Boise River Basin Feasibility Study

Specialist Report:

Water Operations and Hydrology

Boise Project, Idaho

Interior Region 9: Columbia Pacific Northwest

U.S. Department of the Interior May 2020

Page intentionally left blank.

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Page intentionally left blank.

Acronyms and Abbreviations

Acronym or Abbreviation	Meaning
BiOp	biological opinion
cfs	cubic feet per second
DOA	day of allocation
EIS	Environmental Impact Statement
FRM	flood risk management
IDFG	Idaho Department of Fish and Game
M&I	municipal and industrial
NOAA	National Oceanic and Atmospheric Administration
Reclamation	Bureau of Reclamation
RFA	reservoir frequency analysis

Page intentionally left blank.

Table of Contents

List of Figures

List of Tables

Page intentionally left blank.

1. Introduction

The Boise River Basin Feasibility Study is a feasibility study to evaluate increasing water storage opportunities within the Boise River basin by expanding Anderson Ranch Reservoir. The project is located at Anderson Ranch dam and reservoir, the farthest upstream of the three reservoirs within the Boise River system and located 28 miles northeast of the city of Mountain Home in Elmore County, Idaho. Anderson Ranch Dam is a zoned earth fill embankment structure that provides irrigation water, flood control, power generation, and recreation benefits. The reservoir also provides a permanent dead storage pool for silt control and the preservation and propagation of fish and wildlife. Anderson Ranch Dam is operated by the Bureau of Reclamation (Reclamation). Reclamation, in partnership with the Idaho Water Resource Board (IWRB), proposes to raise Anderson Ranch Dam. New water storage would provide the flexibility to capture additional water when available, for later delivery when and where it is needed to meet existing and future demands. The alternatives analyzed in this document include the No-Action Alternative (Alternative A), a 6-foot raise of Anderson Ranch Dam (Alternative B), and a 3-foot raise of Anderson Ranch Dam (Alternative C).

Alternative A provides a basis for comparison with the two action alternatives, Alternative B and Alternative C. Under Alternative A, current baseline conditions would continue, without increasing Anderson Ranch Dam height or constructing associated reservoir rim projects, access roads, or facilities. The expected duration of Alternative B is approximately 51 months and Alternative C is 44 months. Reclamation would continue existing operations of Anderson Ranch Dam. Alternative B proposes to raise the dam by 6 feet from the present elevation of 4196 feet to 4202 feet to capture and store approximately 29,000 additional acre-feet of water. Alternative B would inundate an estimated 146 acres of additional land around the reservoir above the current full pool elevation of 4196 feet. Alternative C proposes to raise the dam by 3 feet to 4199 feet, allowing for the ability to capture and store approximately 14,400 additional acre-feet of water. Alternative C would inundate an estimated 73 acres of additional land around the reservoir above the current full pool elevation of 4196 feet.

Each of the two action alternatives, Alternative B and Alternative C, includes two separate, but similar, structural construction methods for the dam raise, soil cement, or mechanically stabilized earth. Otherwise, the only difference is the dam raise elevations of 6 feet for Alternative B and 3 feet for Alternative C. Project areas are nearly identical for each structural construction method, except for a 200-foot difference in approach road length at the right abutment and an approximate 1-month difference in construction duration. The longer road length is within the dam footprint on previously disturbed ground. Because these differences are negligible, they are not differentiated within the analysis of each alternative. Alternative analysis assumes the longer road length and construction duration, however, a final construction method will be chosen during later phases of engineering evaluation.

Chapter 1 and Chapter 2 of the Boise River Basin Feasibility Study Environmental Impact Statement (EIS) provide a detailed description of the proposed action, project's purpose and need, project area, and alternatives including design features applicable to the action alternatives. This specialist report supports the analysis of expected impacts to water operations and hydrology as described in the EIS.

2. Affected Environment

2.1 Description of Typical Water Operations

Chapter 1 of the EIS describes the primary and extended analysis areas potentially affected by the evaluated alternatives under the Boise River Basin Feasibility Study. The alternatives are evaluated in their respective sections below.

The Boise River Reservoir system is comprised of Anderson Ranch, Arrowrock, and Lucky Peak reservoirs with a total active storage capacity in the system of 949,700 acre-feet. Anderson Ranch Dam, the focus of the EIS, is located approximately 124 river miles upstream of the confluence of the Boise River with the Snake River and is the most upstream reservoir within the system. Anderson Ranch Dam is operated in conjunction with the two downstream dams: Arrowrock and Lucky Peak. Anderson Ranch Reservoir has a live capacity of approximately 450,030 acre-feet, consisting of 36,956 acre-feet of inactive capacity and 413,074 acre-feet of active capacity. The facility is a multipurpose project that stores and releases water from the 980-square-mile drainage area above Anderson Ranch Dam. The authorized purposes of the project include irrigation, flood control, power generation, and recreation. A permanent dead storage pool for the preservation and propagation of fish and wildlife and silt control also exists in Anderson Ranch Reservoir. The reservoir has a minimum pool at elevation 4039.6 feet (0 acre-feet active storage) below which 61,868 acre-feet of water is contained in inactive space (36,956 acre-feet) and dead pool space (24,912 acre-feet). Anderson Ranch Dam has three methods of discharging water from the reservoir that include discharging water through the hollow jet valves, powerhouse, and gated spillway. A 20-foot-diameter, concrete-lined outlet tunnel supplies water to the five hollow jet valves and the powerhouse with a combined hydraulic capacity of approximately 10,000 cubic feet per second (cfs) at full pool (elevation 4196 feet). The powerhouse is located at the base of Anderson Ranch Dam and consists of two 20-megawatt Francis turbine generating units with a total hydraulic capacity of approximately 1,600 cfs (800 cfs per unit). The gated spillway has a crest elevation of 4174 feet and a design capacity of approximately 20,000 cfs. In general, outside of maintenance needs (i.e., of powerplant or jet valves) or flood risk management (FRM) operations, use of the spillway is limited to times when Anderson Ranch Reservoir pool elevations are more than 4174 feet (spillway invert) and required reservoir discharges are greater than approximately 10,000 cfs (combined capacity of the powerplant and outlet works).

The following is a summary of typical water operations at Anderson Ranch dam and reservoir. However, various factors, such as previous year carryover, environmental conditions, maintenance activities, and irrigation demand can affect both the timing and magnitude of discharges (water released from the reservoir).

Starting in the fall and into early spring (September 16 to March 31), the minimum flow target below Anderson Ranch Dam for downstream fish habitat is 300 cfs. Typically, once the minimum flow has been set in the fall, the reservoir maintains a relatively constant elevation through the winter with inflow closely matching outflow. In wet years, the reservoir may fill slightly over the winter, and in dry years, the reservoir may draft slightly. Beginning April 1 and continuing through September 15, the minimum flow target for downstream fish habitat increases to 600 cfs. These minimum flow targets were determined through public meetings and consultation with the Idaho Department of Fish and Game (IDFG). It should be noted, these minimum flow targets may not always be met, and flows lower than the targets described above are possible, particularly in dry water years.

