to the model include three major items. The first is hydrology. The historical hydrology from 1985 through 2024 (a forty-year period) was used as the hydrology input for this model simulation.

Demand inputs, the second major item, were derived from two different sources. The first is demands that are to be simulated as contracts off of the ULS. These data were

provided by the District as annual demands with different monthly distribution patterns applied based on the scenario and the customer. The second was data that was pulled out of Spanish Fork River Commissioner reports that represents the demands of users along the Spanish Fork River.

The third item is model rule logic. This is logic that simulates the implementation of the desired operation policy. This logic allows for multiple scenarios to be developed and is the main driver of differences between the operations in the scenarios.

Each of the input items will be discussed further in **Section 5**. **Section 6** will discuss model assumptions and cover some of the output that ensures the model differences between scenarios are understood. Results and the comparison between scenarios are covered in **Section 7**.

The modeling extents span from Strawberry Reservoir to Utah Lake. The model includes the Diversion from Strawberry Reservoir into the Strawberry Tunnel, the Syar Tunnel, the turnouts to the Diamond Fork System, and the ULS. The Natural system is simulated from the headwaters of Sixth Water Creek, Diamond Fork Creek, and the Spanish Fork River to the Spanish River at Castilla. Diversions from the natural system occur at City Dam to the Power Canal and to users along and from the Power Canal and the Spanish Fork River. The ULS is simulated from the Spanish Fork Flow Control to the Mapleton-Springville Pipeline (MSP), the Spanish Fork Santaquin Pipeline (SFSP) and along the Provo River Canal Pipeline (PRC). Natural Flow and flow from the ULS are simulated along Hobbie Creek. Operational flow and flow from ULS are simulated into the Provo River, with the model ending in Utah Lake.

The model simulates the physical system and has an overlaid accounting system that accounts for the types of water within the model extent. Examples of the types of water include:

- ULS – Central Utah Project (CUP) and Strawberry Valley Project (SVP) water
- Sixth Water, Diamond Fork, and Spanish Fork River – Natural, CUP, and SVP water
- Hobbie Creek – Natural, CUP, and SVP water
- Provo River – Natural, CUP

The two types of project water defined are the CUP and SVP accounts; where CUP is water that is operated by the District, and SVP water is water which is released from Strawberry Reservoir to Strawberry Water User Association (SWUA) members.

Utah Lake has storage accounts that collect water as water flows through the physical system to Utah Lake and through different accounts. The Utah Lake accounts include:

- Inactive – the 160,000 AF of storage in Utah Lake that is considered inactive.
- NonCUWCDPrimary – is the primary storage in Utah Lake that is not part of CUWCD water rights in Utah Lake. Up to 100,238 AF.
- E3419Primary – is primary storage operated by the District in Utah Lake for use in the Utah Lake Jordanelle Exchange (**Section 6.2**). Up to 7,900 AF.
- E3101Primary – is District’s primary storage in Utah Lake used for the Utah Lake Jordanelle Exchange. Up to 16,862.
- E3100Secondary – is the District’s secondary storage in Utah Lake. This storage is used in the Utah Lake Jordanelle Exchange.
- System storage is all other secondary storage in Utah Lake. The storages listed here sum to be the total System storage in Utah Lake and is what is used to determine if Utah Lake crosses the Upper Conversion Line. The Lower Conversion Line is crossed when the accounts owned or operated by the District are converted to the System account and the remaining system accounts cross the Lower Conversion Line.
- CUWCDImport is the District’s Strawberry Reservoir water that has flowed to Utah Lake. This water is accounted for in Utah Lake from water that was released to meet minimum flows in the Sixth Water and Diamond Fork basins, June Sucker flows in the Hobble Creek and Provo basins, and from return flow of CUP water delivered in Utah County. This account supplements the Natural accounts in the Utah Lake Jordanelle Exchange.
- PRWUImport is import water owned by the Provo River Water User Association. This water is not used in this effort.
- SHLCCImport is other imported water owned by Strawberry Highline Canal Company that is not used in this effort.
- SVP StrawbHigh Returns is an account that is used in this model to understand the amount of Strawberry Highline SVP returns that make it to Utah Lake.

Strawberry Reservoir also has accounting. The two storage accounts in Strawberry Reservoir include:

- SVP – Strawberry Valley Project water. This water is accounted for with an initial storage volume. Water is debited from this account when SVP demands call for this water to meet demands. Each year 61,000 AF of water is transferred into the

SVP account at the beginning of the water year and up to 50,000 AF is allowed to be carried over if it is not used.

- CUP – is the District’s water in Strawberry Reservoir. This is the storage on top of the SVP water.

The water is tracked in Strawberry Reservoir to account for storage and allow the model to know how to distribute shortage to customers of each type. SVP water users experience shortage when the sum of demand is greater than the available storage. CUP water users experience shortage when the physical level of Strawberry Reservoir approaches 7,525 feet or the top of the Syar Tunnel Inlet elevation.

Figure 1 shows the model space as it is represented in RiverWare. Note that blue colored lines represent the natural systems of the Spanish Fork River, Hobbie Creek, and Provo Rivers. Orange lines represent the ULS. The following objects were used in the RiverWare model.



Reach Object



Gage Object



Diversion Object



Water User Object



Reservoir Object

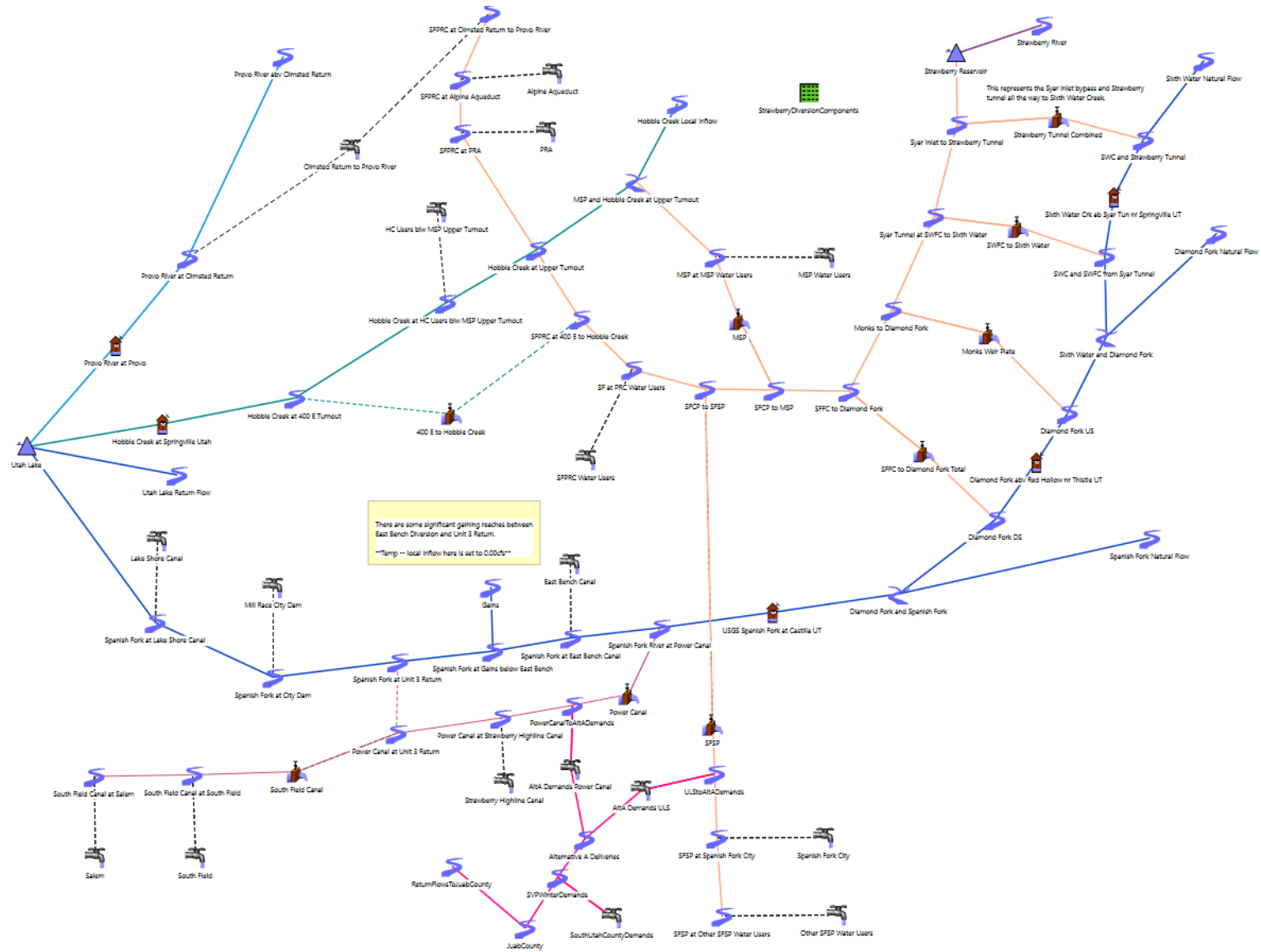


Figure 1 Nebo Regional Water Project EA RiverWare workspace

NEBO EA RiverWare Analysis – Modeling Assumptions and Results

5 MODEL INPUTS

Model inputs drive the model simulation. These inputs are hydrology, demand of water users, and rule logic. This section discusses the input used for modeling simulations and result comparison.

5.1 HYDROLOGY – 1985 TO 2024

The hydrology data used to drive the input of physical water to the model system is daily timestep inflow for the following locations:

- Natural Inflow to Sixth Water Creek that enters the system above the inflow from the Strawberry Tunnel and the USGS gage on Sixth Water Creek near Springville, UT ([USGS 10149000](#))
- Natural Inflow to Diamond Fork Creek that enters the system above the inflow from Monks Weir Plate and above the USGS gage on the Diamond Fork Creek above Red Hollow near Thistle, UT ([USGS 10149400](#))
- Natural Inflow to the Spanish Fork River that enters the system above the confluence with the Diamond Fork Creek and the USGS gage on the Spanish Fork River at Castilla. ([USGS 10153100](#))
- Operational inflow on the Provo River that is derived from the USGS gage on the Provo River near Provo and by removing any observed flow to the Provo River from the ULS. ([USGS 10163000](#))

Figure 2 shows the time series of each of the natural inflow nodes for the simulation water year in water year inflow volumes in thousands of acre-feet (KAF). Also included in **Figure 2** are the water year types that are used to determine variability in water user demand that will be discussed in **Section 5.2**. Note that there are 12 years of dry (designation of 0), 12 years of wet (designation of 2), and 16 years of normal (designation of 1) in the 40 years of simulation.