Beginning January 1 and generally continuing each month through July, the U.S. Army Corps of Engineers–Walla Walla District and Reclamation water management group generate and coordinate seasonal runoff volume forecasts for the Boise River basin. These forecasts are used to determine the reservoir space requirements to meet the FRM objectives in the basin. Reservoir releases from Anderson, Arrowrock, and Lucky Peak reservoirs are adjusted as necessary to meet the FRM objective. During these operations, Anderson Ranch Reservoir discharge varies as the reservoir is operated for FRM and reservoir refill. Discharge from Anderson Ranch Reservoir as recorded at the South Fork Boise River below Anderson Ranch Dam stream gauge for the water years 1981–2019 is shown in Figure 1.

Figure 1 shows that Anderson Ranch Reservoir discharge is often much higher than the 600 cfs minimum flow target during the early spring to early summer period due to FRM operations. After FRM operations have ended (usually early summer), reservoir releases typically range from the minimum flow target of 600 cfs up to the powerplant capacity of approximately 1,600 cfs. These flows are used to satisfy lower system objectives including: downstream irrigation demands; keeping Arrowrock Reservoir above its target minimum pool of 50,000 acre-feet at elevation 3110 feet (actual minimum is 37,912 acre-feet at elevation 3100 feet); and to balance storage in Anderson, Arrowrock, and Lucky Peak reservoirs in preparation for the next water year. The target minimum pool at Arrowrock Reservoir provides a real-time operational storage buffer to ensure it stays above the actual minimum as water is moved from one reservoir to another to meet irrigation demand downstream of Lucky Peak Dam.

After sufficient water for lower system objectives has been released, Anderson Ranch Dam discharge is typically reduced to the minimum flow target of 600 cfs until September 16, when discharge is reduced to the minimum flow target of 300 cfs. Historically, Anderson Ranch Dam discharge has been lower than 600 cfs before September 16 when there is a concern that the water supply may not be adequate to maintain a release of 300 cfs throughout the upcoming winter or when the reservoir is near empty. Conversely, discharge has at times been higher than 300 cfs after September 16 when necessary to meet lower system objectives. Discharge from Anderson Ranch Dam in excess of powerplant capacity are seldom made during the irrigation season unless needed for other lower system objectives.

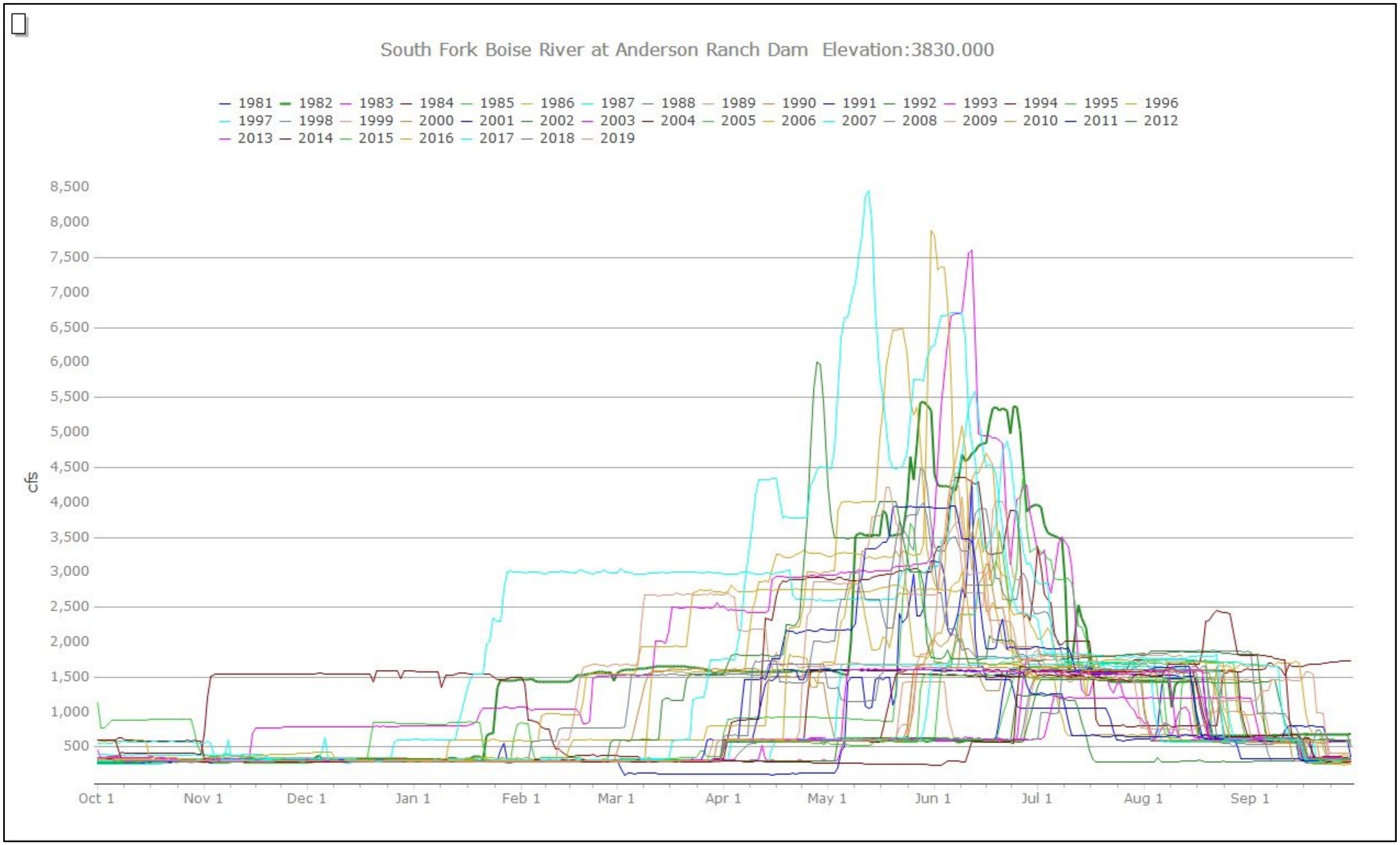

Figure 1. Anderson Ranch Dam historic discharge (cfs) water years 1981–2019

Page intentionally left blank.

3. Environmental Consequences

3.1 Methods for Evaluating Impacts

Evaluating impacts to water operations and hydrology includes using a combination of experience with historical reservoir system operations and quantitative computer modeling. Impacts to water operations and hydrology may be short term (during construction) or long term (after construction) and may be direct (impacts to actual reservoir operations), indirect (impact to meeting secondary operational targets) such as keeping Arrowrock Reservoir above its minimum target pool elevation of 3110 feet (actual minimum pool is 3100 feet), and/or cumulative (effects added to other projects' effects). Quantitative modeling results include figures of median, 10th/90th percentiles, and minimum and maximum values for various flow and reservoir conditions of the No-Action Alternative, Alternative B, and Alternative C. Impacts are determined by analyzing the difference in these values among the alternatives to identify the extent or duration (i.e., significance) of an impact to operational criteria.

The evaluation is based on historical hydrology and four different demand scenarios (used to capture the range of possible release timings and durations of the new storage volume) compared to the No-Action Alternative (continue unchanged from current operations). The model used to simulate the scenarios was the Boise Planning Model, a RiverWare version 7.5-based model (Regents of the University of Colorado, 2019). The model includes logic to simulate competing water demands in the system while adhering to legal water rights and physical constraints. Competing water demands include irrigation, flood control, minimum flow targets, ecological flow releases, and ecological storage constraints. The model was run at a daily time-step over a 50-year period (October 1, 1958, through September 30, 2008). More information about the water operations evaluation including analysis using climate change hydrology is included in Appendix F, Boise River Basin Feasibility Study–Water Operations Technical Memorandum.