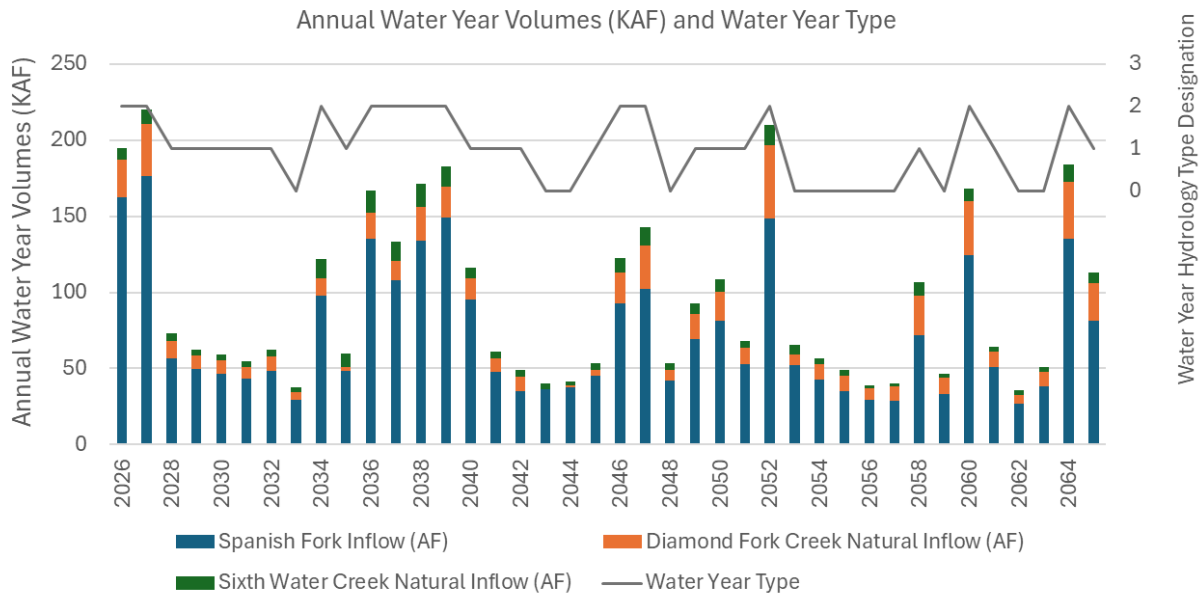


Figure 2 Hydrology Sequencing for the Spanish Fork River, Diamond Fork Creek, and Sixth Water Creek (KAF) with Water Year Hydrology Designation

5.2 DEMAND INPUTS

Demands are input through demand requests of different water users. An individual water user has a request for water that is satisfied with the water that is available to that water user. In this effort, users are broken into two main groups. The first is SVP water users that can receive Natural flow and SVP water in the river to satisfy their demand. Those users in the model are:

- East Bench Canal
- Mill Race City Dam
- Lake Shor Canal
- South Field
- Salem
- Strawberry Highline Canal

The demand requests for these users were developed using historical records from Spanish Fork River Commissioner data. Historical data from 2008 to 2024 was used to determine the total Natural and SVP demand for each water user. Then, a method of determining year types using the historical natural flow record was used to calculate

demands for years that are outside the historical record. This allows the model to determine demand requests derived from historical data by similar year type.

The second demand group are water users not on the ULS. These could be both SVP and CUP water users. The SVP water users include those uses from the MSP and those that receive water from the SFSP. The data for the ULS SVP water users was derived from Table 3-7 of the 2004 Supplement to the 1988 Definite Plan Report (DPR). The ULS CUP water uses are also based on that table, but some volumes are different. The water users who receive water from the ULS include:

- Mapleton-Springville Water Users from the MSP (SVP and CUP)
- Mapleton Springville Water Users who receive water from the PRC (CUP)
- Spanish Fork City who receives water from the SFSP (SVP and CUP)
- Other SFSP Water users who receive water from the SFSP (CUP)
- Salt Lake County water demands delivered through the Provo River Aqueduct (PRA) and the Alpine Aqueduct (CUP)
- June Sucker Delivery at the following Locations
 - MSP Upper Turnout to Hobble Creek (CUP)
 - 400 E to Hobble Creek Turnout from the PRC (CUP)
 - Olmsted Return Flow to the Provo River (CUP)

Table 1 shows the annual demands that will be input to the model. Discussion on monthly patterns and the category of water user is in subsequent sections.

Baseline demands use an agricultural monthly demand pattern. This requires water to meet a 20 cubic foot per second (cfs) minimum flow through the Strawberry Tunnel to be released from Strawberry Reservoir in winter months. In the alternative scenario, as M&I demand converts to indoor use from agriculture, some of that demand is required in winter months. When demands in winter months satisfy the 20 cfs minimum flow from Strawberry Reservoir, the water used in the Baseline simulation is not released. This will ultimately be a savings in the Spanish Fork River Column for the Utah Lake Delivery of Bonneville Unit Water (CUP) in the Alternative scenario.

Similarly, changing the demand pattern from agriculture to M&I Indoor with the SVP water decreases the Total Spanish Fork River to Irrigated Lands volume for the SVP water. Approximately 10,600 AF of conversion to South Utah County Cities occurs out of that agricultural water in the Baseline Scenario.

Table 1 Baseline Demands from the ULS all units are in Acre-Feet (AF), some values are modeled output from the Baseline scenario

	Spanish Fork - Santaquin Pipeline	Mapleton-Springville Lateral Pipeline	Spanish Fork - Provo Reservoir Canal Pipeline	Spanish Fork River	Total
	SFSP	MSP	SFPRC	SFR	
Bonneville Unit Water					
SLC M&I	0	0	22,000	0	22,000
S. Utah County M&I	15,982	4,763	2,346	0	23,090
Utah Lake Delivery	0	6,500 ¹	15,500 ¹	11,555	33,155
Subtotal - B.U.	15,982	11,263	39,846	11,555	78,646
SVP Irrigation Water					
S. Utah County Cities	7,320	2,880	0	0	10,200
Irrigated Lands	0	7,380	0	40,180 ³	47,561
Subtotal - SVP	7,320	10,260	0	40,180	57,761
Total	23,302	21,523	39,846	51,735	136,407

¹ These are allocation amounts for June Sucker Recovery Implementation Program (JSRIP). In any given year, there could be more or less than the 22,000 AF released from Strawberry Reservoir but the model attempts to use as much as possible to meet JSRIP flows while maintaining an average of or less than the 22,000 AF.

² This value of 11,555 AF is a model simulated need of CUP water to meet minimum flows from Strawberry Tunnel, in the Sixth Water Creek and Diamond Fork Creek basins.

³ The Alternative Scenario will convert from the 40,180 AF of irrigated volume that is computed as necessary to meet Baseline demand for agriculture. This value will decrease on average with approximately 10,600 AF on average converting to M&I Water in the Alternative simulation.

5.2.1.1 Monthly Demand Distribution

For any demand that was given an annual volume from **Table 1**, a corresponding monthly pattern was required to distribute it to monthly volumes. For some uses, the demand pattern changed based on the conversion from Agricultural (Ag) to Municipal and Industrial uses (M&I). The demands in both the Baseline scenario and the Alternative scenario convert from Ag to M&I uses; **Figure 3** and **Figure 4** demonstrate this.

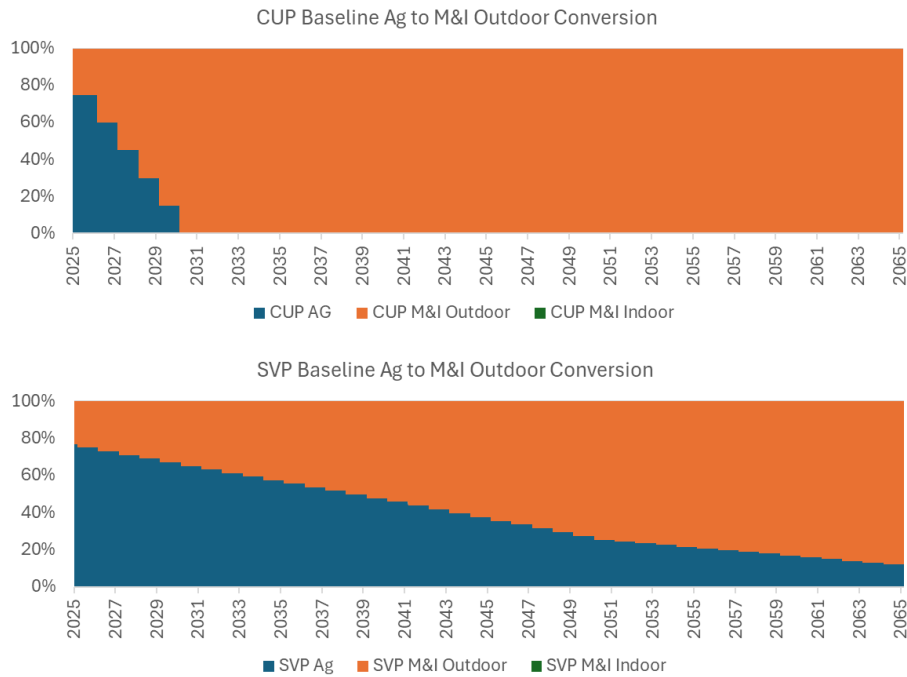


Figure 3 Baseline Conversion from Ag to M&I Outdoor Use for CUP and SVP Demands

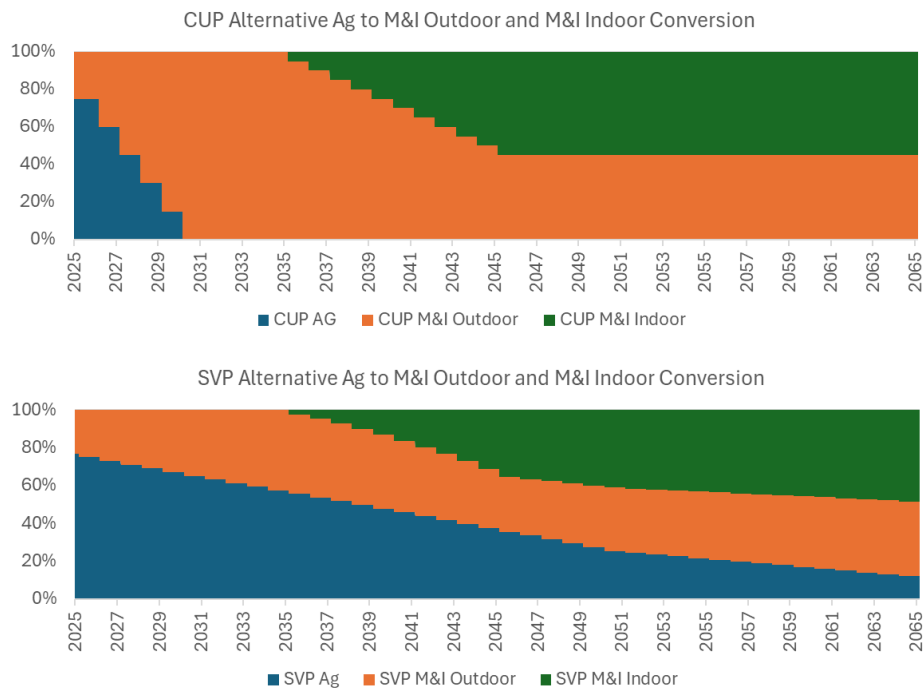


Figure 4 Alternative Conversion from Ag to M&I Outdoor and M&I Indoor Use

The monthly patterns for each type of water based on conversion are shown in **Table 2** and **Table 3**.

Table 2 Baseline Monthly Distribution to Different uses

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Salt Lake County ULS M&I	4%	4%	4%	5%	10%	8%	20%	18%	15%	5%	4%	4%
South Utah County ULS Ag (SFSP)	0%	0%	0%	2%	11%	18%	24%	26%	18%	0%	0%	0%
MSP Water Users ULS	3%	2%	2%	15%	13%	17%	16%	15%	6%	4%	3%	3%

Table 3 Alternative Monthly Distribution to Different uses

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Salt Lake County ULS M&I	4%	4%	4%	5%	10%	8%	20%	18%	15%	5%	4%	4%
South Utah County ULS Ag (MSP and SFSP)	0%	0%	0%	2%	11%	18%	24%	26%	18%	0%	0%	0%
South Utah County ULS M&I Outdoor (MSP and SFSP)	0%	0%	0%	4%	11%	18%	24%	22%	17%	5%	0%	0%
South Utah County ULS M&I Indoor (MSP and SFSP)	8%	7%	8%	7%	9%	10%	11%	10%	9%	8%	7%	7%

The SVP water users that receive water from the Spanish Fork River have a historic volume that is spread out across the year in a monthly pattern as well. **Figure 5** and **Figure 6** show examples of simulated years from Water Years 2039 to 2041 from the Baseline scenario and the Alternative scenario, respectfully.

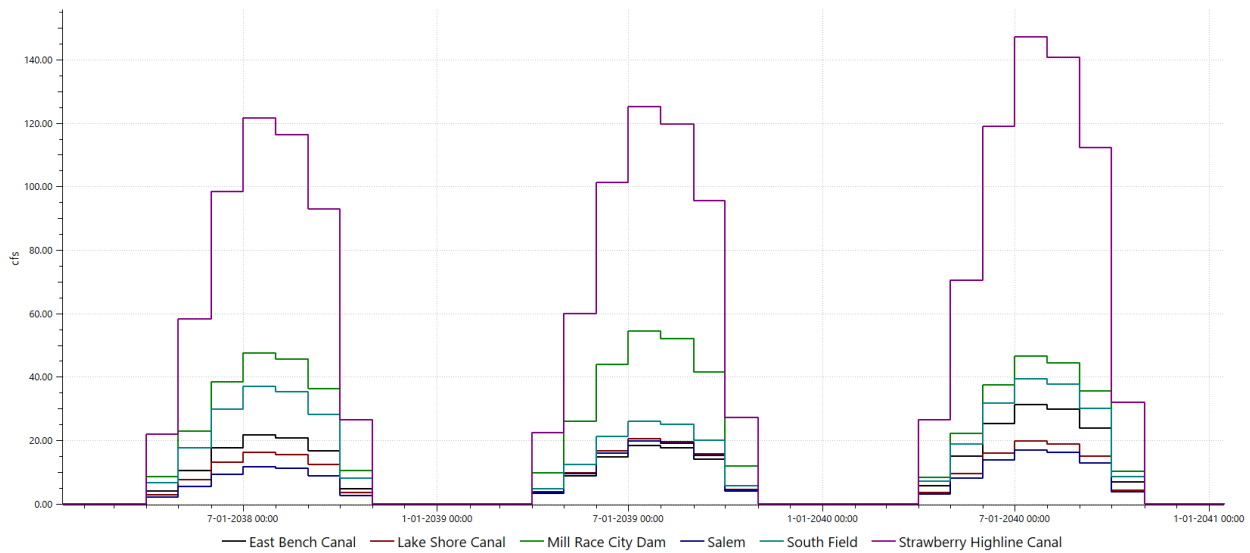


Figure 5 Example SVP Natural Flow users total demand over different years in the Baseline scenario. Notice that there is no Winter Demand for those users in the Baseline scenario.

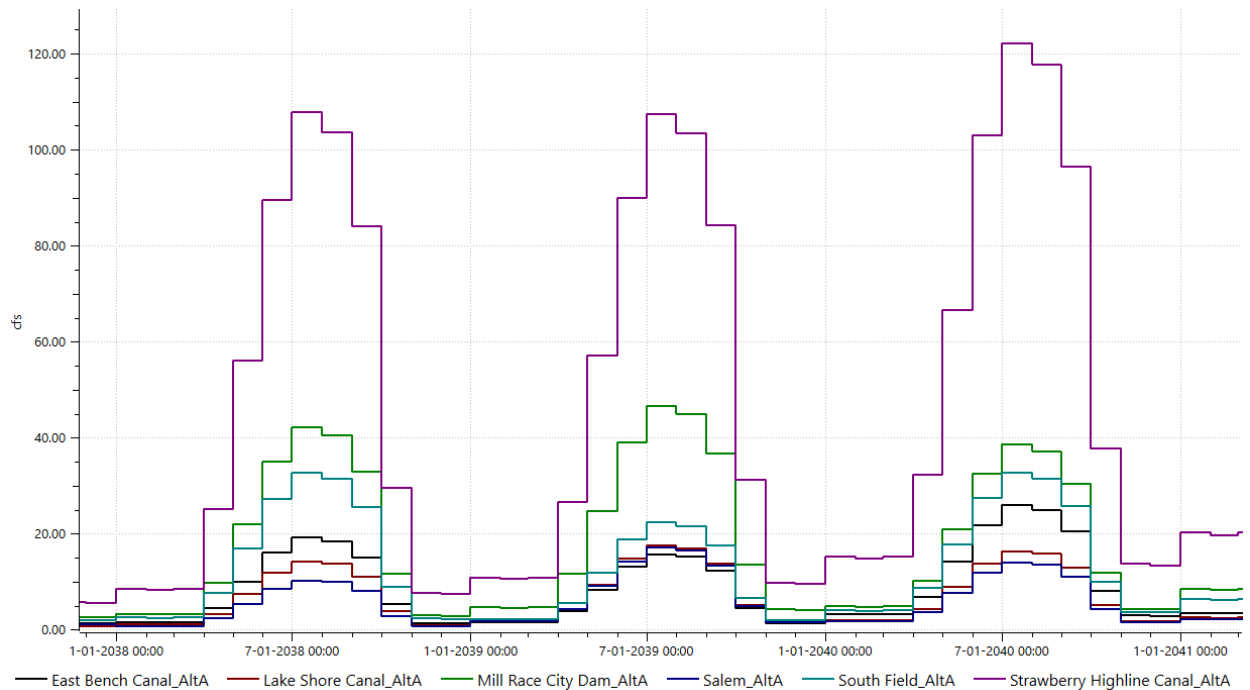


Figure 6 Example SVP Natural Flow users total demand over different years in the Alternative scenario. Winter Demands have started based on the conversion from Ag to M&I Indoor demand.

5.2.1.2 Return Flow Percentages

Each of the different kinds of water use (Ag, M&I Outdoor, M&I Indoor) results in a different consumptive use and a resulting return flow assumption for the return flows

to Utah Lake. Only water users in Utah County can return water to Utah Lake. Users in Salt Lake County are assumed to be 100% consumptive in their use.

Table 4 Return Flow Fractions by water type of water that returns to Utah Lake

Agriculture	35%
M&I Outdoor	9%
M&I Indoor	80%

When water returns to Utah Lake, it does so differently in the Baseline Scenario than in the Alternative Scenario. SVP returns to Utah Lake in the Baseline Scenario return water to the System account in Utah Lake. SVP returns to Utah Lake in the Alternative scenario return water to the CUWCD Import account in Utah Lake. All CUP returns to Utah Lake go to the CUWCD Import account in Utah Lake. The CUWCD Import account has a much greater volume in the Alternative Scenario as a result. As the CUWCD Import account is greater, the System account has less volume.

5.3 POLICY LOGIC

The last item of model input is the policy logic that operates the system. The policy logic for this analysis sets water user demands, reservoir releases and diversions to meet demands, minimum flows and June Sucker flow request, the physical and accounting flows in the system, and checks tunnel capacities. There are three different policy sets in the model. These include:

- Initialization Rules – rules that set information in the model prior to the model solving the first timestep. These rules set diversion requests, initialize storages, and set the model to solve with information that is available.
- Object Level Accounting Methods – rule logic that helps the accounting solution solve. These methods allow for a generic solution to reconcile physical flows into the accounting space. Object Level Accounting Methods are used to set evaporation to accounts on reservoirs, local inflows to accounts on reach objects, and other accounting solution methods.
- Ruleset – rules that execute in a prescribed order on each timestep. These rules solve the model solution and set various variables in the system. Each rule can set physical and or accounting variables in the system. RiverWare executes these rules in the specified order and executes rules as many times as allowed by the rule logic.

6 MODEL ASSUMPTIONS AND SCENARIO REVIEWS

Modeling assumptions were made for these scenarios that are discussed in the following section.

6.1 FLOW CONSTRAINTS IN THE ULS

Constraints for the various tunnels and pipelines were used to limit the amount of flow through those systems. **Table 5** shows those limitations. See **Section 7.3** for results of flows through these pipelines.