Unlike real-time operations where runoff volumes need to be continually estimated throughout the season, the Boise Planning Model uses a "perfect forecast" where the runoff volume is already known. In some cases, the difference between historical operations and modeled operations is the result of the forecasted runoff volume because this drives FRM operations. In real-time operations, forecasted runoff volume is continually changing as the snow accumulation and runoff season progresses, inevitably causing flows to increase or decrease more often than what the model results show. This is important to keep in mind when interpreting the results of this modeling effort. Although the limitations of modeling may not capture all the complexities of real-time operations, it does provide a method to compare the results of different alternatives.

3.1.1 Assumptions

The following assumptions were made for this analysis.

- The analysis area encompasses Anderson Ranch Reservoir, the South Fork Boise River between Anderson Ranch Dam and Arrowrock Reservoir, Arrowrock Reservoir, Lucky Peak Reservoir, and downstream of Lucky Peak Reservoir to the Boise River at Glenwood Bridge gauge location.
- Impacts are assessed for the short term (during construction) and long term (after construction).
- The No-Action Alternative for this analysis is the modeled no-action condition (representing current reservoir operations) that was developed using the quantitative modeling described above.

3.1.2 Significance Criteria

The following criteria were used to determine whether an impact would qualify as a significant impact.

- Reduce the ability to provide system FRM for any period of time where the No-Action Alternative would have met FRM objectives. Significance of impact is not a discrete value, rather it is relative to the no-action condition.
- Reduce the ability to meet irrigation deliveries for any period of time where no action would have met irrigation deliveries. Significance of impact is not a discrete value, rather it is relative to the no-action condition.
- Reduce the ability to meet ecological constraints at Anderson Ranch reservoir and dam as compared to the no-action condition including:
    - 300 cfs target minimum flow from September 16 to March 31,
    - 600 cfs target minimum flow from April 1 to September 15, and
    - minimum pool elevation of 4039.6 feet (0 acre-feet active content).
- Reduce the ability to meet the minimum pool elevation of 3100 feet (37,912 acre-feet content) at Arrowrock Reservoir for any period of time as compared to the no-action condition.

3.2 Direct, Indirect, and Cumulative Impacts

3.2.1 Alternative A – No Action

Under Alternative A - No-Action, there would be no change to system operations as described in Section 2. Anderson Ranch dam and reservoir would continue to be operated in conjunction with Arrowrock and Lucky Peak dams and reservoirs based on water availability, irrigation demand, ecological constraints, and FRM requirements. There would be no additional storage space added to Anderson Ranch Reservoir (i.e. no opportunity for new (junior) water users to utilize new storage in Anderson Reservoir) and reservoir levels would not be increased. The modeling results for the No-Action Alternative are discussed here.

Modeling Results

The figures and tables below summarize the modeling results of the No-Action Alternative. The results in this analysis are generated from modeling the 50-year period from October 1958 through September 2008. Previous modeling completed for the Boise Feasibility Study (Reclamation, 2017) was done on a 28-year period from October 1980 through September 2008 and showed different results and refill probabilities. The longer period of record used in the EIS provides a wider range of runoff and storage conditions and sequencing of year types (wet versus dry). Refer to Appendix G, for differences in results and hydrology in the EIS due to using the different period of records.

In the summary plots below (see Figure 2 for an example), the median daily value of the 50-year modeled period for the No-Action Alternative is represented by the solid thin black line. The 10th-and 90th-percentile values of the 50-year modeled period for the No-Action Alternative are represented by light grey shading. The 10th- and 90th-percentile ranges were used to illustrate the predicted operational ranges in which 80% of all values would fall within these bounds. The dashed black lines represent the absolute maximum and minimum values of the 50-year modeled period for the No-Action Alternative. The 10th percentile is the value for which 10% of the data points are higher than the range. The 90th percentile is the value for which 10% of the data points are lower than the range.

Boise River System Storage

Median values for the No-Action Alternative (black line) indicate the lowest Boise River system storage typically occurs in October (after irrigation season ends) and in April (due to meeting FRM system space requirements; (Figure 2). Typical maximum system storage for the median value occurs in late to early July after FRM operations have ended. After maximum system storage occurs, the system begins to draft (decrease) to meet downstream irrigation demand.

The minimum system storage of approximately 52,000 acre-feet has occurred between July and October due to very dry water years. The maximum system storage carryover (after irrigation season ends) in mid-October was approximately 676,000 acre-feet.

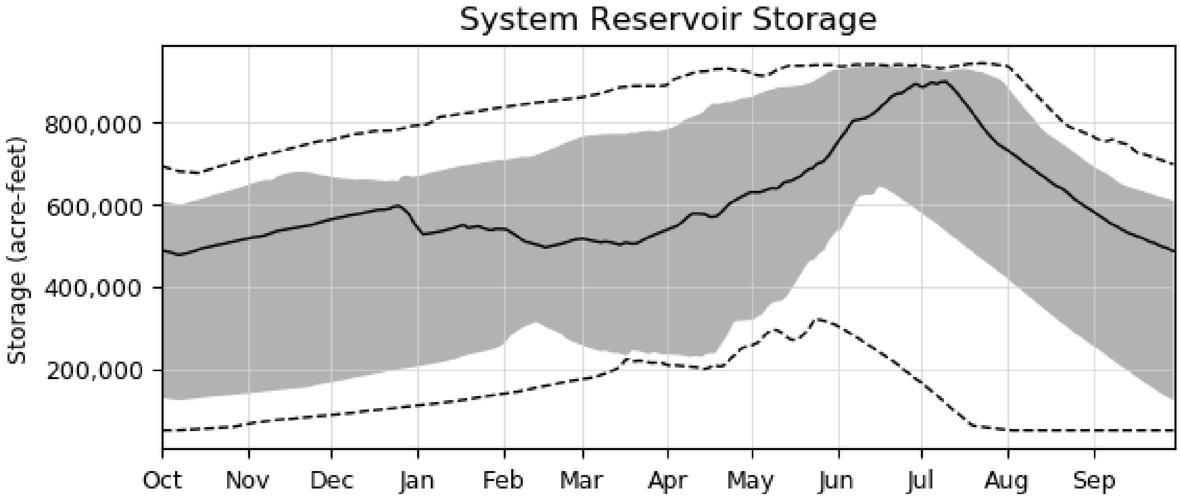

Figure 2. Boise River system summary plot depicting the daily median storage content for the No-Action Alternative (black line). The shaded grey region represents the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir

Anderson Ranch Reservoir Storage and Water Surface Elevation

Median results for the No-Action Alternative (black line) indicate the lowest Anderson Ranch Reservoir storage typically occurs in mid-April (due to meeting FRM space requirements; Figure 3). Typical maximum Anderson Ranch Reservoir storage for the median value occurs in late June to early July and after FRM operations have ended. After maximum Anderson Ranch Reservoir storage occurs, the reservoir begins to draft to meet downstream lower system objectives.