Table 5 Pipeline Capacities used in the modeling of scenarios

Capacities	cfs
Mapleton Springville Pipeline	125
Provo River Canal	120
Syar Diversion	660
Diamond Fork Pipeline	560
Spanish Fork Canyon Pipeline	365

6.2 UTAH LAKE JORDANELLE EXCHANGE

The model computes the need for Utah Lake Jordanelle Exchange if the total System water does not cross either the Normal Conversion Line or the Lower Conversion Line. The Normal Conversion line is crossed when the total storage less import accounts cross the line. The District can elect to forego their storage rights and lower the conversion line. In that case, the total storage less import accounts less the District's system accounts are used to know if the Lower Conversion Line is crossed. In either case a volume of System water is needed to be exchanged in Utah Lake from District accounts to the general system account. The volumes of System water exchanged were either retrieved from historical records or created using similar year types based on hydrology where they were not in historical records. In both the Baseline and the Alternative scenarios, the need for exchange occurs in similar years. **Table 6** shows the results of the exchanges for each of those years and further discussion follows.

Table 6 Utah Lake Jordanelle Exchange Results, all unites are in Acre-Feet

Year	Scenario	System Water to be Exchanged	District System Accounts Exchanged	CUWCD Import Exchanged	Required Supplemental Water
2054	Baseline	67,779	67,779	0	0
	Alternative	67,779	67,779	0	0
2055	Baseline	68,158	41,131	27,027	0
	Alternative	68,158	36,986	31,172	0
2056	Baseline	27,510	27,510	0	0
	Alternative	27,510	26,783	727	0
2057	Baseline	59,731	39,217	20,514	0
	Alternative	59,731	37,304	22,427	0
2058	Baseline	180,305	81,835	66,866	31,604
	Alternative	180,305	72,790	107,515	0
2061	Baseline	80,995	80,995	0	0
	Alternative	80,995	80,995	0	0
2062	Baseline	33,321	33,321	0	0
	Alternative	33,321	33,321	0	0
2063	Baseline	37,695	37,695	0	0
	Alternative	37,695	37,695	0	0

Due to the change in return flow to Utah Lake, the Alternative scenario has less overall System storage which is realized in the available System storage the District can use for exchange. Notice the colored cells in 2055, 2056, 2057 and 2058, the years when CUWCD Import water is required for exchange. In each of the years, the amount of System water available for exchange is higher in the Baseline scenario. In the 2058 simulation, the Baseline scenario shows a need for additional water from either Strawberry Reservoir or Jordanelle Reservoir release to make up for the System water in the Provo Reservoirs. The Alternative has enough CUWCD Import water to make up for the exchange where the Baseline scenario does not. This is related to the amount of return flow going to the CUWCD Import account in the Alternative Scenario.

6.3 JUAB COUNTY DELIVERIES IN THE ALTERNATIVE SCENARIO

In the Alternative Scenario, 6,000 AF of water is sent to Juab County. This water is conserved from piping the Strawberry Highline Canal and reducing losses. In the RiverWare model, this is taken out of return flows to Utah Lake. For a given year, the return flow to Utah Lake is reduced by 6,000 AF. When compared to the Baseline return flows, the Alternative return flows are 6,000 AF less in the first ten years of model simulation when the Ag to M&I Indoor ratios are the same between the two scenarios.

When the M&I Indoor demand in the Alternative scenario starts consuming less water the return flow to Utah Lake increases. Over time, that increase is greater than the 6,000 AF of water that goes to Juab County and the return flow volume to Utah Lake is greater in the alternative scenario. .

Figure 7 shows the comparison of consumptive use that is computed using diversion data multiplied by the assumed return flow percentages for each water use type. The figure also shows the amount of water going to Juab County each year (6,000 AF) and the difference in return flow to Utah Lake. Notice that when the consumptive use is equal (the first ten years), the difference in return flow is the same as the delivery of water to Juab County indicating that return flow is captured and delivered.

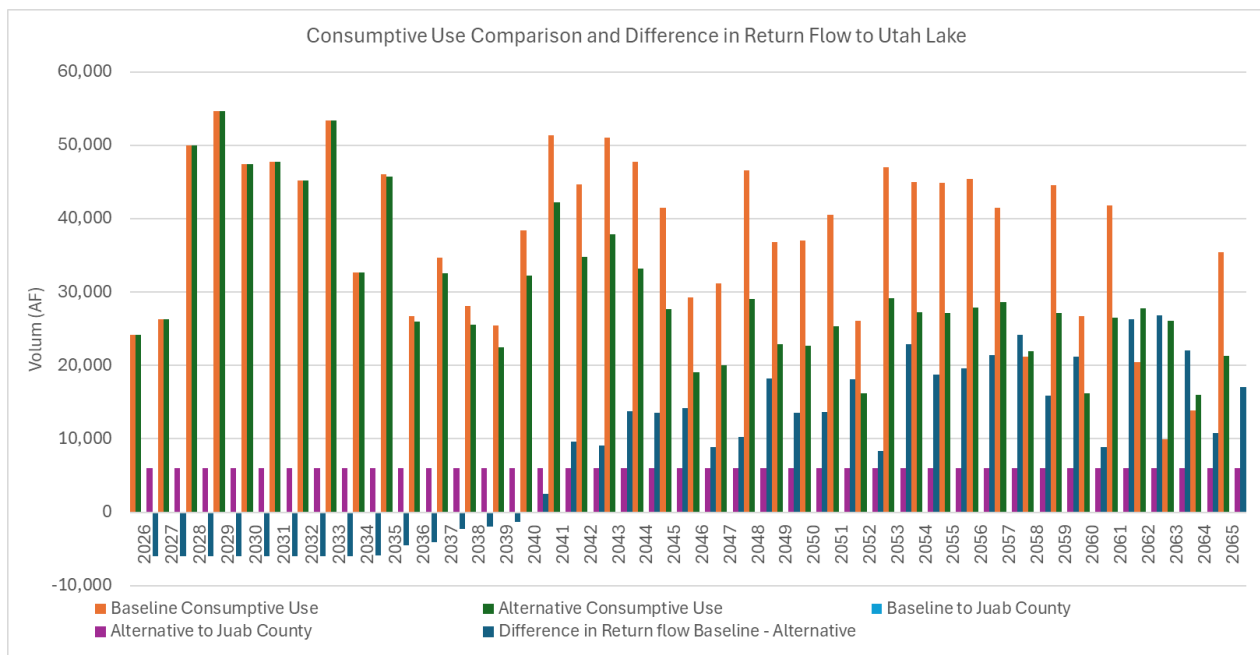


Figure 7 Consumptive Use Comparison, Delivery to Juab County, and Difference in Annual Return Flow Amounts to Utah Lake

6.4 ANNUAL DELIVERY COMPARISONS

To summarize average annual deliveries, tabular data similar to the format of **Table 1** can be used. **Table 7** and **Table 8** show the delivery volumes from each of the scenarios with notable differences in the average annual volumes to help explain the savings in consumption.

Table 7 Baseline Average Annual Delivery Volumes by Location and Use

	Spanish Fork - Santaquin Pipeline	Mapleton-Springville Lateral Pipeline	Spanish Fork - Provo Reservoir Canal Pipeline	Spanish Fork River	Total
	SFSP	MSP	SFPRC	SFR	
Bonneville Unit Water					
SLC M&I	0	0	19,982	0	19,982
S. Utah County M&I	14,582	4,346	2,141	0	21,069
Utah Lake Delivery	0	5,941	10,914	11,555	28,410
Spilled to Utah Lake	0	0	0	4,803	4,803
Subtotal - B.U.	14,582	10,287	33,037	16,358	74,265
SVP Irrigation Water					
S. Utah County Cities	7,320	2,880	0	0	10,200
Irrigated Lands	0	7,380	0	38,500	45,881
Subtotal - SVP	7,320	10,260	0	38,500	56,081
Total	21,902	20,547	33,037	54,859	130,345

The Baseline annual average delivery values shown in **Table 7** are less than the demands that were presented in **Table 1**. Some of this has to do with reductions placed on water users due to low Strawberry Reservoir storage. For instance, the 38,500 AF of SVP Irrigated Lands volume is less than the 40,180 AF for the demand of that SVP water in **Table 1**. This is due to several reasons. First, the hydrology available to the SVP water users requires less SVP water delivered as supplement, and two, reductions in demands being placed on SVP water users when the Strawberry Reservoir SVP account volume is not enough to meet all SVP water requests. The CUP Utah Lake Delivery is less in **Table 7** than in **Table 1**. This is due to less June Sucker Recovery Implementation Program (JSRIP) water being required than was made available.

Moving to **Table 8**, notable differences are highlighted and underlined when there is a departure from Baseline results. The Spanish Fork Utah Lake Delivery of CUP water is reduced due to the M&I Indoor demands in winter months that can satisfy the minimum Strawberry Tunnel flow. The Baseline scenario uses more CUP water to satisfy that flow than the Alternative scenario. The other notable difference is the conversion of Irrigated Lands SVP to M&I Indoor SVP. Similar average total volumes of SVP are shown between the two alternatives; however, the demand is shifted to different uses. Note that the total demand to cities and irrigated lands is slightly higher

for every location but the total delivery from Strawberry Reservoir is less due to reduction of Spanish Fork River CUP deliveries.

Table 8 Alternative Average Annual Delivery Volumes by Location and Use

	Spanish Fork - Santaquin Pipeline	Mapleton-Springville Lateral Pipeline	Spanish Fork - Provo Reservoir Canal Pipeline	Spanish Fork River	M&I Indoor Treated SVP	Total
	SFSP	MSP	SFPRC	SFR		
Bonneville Unit Water						
SLC M&I	0	0	21,678	0		21,678
S. Utah County M&I	15,745	4,693	2,311	0		22,749
Utah Lake Delivery	0	6,223	11,332	<u>5,762</u>		23,317
Spilled to Utah Lake	0	0	0	4,803		4,803
Subtotal - B.U.	15,745	10,916	35,320	10,566		72,546
SVP Irrigation Water						
S. Utah County Cities	7,322	2,880	0	0	10,593	20,795
Irrigated Lands	0	7,381	0	27,973		35,354
Subtotal - SVP	7,322	10,261	0	27,973	10,593	56,149
Total	23,066	21,177	35,320	38,538	10,593	128,695

6.5 STRAWBERRY SHORTAGE DISCUSSION FOR CUP AND SVP DIVERSIONS

Reductions to both categories of water (CUP and SVP) were allowed to occur if Strawberry Reservoir approached low levels. A summary of the logic to implement those reductions is described here:

- SVP reductions occur when the SVP demand at the beginning of the water year is greater than the storage of SVP water after 61,000 AF of water is transferred into the SVP bank. If the demand is greater than the available Strawberry Reservoir SVP storage, a reduction fraction is applied, and deliveries are reduced by that fraction.
- CUP reductions occur at two levels in Strawberry Reservoir.
 - First, if Strawberry elevation is lower than the top of the Syar Inlet (7,525 feet), CUP Deliveries are cut off entirely for the period of time Strawberry pool elevation is below the inlet.
 - Second, if Strawberry Reservoir CUP Storage is less than 95,000 AF on January 1 of a year, CUP Deliveries are assigned a 50% reduction for that

year. If the Strawberry Reservoir CUP Storage in the subsequent January is greater than 95,000 AF, the reduction is removed.

SVP reductions occur in both the Baseline and Alternative scenarios. For CUP, reduction only occurs in the Baseline scenario (both types). **Figure 8** shows the comparison between allocation fractions for both types of water and both scenarios.

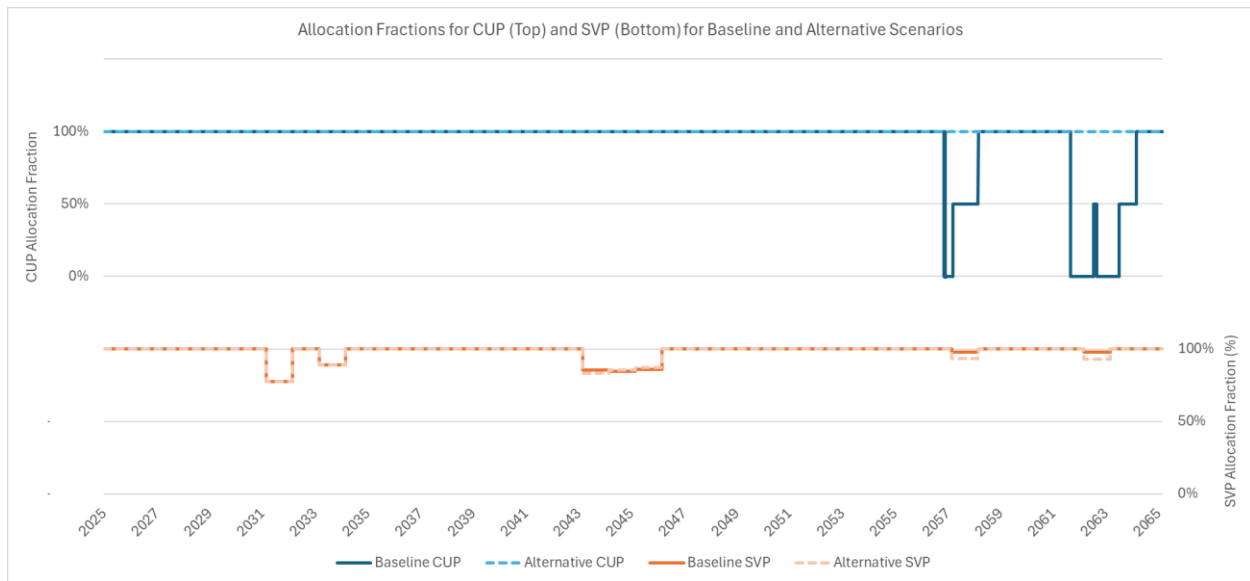


Figure 8 Reduction Fractions due to Low Storage in Strawberry Reservoir

7 RESULTS AND COMPARISON

The Results section provides figures and brief narrative for use in the EA. The figures and narrative explain how water from the top of the system, starting at Strawberry Reservoir, flows through the various locations to Utah Lake.

7.1 STRAWBERRY RESERVOIR COMPARISON – POOL ELEVATION

Strawberry Reservoir is higher in the Alternative scenario. Deviation in pool elevation begins when indoor use in the Alternative starts. In the winter months, this indoor demand allows for diversion from Strawberry Reservoir to meet the Strawberry Tunnel minimum flow. This displaces any need for more stored water, that was released in the Baseline scenario, to be released in the alternative. This accumulation of saved storage results in Strawberry Reservoir being higher in the Alternative simulation (**Figure 9**).

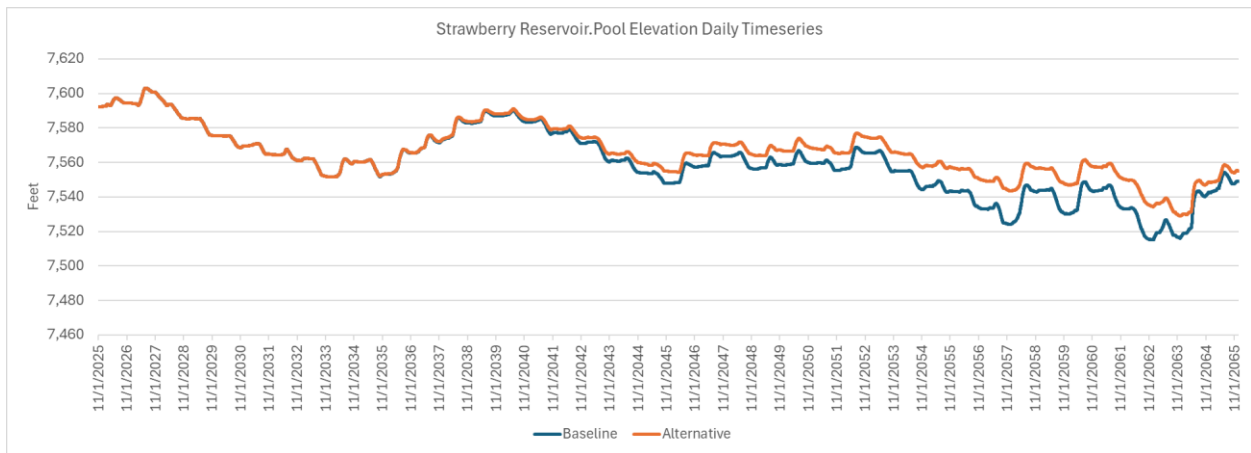


Figure 9 Timeseries Comparison of Strawberry Reservoir Pool Elevation

Viewing an exceedance probability plot of Strawberry Reservoir’s pool elevation (Figure 10), Strawberry Reservoir is always above the 7,525 foot Syar Tunnel inlet elevation in the Alternative scenario under these demand and hydrology sequencing inputs. The Baseline scenario release of water through the winter results in elevations below the inlet elevation.

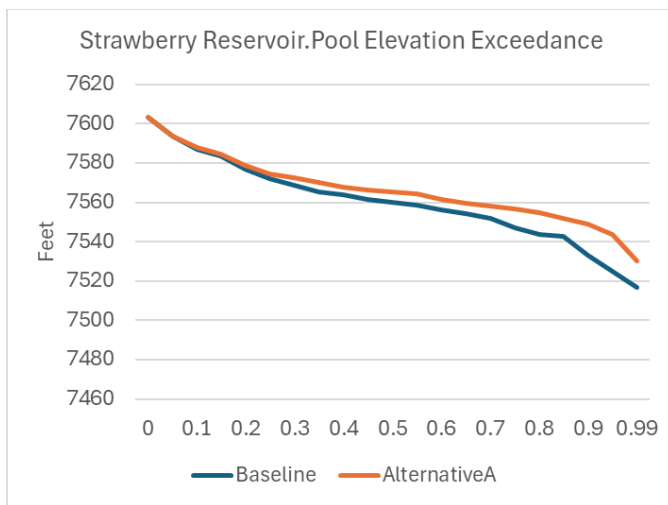


Figure 10 Exceedance Probability Comparison of Strawberry Reservoir Pool Elevation

Table 9 shows the annual water surface fluctuations in feet per year. This ignores the difference in elevation and evaluates the amount of change between the maximum and minimum elevations of a year.

Table 9 Strawberry Reservoir Annual Water Surface Fluctuations by Water Year

Simulated Water Year	Annual Water Surface Fluctuations in Strawberry Reservoir Baseline		Annual Water Surface Fluctuations in Strawberry Reservoir Alternative A		Difference Between Baseline and Alternative A	
	ft	in	ft	in	ft	in
2026	5.17	61.99	5.17	61.99	0.000	0.000
2027	9.97	119.69	9.97	119.69	0.000	0.000
2028	15.24	182.94	15.24	182.94	0.000	0.000
2029	9.96	119.49	9.96	119.49	0.000	0.000
2030	7.08	85.00	7.08	85.00	0.000	0.000
2031	6.32	75.84	6.32	75.84	0.000	0.000
2032	6.45	77.43	6.45	77.43	0.000	0.000
2033	10.40	124.74	10.40	124.74	0.000	0.000
2034	10.46	125.53	10.46	125.53	0.000	0.000
2035	10.03	120.35	9.83	117.94	-0.201	-2.413
2036	14.81	177.67	14.78	177.39	-0.023	-0.278
2037	10.50	126.05	10.45	125.38	-0.056	-0.673
2038	14.42	173.10	14.33	171.91	-0.099	-1.189
2039	7.20	86.40	7.05	84.63	-0.148	-1.771
2040	6.56	78.67	5.71	68.50	-0.847	-10.164
2041	8.87	106.42	7.49	89.88	-1.378	-16.536
2042	8.16	97.88	6.78	81.41	-1.372	-16.470
2043	11.91	142.98	9.96	119.55	-1.952	-23.428
2044	8.22	98.62	6.24	74.84	-1.982	-23.783
2045	6.94	83.29	5.14	61.72	-1.798	-21.575
2046	11.85	142.16	11.18	134.19	-0.665	-7.977
2047	8.36	100.36	7.63	91.58	-0.732	-8.781
2048	9.30	111.61	6.88	82.57	-2.419	-29.034
2049	6.99	83.84	6.05	72.66	-0.932	-11.179
2050	8.50	101.99	7.50	90.02	-0.997	-11.968
2051	6.01	72.16	3.88	46.50	-2.138	-25.657
2052	13.67	164.08	11.88	142.59	-1.790	-21.483
2053	12.32	147.79	9.16	109.89	-3.158	-37.901
2054	11.04	132.42	8.77	105.28	-2.262	-27.144
2055	6.72	80.60	3.99	47.84	-2.730	-32.762
2056	9.96	119.46	6.75	81.00	-3.205	-38.464
2057	11.77	141.23	6.97	83.58	-4.804	-57.653
2058	22.79	273.44	16.07	192.79	-6.721	-80.649
2059	14.22	170.62	8.95	107.36	-5.272	-63.263
2060	18.65	223.76	14.62	175.47	-4.024	-48.287
2061	13.08	156.95	8.27	99.21	-4.812	-57.738
2062	18.41	220.97	15.86	190.29	-2.557	-30.687
2063	11.84	142.08	9.68	116.20	-2.157	-25.886
2064	27.34	328.09	20.79	249.49	-6.550	-78.604
2065	13.57	162.81	11.45	137.41	-2.117	-25.401