The minimum reservoir storage was never lower than the minimum pool of 0 acre-feet (pool elevation of 4039.6 feet) during the 50-year modeled period. The maximum reservoir carryover storage after irrigation season ends in mid-October was approximately 400,000 acre-feet, which occurred during very wet years.

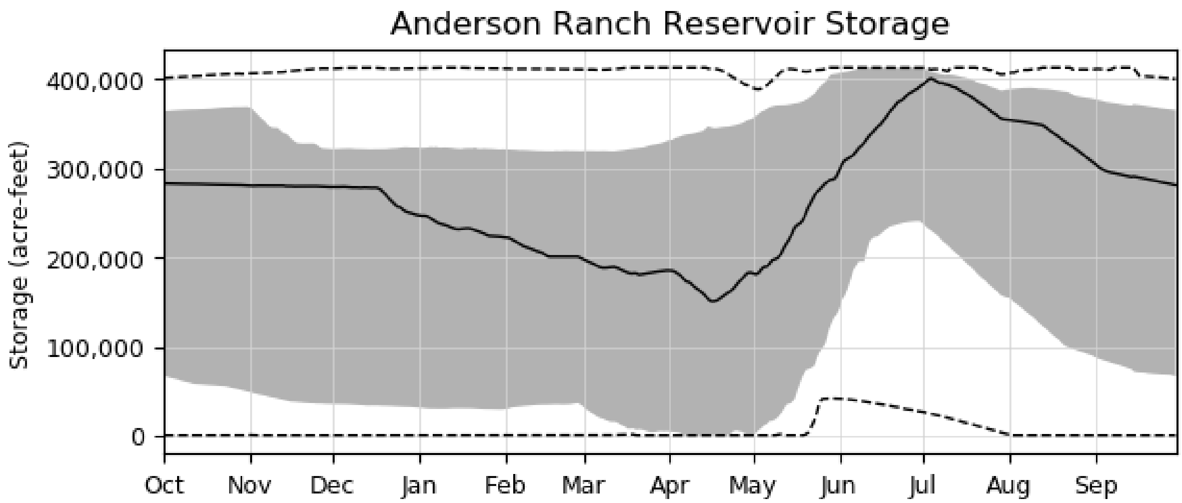

Figure 3. Anderson Ranch Reservoir summary plot depicting the daily median storage content range for the No-Action Alternative (black line). The shaded grey region represents the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Streamflow in the South Fork Boise River below Anderson Ranch Dam

The No-Action Alternative median streamflow (black line) in the South Fork Boise River below Anderson Ranch Dam shows that flows typically are at the target minimum flow of 300 cfs from October to the end of March (Figure 4). In April, streamflow increases to meet the 600 cfs target minimum flow and to control the refill of Anderson Ranch Reservoir and meet FRM operations. At the end of July, median streamflow transitions to moving water downstream to meet lower system objectives at an approximate flow rate of 1,600 cfs (powerplant capacity, dependent on head). The reduction in streamflow that occurs in late July and then subsequent increase in mid-August is a result of limitations of the model rule logic. The median streamflow increasing from 600 cfs in mid-August coincides with when Arrowrock Reservoir reaches its target minimum pool elevation of 3110 feet in the modeled scenario. In real-time operations, flows would not drop to the 600 cfs minimum at the end of July as shown in the modeled results, but instead would remain near powerplant capacity into August to reduce unnecessary changes in streamflow. The system (Anderson, Arrowrock, and Lucky Peak reservoirs) are in series, so the movement of water from Anderson Ranch Reservoir does not need to be delivered at exact time downstream irrigation demand calls for it but can be "shaped" depending on operational needs, such as recreational boating flows or maximizing the generation of hydroelectricity. While flows are typically shaped to meet the powerplant capacity, there may be times that a flowrate other than powerplant capacity or the minimum flow target may be needed, for instance when there is a maintenance requirement at one of the system reservoirs and a different flow rate is needed.

Maximum streamflow occurred in late April through mid-May with peak streamflow slightly above 6,000 cfs which coincides with when Anderson is operated to control the reservoir refill and meet FRM objectives. Minimum flows show that the target minimum flows (300 cfs and 600 cfs depending on time of year) have not always be meet, specifically in very dry water years (occurred in 1992 and 2002 in modeled period).

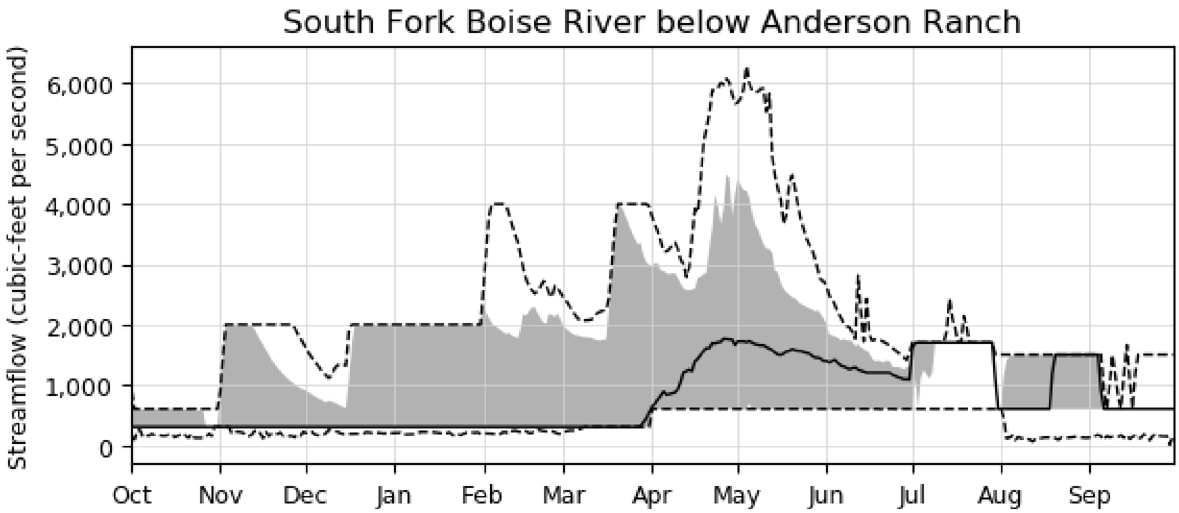

Figure 4. South Fork Boise River below Anderson Ranch Dam streamflow summary plot depicting the daily median range for the No-Action Alternative (black line). The shaded grey region represents the 10th-percentile to 90th-percentile range; the dashed lines represent the maximum and minimum values.

Anderson Ranch Dam Spillway

Modeling of the No-Action Alternative indicates no requirement to use the spillway at Anderson Ranch Dam. When pool elevations are more than 474 feet, releases more than 10,000 cfs require use of the spillway. The maximum discharge from Anderson Ranch Reservoir for the No-Action Alternative was approximately 6,000 cfs and therefore the use of the spillway was determined to not be required. It should be noted that in real-time operations, the spillway may be used as needed for flexibility during FRM operations or may be required due to maintenance needs of either the powerplant or outlet tubes.

Arrowrock Reservoir Storage and Water Surface Elevation

Modeling results for the No-Action Alternative (black line) indicate the lowest median Arrowrock Reservoir storage typically occurs in mid-August due to drafting to meet downstream irrigation demand (Figure 5). During this time, water from Anderson Ranch Reservoir is delivered to meet downstream lower system objectives which includes keeping Arrowrock Reservoir above its target minimum content of 50,000 acre-feet. Maximum reservoir storage for the median value occurs from mid-December through mid-July.