7.2 STRAWBERRY RESERVOIR COMPARISON – DIVERSION

Strawberry Reservoir diversion differences are shown in **Figure 11** and **Figure 12**

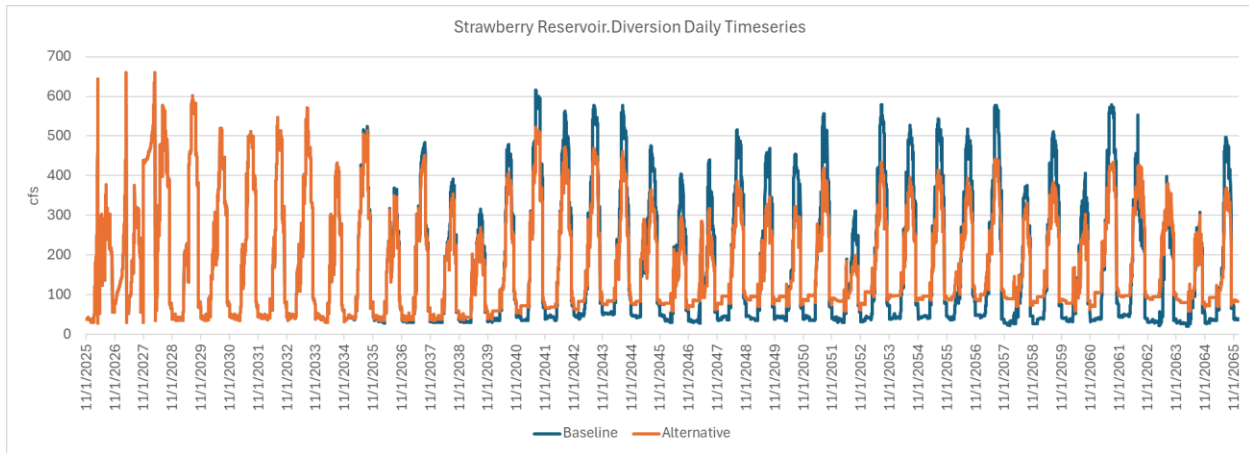


Figure 11 Strawberry Reservoir Diversion Time series Comparison

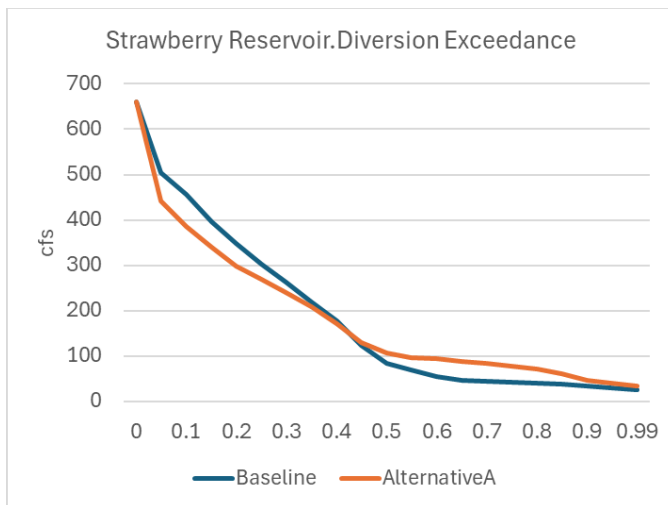


Figure 12 Exceedance Probability Comparison of Strawberry Diversion

7.3 FLOW IN EACH OF THE PIPELINES (CANYON, SFSP, MSP, PRC)

Flows downstream of the Spanish Fork Flow Control Structure are limited to the capacities of those pipes. Changes in the flows in the pipes are limited to the Canyon Pipeline (**Figure 13**), the MSP (**Figure 14**), and the SFSP (**Figure 15**). Differences are not observed in the flows to the PRC (**Figure 16**).

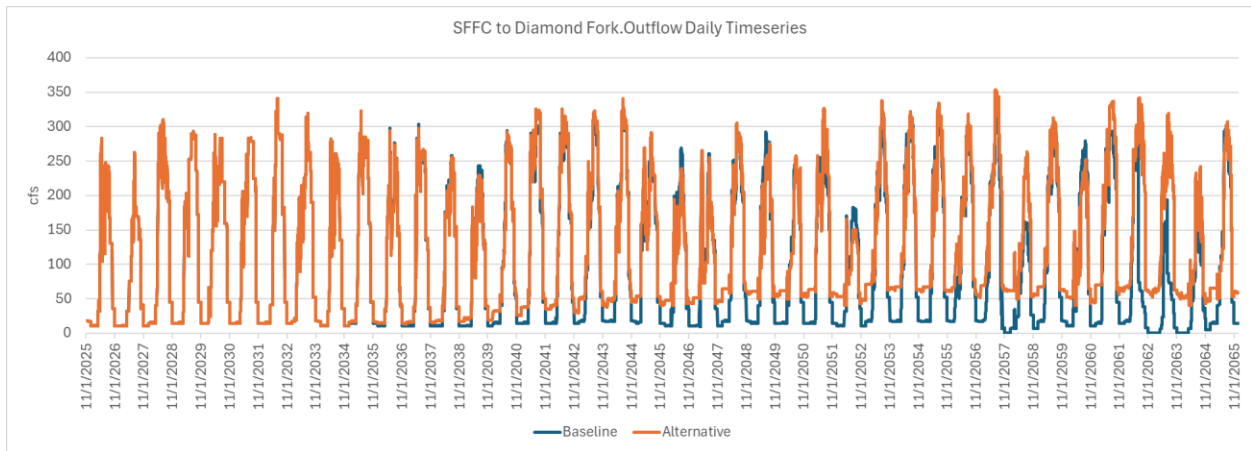


Figure 13 ULS flows in the Canyon Pipeline downstream of the Spanish Fork Flow Control Structure

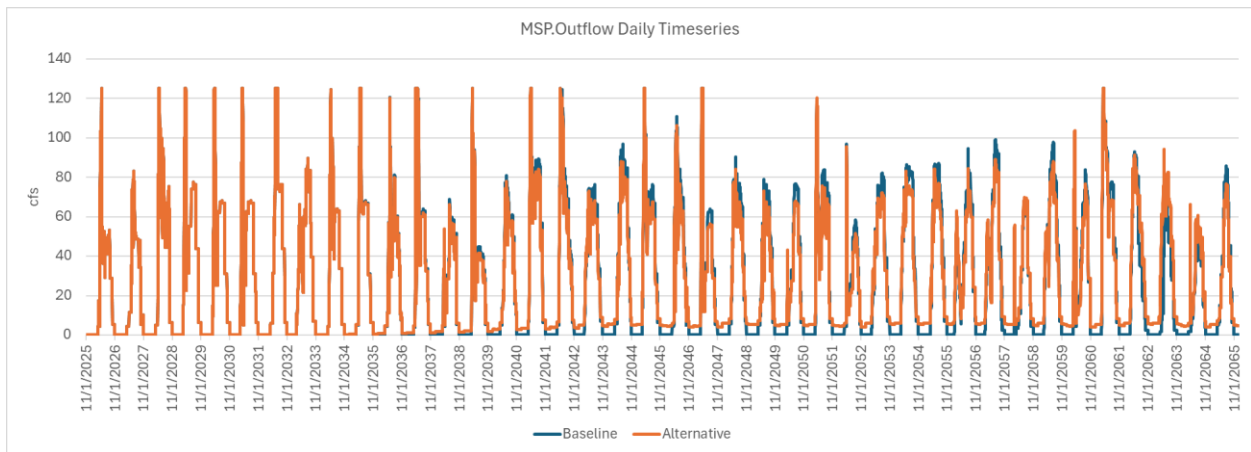


Figure 14 Flows into the MSP

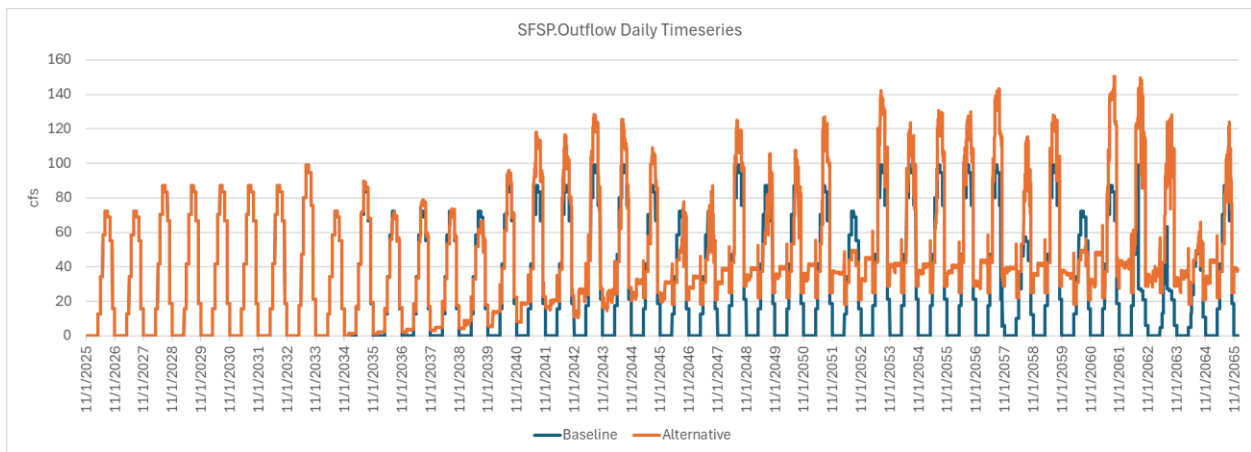


Figure 15 Flows into the Spanish Fork Santaquin Pipeline

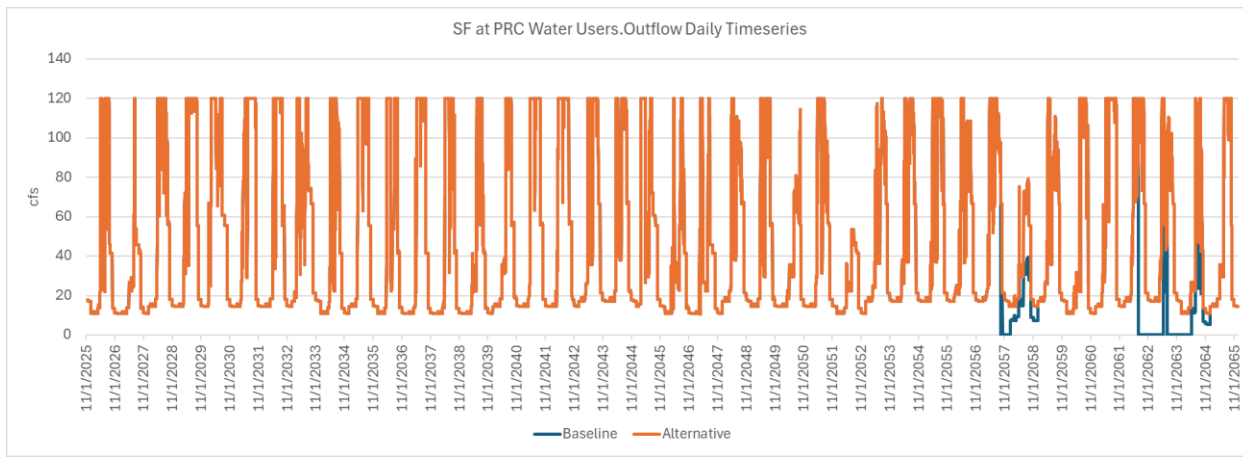


Figure 16 Flows into the Provo River Canal Pipeline

7.4 TOTAL NATURAL FLOW USE

Natural flow use changes between the Baseline and Alternative scenarios. When consumptive use is the same in the first decade of model simulation, the Natural flow use is the same. As the M&I Indoor demands conversion occurs in the Alternative scenario, Natural flow is used in different amounts – generally less. This is due to a lower summer demand and lack of Natural flow being used to meet winter demands. Generally, when the Alternative scenario uses less Natural flow, it is in wetter hydrological periods where Natural flow meets higher Baseline demands in the irrigation season. This is the opposite in dry hydrology years. In drier years, the demand pattern for the Alternative scenario allows for more Natural flow to be delivered during periods of higher demand for indoor use than a traditional irrigation demand. Thus, more Natural water is used in the Alternative scenario. Evaluation of each year is shown in Figure 17.

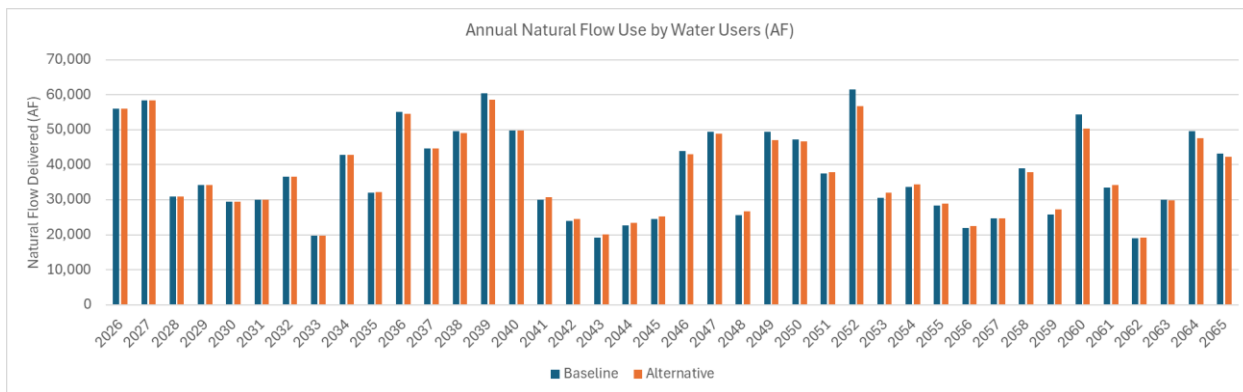


Figure 17 Natural Flow Delivered to Water Users

7.5 FLOW COMPARISONS (CASTILLA, INFLOW TO UTAH LAKE)

Flows in the Spanish Fork River are different in the Alternative scenario. Flows at Castilla are reduced due to more water flowing in the ULS resulting in less flow during summer months (**Figure 18** and **Figure 19**). Flows into Utah Lake are different due to less winter flow making it to Utah Lake (**Figure 20** and **Figure 21**)

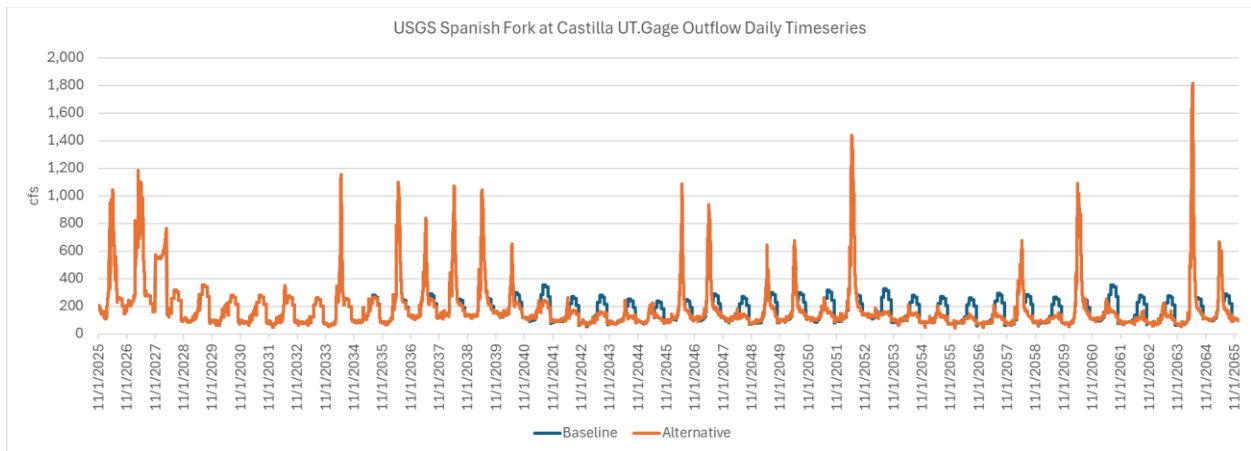


Figure 18 Spanish Fork River at Castilla Flow

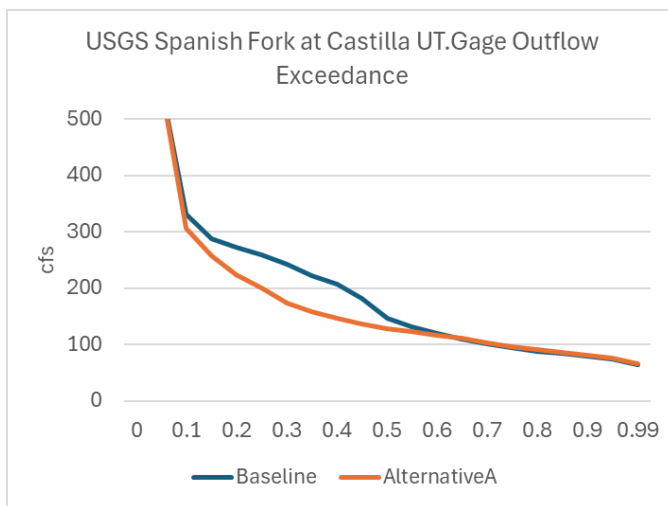


Figure 19 Exceedance Probability Comparison of flows on the Spanish Fork River at Castilla

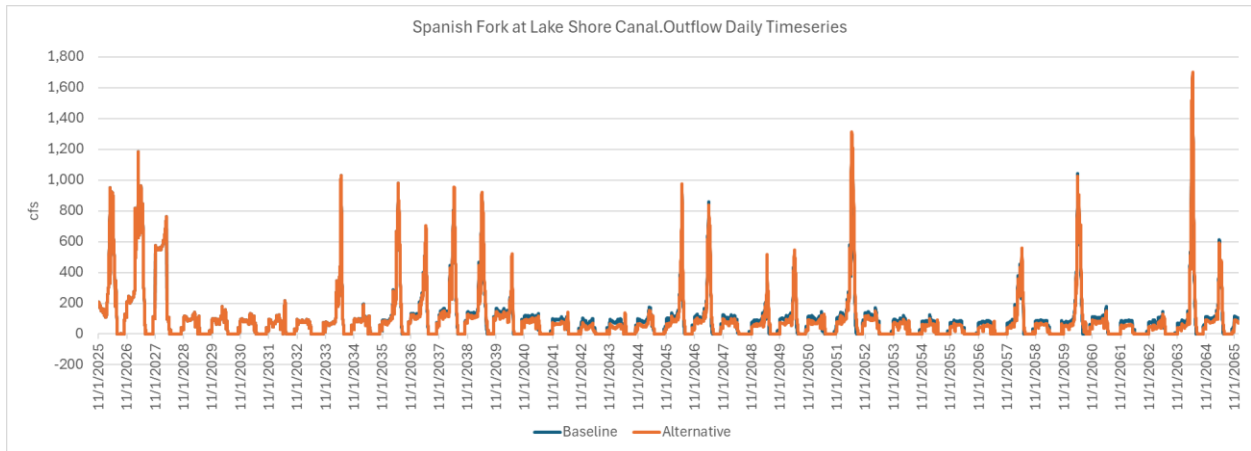


Figure 20 Flows in the Spanish Fork River to Utah Lake downstream of all users.

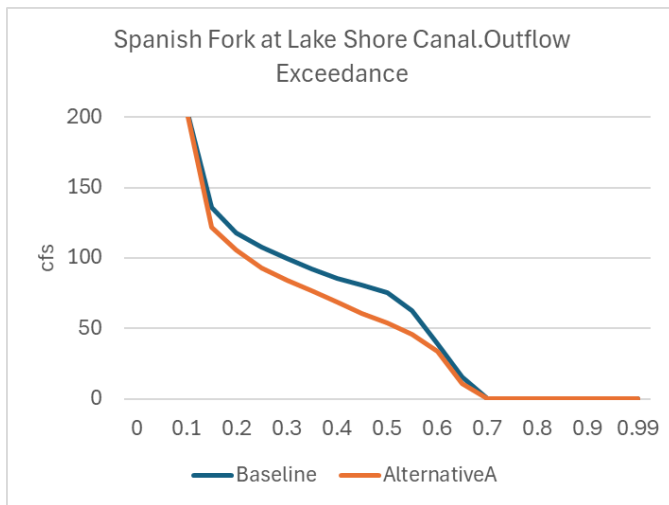


Figure 21 Exceedance Probability Comparison of flows in the Spanish Fork River to Utah Lake

Return flows to Utah Lake change due to the changing use patterns used in the Alternative scenario. Two main differences appear in **Figure 22** and **Figure 23**. The first difference is a decrease in overall returns to Utah Lake for the first ten years of comparison. This is due to similar consumptive use amounts before indoor use starts and the use of return flow for delivery to Juab County flows. The second difference is after indoor uses start, the efficiency of the 80% return of those volumes adds more return flow consistently through the year back to Utah Lake. Overall, there is less consumptive use in the basin and more return to Utah Lake.