The minimum Arrowrock Reservoir storage never drafted below the target minimum pool of 50,000 acre-feet (actual minimum pool is 37,912 acre-feet) during the 50-year modeled period. Using the target minimum content of 50,000 acre-feet in the modeling aligns with real-time operations by providing a storage “buffer” while also in real-time operations there have been times (e.g., due to required maintenance) that the reservoir has drafted below the target minimum content.

The maximum Arrowrock Reservoir carryover storage after irrigation season ends in mid-October was approximately 200,000 acre-feet, which occurred during very wet years.

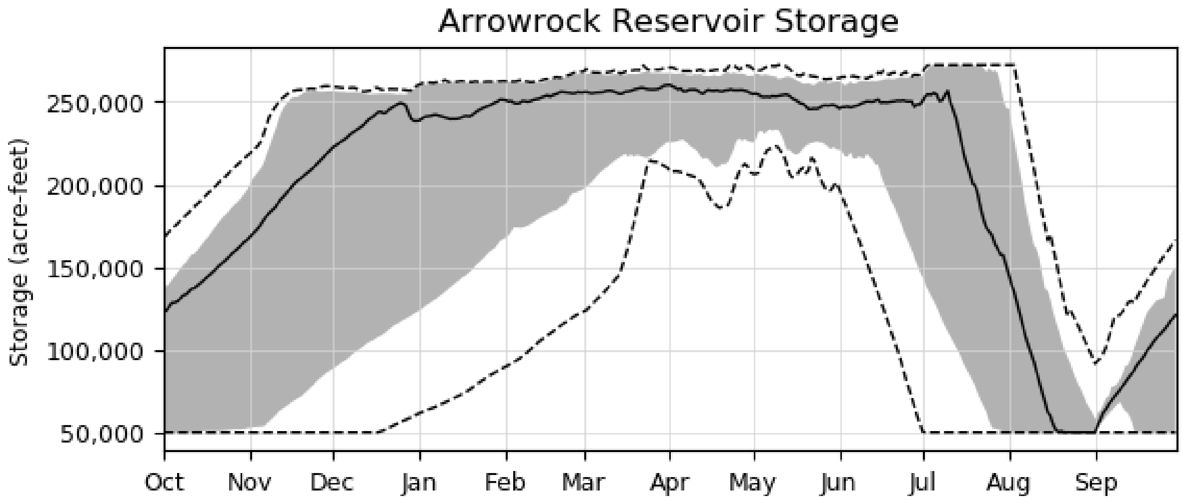

Figure 5. Arrowrock Reservoir storage summary plot depicting the daily median storage content range for the No-Action (black line). The shaded grey region represents the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values.

Lucky Peak Reservoir Storage and Water Surface Elevation

Modeling results for the No-Action Alternative (black line) indicate the lowest median Lucky Peak Reservoir content typically occurs in early October through February (Figure 6). During this time, Lucky Peak Reservoir is operated to stay below the target "elk pool" elevation of 2960 feet. The term elk pool refers to a soft operational target of holding the water surface elevation of Lucky Peak Reservoir at a level no higher than 2960 feet (63,600 acre-feet content) during January and February each year to reduce potential elk mortality while crossing the Mores Creek arm of the reservoir. This soft target cannot always be met, particularly in late February when Arrowrock Reservoir approaches full and begins to pass inflow into Lucky Peak Reservoir, causing it to fill above the 2960 feet level (as shown by grey shading up to the 10th percentile and maximum values). Maximum Lucky Peak Reservoir content for the median value occurs from mid-June through mid-August. After mid-August, the reservoir begins to draft to meet the remaining irrigation demand for the season as well as draft back down to the elk pool. As can be seen in the 10th- and 90th-percentile shading, the timing of when Lucky Peak Reservoir is full for recreation can vary based on whether it is a dry or wet water year, where a dry year may fill earlier (due to little FRM requirements) but draft sooner and a wet year may fill later (due to more FRM requirements) but stay full later in the season (sometimes until Labor Day).

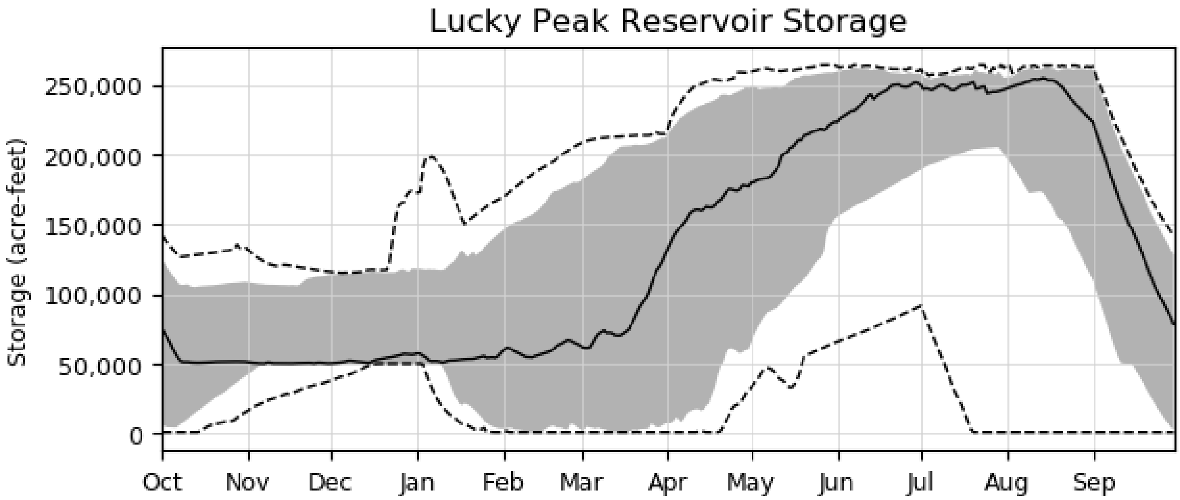

Figure 6. Lucky Peak Reservoir summary plot depicting the daily median storage range for the No-Action (black line). The shaded grey region represents the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values.

Streamflow at Boise River at Glenwood

The Anderson, Arrowrock, and Lucky Peak systems are collectively operated to provide FRM operations and limit flows (when possible) to 6,500 cfs or less at the Boise River at Glenwood Bridge location. As stated earlier, the model uses a "perfect forecast" where the runoff volume is already known. This is important to keep in mind when interpreting the modeling results because 10th percentile streamflow during the modeled period was limited to 6,500 cfs while historical operations have resulted in higher flows (and as shown by maximum values). Although the modeling assumptions may not capture all the complexities of real-time FRM operations, it does provide a method to compare the results of different scenarios (No-Action Alternative versus other alternatives).

The No-Action Alternative median streamflow (black line) at the Boise River at Glenwood Bridge location shows that flows typically are at the target streamflow maintenance flow of approximately 240 cfs (as jointly coordinated by Reclamation and IDFG) from October to early April (Figure 7). In April, the flows increased due to FRM operations to control the refill of the system and meet forecast-based space requirements. Median flows decrease back down to irrigation demand by mid-June and remain there until the end of irrigation season.