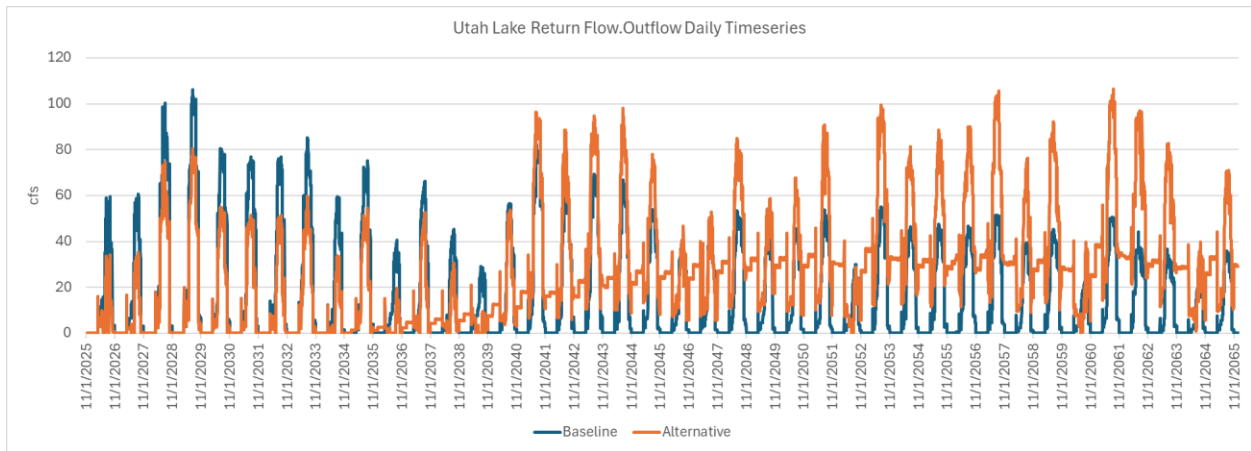


Figure 22 Utah Lake Return Flow as computed with change in consumptive use

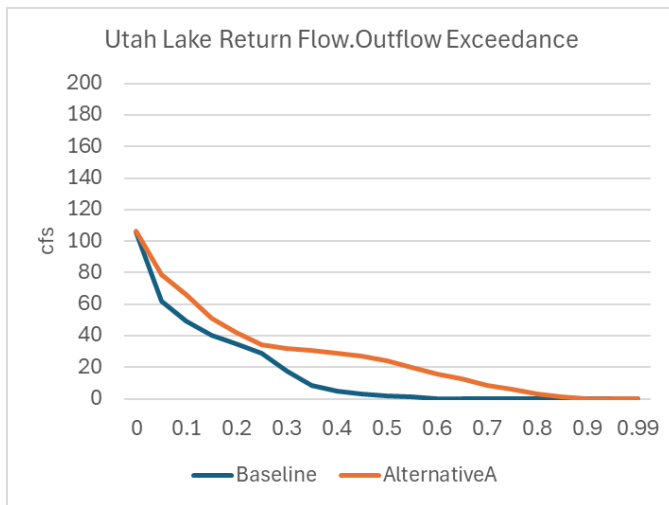


Figure 23 Exceedance Probability Comparison of Return flow to Utah Lake

7.6 UTAH LAKE COMPARISON

Comparison of Utah Lake pool elevation are shown in **Figure 24** and **Figure 25**. There is very little change in the beginning of the scenario where Utah Lake is slightly lower in the alternative due to the Juab County deliveries coming from return flows to Utah Lake. When the return flows are greater later in the simulation, the Utah Lake pool Elevation is higher. Annual Fluctuations between the annual maximum elevation and the annual minimum for each year are shown in **Table 10**.

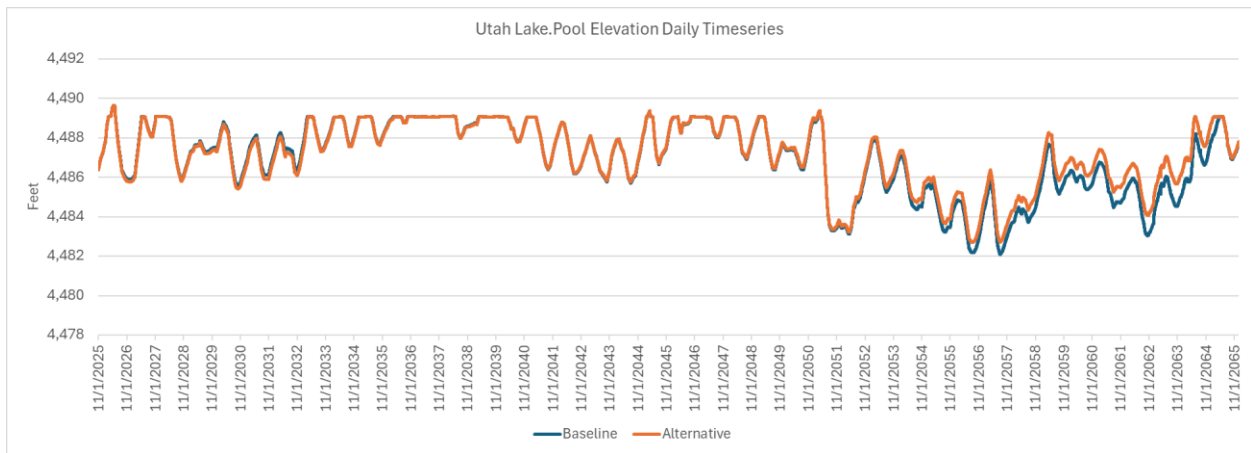


Figure 24 Utah Lake Pool Elevation comparison

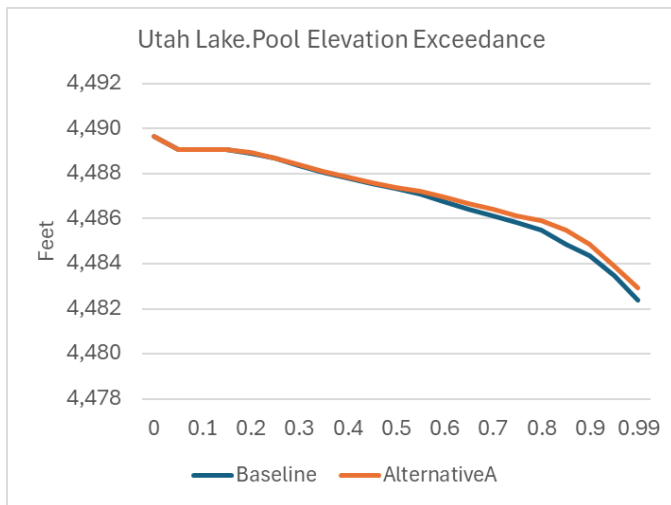


Figure 25 Probability Exceedance Comparison of Utah Lake Pool Elevation

Table 10 Annual Fluctuation for water years on Utah Lake

Simulated Water Year	Annual Water Surface Fluctuations in Utah Lake Baseline		Annual Water Surface Fluctuations in Utah Lake Alternative A		Difference Between Baseline and Alternative A	
	ft	in	ft	in	ft	in
2026	3.73	44.77	3.84	46.05	0.107	1.282
2027	3.22	38.60	3.32	39.89	0.108	1.293
2028	3.24	38.83	3.30	39.62	0.065	0.783
2029	1.77	21.24	1.77	21.25	0.001	0.015
2030	3.22	38.61	3.28	39.42	0.067	0.803
2031	2.42	29.01	2.43	29.17	0.014	0.167
2032	2.17	26.00	2.18	26.20	0.016	0.197
2033	2.71	32.52	2.98	35.72	0.266	3.198
2034	1.50	17.97	1.55	18.56	0.049	0.588
2035	1.45	17.39	1.49	17.93	0.046	0.547
2036	1.07	12.85	1.12	13.41	0.047	0.567
2037	0.04	0.44	0.04	0.44	0.000	0.004
2038	1.13	13.55	1.14	13.64	0.007	0.088
2039	0.52	6.18	0.55	6.58	0.033	0.396
2040	1.27	15.27	1.28	15.36	0.008	0.092
2041	2.67	32.01	2.64	31.62	-0.032	-0.388
2042	2.63	31.54	2.60	31.21	-0.027	-0.325
2043	2.34	28.11	2.29	27.48	-0.052	-0.630
2044	2.24	26.86	2.20	26.39	-0.039	-0.470
2045	2.70	32.41	2.67	32.01	-0.033	-0.400
2046	1.58	18.97	1.53	18.39	-0.048	-0.580
2047	1.07	12.80	1.03	12.31	-0.041	-0.486
2048	2.17	26.03	2.10	25.24	-0.066	-0.792
2049	2.68	32.13	2.62	31.44	-0.058	-0.692
2050	1.33	15.90	1.26	15.08	-0.068	-0.821
2051	6.07	72.79	6.01	72.15	-0.053	-0.642
2052	3.01	36.17	3.05	36.61	0.036	0.435
2053	2.64	31.68	2.55	30.64	-0.087	-1.038
2054	2.73	32.77	2.64	31.65	-0.093	-1.113
2055	2.47	29.63	2.38	28.51	-0.093	-1.122
2056	2.67	32.00	2.57	30.82	-0.099	-1.184
2057	3.80	45.59	3.66	43.92	-0.139	-1.673
2058	1.50	17.99	1.48	17.73	-0.022	-0.263
2059	3.26	39.12	3.21	38.56	-0.047	-0.559
2060	0.99	11.92	0.94	11.28	-0.054	-0.648
2061	2.29	27.48	2.17	26.06	-0.119	-1.423
2062	2.92	35.06	2.66	31.93	-0.261	-3.136
2063	2.90	34.77	2.91	34.93	0.013	0.162
2064	3.65	43.83	3.42	41.07	-0.230	-2.762
2065	2.36	28.27	2.13	25.50	-0.231	-2.773