Maximum streamflow occurred in May and June due to FRM operations for large runoff volume water years where streamflow reached approximately 8,500 cfs. Looking at the 10th-percentile flows shows that FRM operations can occur as early as November when streamflow was approximately 2,000 cfs. Minimum streamflow remained near the streamflow maintenance flow of approximately 240 cfs during the non-irrigation season and the carriage flow of approximately 240 cfs during the irrigation season.

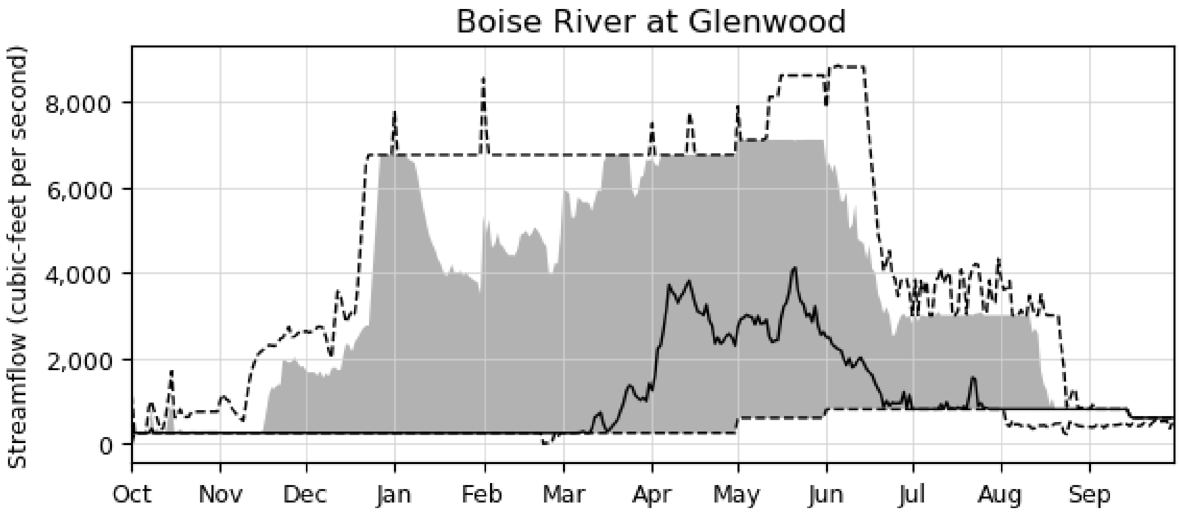

Figure 7. Boise River at Glenwood summary hydrograph depicting the daily median streamflow for the baseline condition (black line). The shaded grey region represents the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values.

Flow Augmentation

On May 5, 2008, National Oceanic and Atmospheric Administration (NOAA) Fisheries released a new biological opinion (2008 Upper Snake River BiOp; NOAA Fisheries, 2008) for the continued operations and maintenance of Reclamation projects in the Snake River basin above Brownlee Reservoir. The Boise River system is part of the larger Upper Snake River basin and covered by the 2008 Upper Snake BiOp. As described in the proposed action in the 2008 Upper Snake River BiOp, and as mandated by the 2004 Snake River Water Rights Act of 2004, Reclamation is required to provide water for downstream ecological needs, specifically to benefit migrating salmon and steelhead, known as “flow augmentation water” or flow augmentation. The flow augmentation water is provided from multiple sources including: Reclamation’s uncontracted, powerhead reservoir space, annual storage rentals, acquired natural flow water rights, and leased natural flow water rights. Each year, Reclamation relies heavily on annual rentals from water users to acquire storage water for its flow augmentation program. The annual target for flow augmentation from the entire Upper Snake system is 427,000 acre-feet and can be as much as 487,000 acre-feet, depending on annual water supply conditions.

Separate from flow augmentation requirements as previously noted, through interagency coordination, Reclamation works with NOAA Fisheries and the Columbia River Technical Management Team to coordinate Upper Snake River system flow augmentation releases. Upper Snake River flow augmentation is intended to enhance flows in the lower Snake and Columbia rivers for out-migrating juvenile salmon and steelhead. Flow objectives and actual flows at Lower Granite Dam during the spring migration period are used to help determine flow augmentation release timing. The flow objectives at Lower Granite Dam vary between 85,000 cfs and 100,000 cfs (depending on water supply forecasts) during the spring (April 3–

June 20). It is important to note that Lower Granite Dam flow objectives are guidelines and often difficult to meet throughout the entire fish migration period, especially in dry years.

The timing of flow augmentation releases depends on the individual basin and source of water. In the 2008 BiOp, Reclamation committed to shifting releases to earlier in the migration season when Snake River flows are more beneficial to Federally protected out-migrating juvenile salmon and steelhead. The primary goal of the earlier releases is to minimize the amount of warmer water provided in August and to shift it into July or earlier. The opportunity and ability to shift the releases would vary depending on the water year type, total augmentation volume available, and from which basin the augmentation originates.

Delivering water earlier in the Boise River basin for flow augmentation relies on a combination of two strategies. First, in flood-control years when the system is assured to fill, some portion of the augmentation volume would be delivered by reserving an equivalent amount of system space that is not allowed to refill. In other words, as flood-control operations near their end, releases are not decreased to fill the last remaining space; that vacant space is considered to have been delivered as flow augmentation instead. In dry years, when the reservoir system is not going to completely refill, the flow augmentation can be released the day of allocation (DOA; the date in water rights accounting where storage accounts have reached their maximum accrual).

It should be noted that current model limitations result in flow augmentation releases beginning only after the DOA. The delay in the release of flow augmentation water can be seen where 10th- percentile flows recede in June leading up to the DOA and then slightly increase after the DOA has occurred. In real-time, operations are conducted such that the system can opportunistically not fill the entire storage space, which allows water to be released earlier in the season and allows flows to decrease in late July and early August as shown in Figure 7. In real-time operations, the portion of space not filled counted toward flow augmentation must be verified after the DOA to validate that the space could have been refilled. This real-time operation results in more of the flow augmentation volume being released earlier in the season unlike what is shown in the model results (because of the variability in this operation, the model was not able to simulate it).

3.2.2 Alternative B – 6-foot Dam Raise with Associated Projects

Alternative B (preferred alternative) is a 6-foot Anderson Ranch Dam raise with associated projects (Cow Creek Road realignment and regrading, reducing road curvature near the approach of the dam). The 6-foot raise increases the storage capacity of Anderson Ranch Reservoir by approximately 29,000 acre-feet to a total active capacity of approximately 442,074 acre-feet. The 6-foot dam raise equates to a 6.4% increase in the active capacity of Anderson Ranch Reservoir and a 3% increase in the system (Anderson, Arrowrock, and Lucky Peak reservoirs).

Construction Period

Construction activities associated with the 6-foot dam raise would require Anderson Ranch Reservoir to be no higher than the proposed pool restriction elevation and would require the installation of a coffer dam (Reclamation, 2019). Pool restrictions down to either elevation 4174 feet or 4184 feet are currently proposed based on the flood routing study performed by the Reclamation Technical Services Center. If Alternative B is found feasible by the Commissioner of Reclamation, a more in-depth reservoir frequency analysis (RFA) would be completed to determine the optimal pool restriction. Based on the current analysis, the optimal restriction is assumed to be higher (less restrictive) than the currently proposed restriction elevation of 4174 feet. For purposes of the EIS analysis, the more conservative restriction elevation of 4174 feet (restriction) are summarized as impacts due to this lower restriction elevation would have larger impacts should a higher (less restrictive) restriction elevation be determined after the RFA is completed during final design. The current construction schedule requires Anderson Ranch Reservoir to be drafted to the 4174-foot pool restriction elevation by the end of August and for pool elevations to remain below this level for a total of approximately 42 months.

Depending on the first year of construction hydrologic conditions, outflows from Anderson Ranch Reservoir to meet lower system objectives would likely be sufficient to draft the reservoir to the 4174-feet restriction elevation by the end of August. If water supply conditions are higher than average and the reservoir is not projected to meet the 4174-feet restriction target by then end of August, releases would be adjusted (increased discharge or duration) as needed earlier in the season to meet the restriction elevation but would remain near typical historical flows during this time (Figure 1). Within the constraints of system FRM space requirements, the additional water released from Anderson Ranch Reservoir would be stored in either Arrowrock or Lucky Peak reservoir for the following irrigation season.

Modified FRM Operations during Construction

As stated earlier, Anderson Ranch Reservoir is operated in conjunction with Arrowrock and Lucky Peak reservoirs to provide FRM. Reducing Anderson Ranch Reservoir active space during the dam raise construction period could result in impacts to the existing FRM operations. Potential impacts to FRM operations caused by the pool restriction during the construction period of the Anderson Ranch Dam raise is summarized below but a more detailed description of the analysis can be found in Appendix G.

There is no specific FRM objective immediately downstream of Anderson Ranch Reservoir. Discharge from the reservoir varies during the spring as the reservoir is operated for FRM and reservoir refill. Spillway use at Anderson Ranch Dam is limited to emergencies or if required during FRM operations. In general, the discharge is targeted to remain lower than 9,500 cfs to limit localized flood damages downstream of the dam (based on minimal impacts experienced in 2017 at a discharge of 9,500 cfs). For purposes of this FRM analysis, Anderson Ranch Reservoir outflows were conservatively limited to approximately 7,200 cfs to represent the maximum outflow (hydraulic capacity) when the reservoir is at 0 acre-feet active storage. Doing this limited Anderson Ranch Reservoir outflows during evacuation or holding FRM space when the reservoir was near empty even though hydraulic capacities greater than this would be available as the reservoir refills.

A multi-stepped approach was taken to determine the magnitude, duration, and likelihood of impacts to system FRM operations as a result of the Anderson Ranch Reservoir pool restriction during the dam raise construction period. Screening criteria were developed to focus the analysis on the historical hydrologic conditions that were likely to cause impacts. Historical runoff volume hindcasts developed for this analysis along with the model results were used to identify historical water years falling within the screening criteria. Finally, the screened historical water years were analyzed in depth using the Reclamation real-time operations spreadsheet model. Simulations of FRM operations under the existing condition (baseline) and the Anderson Ranch Reservoir 4174 pool restriction (restriction) were completed, allowing for a comparison of the two operations. Any difference between the two simulations could be attributed to impacts from the pool restriction.

The following FRM impact analysis criteria were used in this analysis to screen historical water years requiring additional in-depth analysis using the spreadsheet.

1. Impact to static system space requirement
    a. November 1–December 31 space requirement of 300,000 acre-feet (165,000 acre-feet in lower system)
    b. January 1–March 30 minimum space requirement of 300,000 acre-feet to 50,000 acre-feet depending on forecast
2. Impact to dynamic forecast based system space requirement (January 1–July 15)
    a. Total system FRM space requirement greater than available due to restriction
    b. Total system FRM space requirement requiring space to be provided by Anderson Ranch Reservoir
3. Change in flow below Lucky Peak Dam that increased flows to 6,500 cfs or more.
4. Change in flow below Anderson Ranch Dam that increased flows to more than 5,000 cfs.

Table 1 summarizes the 21 water years (ranked by the January-through-July historical runoff volume) that were identified for this analysis using the Reclamation spreadsheet model. Water years that were identified had historical runoff volumes that ranged from 198% to 92% of average (1981–2010 average period).

Table 1. Summary of water years analyzed using the spreadsheet (thousands of acre-feet)

WY	Jan-Jul (kaf)	Jan-Jul (% avg)
2017	3,146	198%
1997	3,127	197%
1965	3,111	195%
1971	3,013	189%
1983	2,893	182%
1974	2,841	178%
1982	2,811	177%
1972	2,787	175%
1956	2,703	170%
1952	2,505	157%
1996	2,487	156%

WY	Jan-Jul (kaf)	Jan-Jul (% avg)
2006	2,440	153%
1984	2,414	152%
1969	2,290	144%
1958	2,205	139%
1951	2,180	137%
1975	2,116	133%
1957	2,111	133%
1978	1,980	124%
1993	1,857	117%
2008	1,501	94%
1960	1,472	92%

Initial conditions for the spreadsheet analysis started with the assumption that carryover storage from the previous water year was above average and the initial space provided was the 300,000 acre-feet static space requirement from November 1 through December 31. This assumption provides the worst-case carryover scenario for FRM purposes. The following summarizes the FRM impacts due to the restriction scenario found using the spreadsheet analysis.

- The restriction scenario did not increase the annual peak flow frequency of the Boise River at Glenwood Bridge for the 1950–2019 period.
- For all water years that would require more system FRM space than available or would require space in Anderson.

  The restriction scenario was able to keep flows at Glenwood to 6,500 cfs or less (except for 1983 and 2017).
  When the baseline and restriction did not draft the system to empty, there were minimal if any changes in flow below Anderson Ranch Dam and at Glenwood
  When the baseline did draft the system empty, the restriction scenario was not able to provide the total system FRM space required and resulted in flows decreasing sooner during the evacuation period (due to system being empty earlier) and staying at 6,500 cfs for longer during refill.
  For higher water years, some space would need to be reserved to limit flows to the 7,200 cfs target. This would need to be further investigated if the project moves forward and may be a designated percent of total system space that would be required to be held in Anderson Ranch Reservoir.

- This analysis used a target flow of 6,500 cfs at Glenwood Bridge, while historically, higher flows than this have been required. For instance, over the last 10 water years, peak flows at Glenwood Bridge have exceeded 6,500 cfs for 4 of the water years. Using 6,500 cfs in this analysis provides a conservative method to determine the FRM risk.
- Below Anderson Ranch Reservoir, the restriction scenario had similar flows to the baseline with most differences occurring when flows reduced earlier during the evacuation period but remaining higher during refill.

Based on the analysis, it appears the risk to FRM operations is low during the 4174 restriction. Having said that, FRM mitigation measures during the pool restriction would be necessary. The following is a list of preliminary FRM mitigation measures that would need to be adhered to during the 4174 restriction.

1. Provide the November 1–December 31 space requirement of 300,000 acre-feet (165,000 acre-feet in lower system).
2. Provide the January 1–March 30 minimum space requirement of 300,000 acre-feet to 50,000 acre-feet depending on forecast.
3. Provide the dynamic forecast-based system space requirement (January 1–July 15) or draft system to empty, whichever is less.
4. Develop guidance for the percent of total system space that would be required to be held in Anderson Ranch Reservoir based on a local reservoir runoff volume forecast and maximum target discharge.
5. Identify operational triggers when construction would need to be delayed due to severe hydrologic conditions and develop action plan to identify lead times required to demobilize equipment.

Modeling Results for Construction Period

Modeling results for the restriction are provided below. The results presented below are from the entire 50-year modeled period and although the proposed restriction duration is estimated to only last 4 years, this 50-year analysis does provide a bound of all consecutive 4-year sequences contained within the modeled period. Median modeling results for the restriction (red line) indicate a similar pattern (although lower) of system content refill and draft as compared to the No-Action Alternative (Figure 8). As compared to the No-Action Alternative the restriction median peak system content was approximately 73,000 acre-feet less. The maximum system content of the restriction diverges from the No-Action Alternative starting in November and remains up to approximately 96,000 acre-feet less until the end of August. Minimum system content is similar between the restriction and No-Action Alternative.

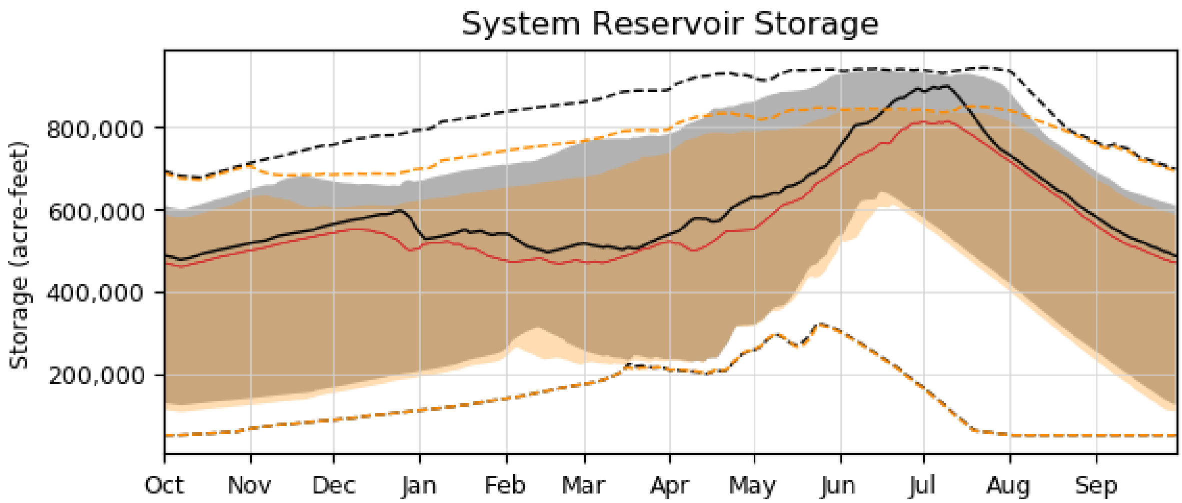

Figure 8. Boise River reservoir system storage hydrograph depicting the daily median storage content range for the restriction (red line) and daily median for the No-Action Alternative (black line). The shaded orange region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by the restriction and the No-Action Alternative, respectively. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Median modeling results for the restriction (red line) indicate a similar pattern of Anderson Ranch Reservoir content refill and draft as compared to the No-Action Alternative (Figure 9). The median peak of the restriction was approximately 95,000 acre-feet less but with the same timing of refill. The median content of the restriction shows deeper required drafts to meet FRM requirements. The maximum Anderson Ranch Reservoir content of the restriction is near consistently 96,500 acre-feet less than the No-Action Alternative. Minimum reservoir storage is similar between the restriction and No-Action Alternative and never drafted below the minimum pool of 0 acre-feet.

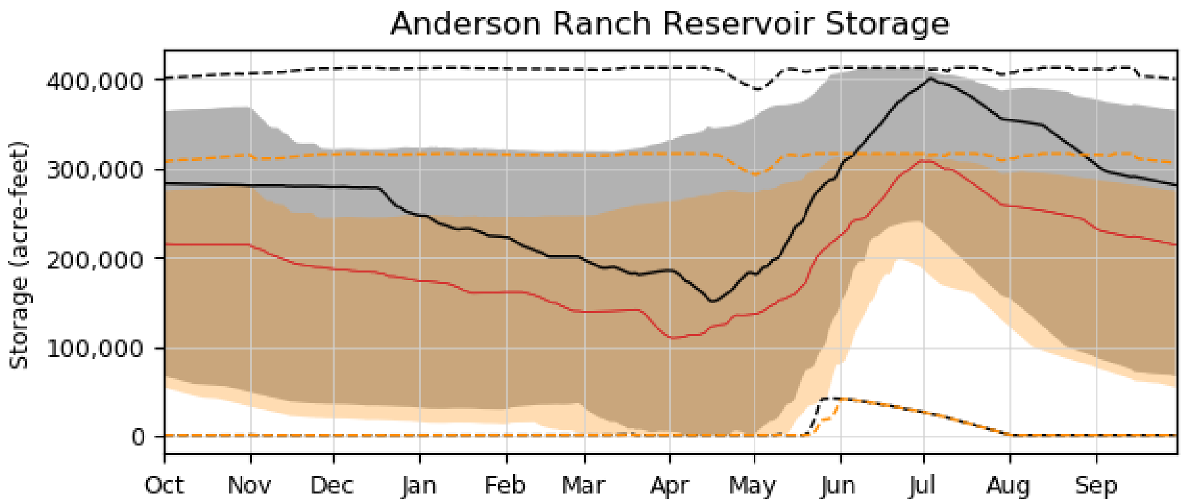

Figure 9. Anderson Ranch Reservoir storage hydrograph depicting the daily median storage content range for the restriction (red line) and No-Action Alternative (black line). The shaded orange region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by the restriction and the No-Action Alternative, respectively. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Drawdown of Anderson Ranch Reservoir storage during the construction period has the potential to result in reduced fill to reservoir storage accounts. The amount of shortfall would be dependent on runoff conditions. Only in the driest of years does Anderson Ranch Reservoir pool elevation remain below the restriction elevation of 4174 feet. In other years, the volume of shortfall can be defined as the difference between the fill amount the reservoir could have achieved under normal operations and the amount of fill achieved under the pool restrictions.

This analysis focuses on the maximum potential shortfall, representing a condition where the reservoir could have filled completely, but the restriction limited the amount of fill. This analysis also assumes that the ability to fill downstream reservoirs would not be impacted by the Anderson Ranch Reservoir restriction. The maximum volume of shortfall per year under the restriction is then calculated as the full-pool volume minus the restricted-pool volume, resulting in a shortfall of approximately 97,000 acre-feet per year that would have completed refilled.

Assuming the shortfall volume would be shared proportionally among current Anderson Ranch Reservoir space holders, the maximum shortfall volume for each space holder is calculated as the total shortfall volume multiplied by the percent of total space owned. The shortage assumption above would need to be coordinated with current space holders using the mitigation measures (or others identified) provided in Section 3.4 but shortage assumptions would need to be modified if agreement between space holders is not found. Inactive space in Anderson Ranch Reservoir is not included in the shortage assumptions because including this has the potential to impact the reliability of flow augmentation. Table

2 depicts the amount of space owned, the percent of space owned, and the shortfall volume per year under two different restriction elevations (4174 feet and 4184 feet) for each Anderson Ranch Reservoir space holder. Based on modeling results of the No-Action Alternative, a maximum shortfall of 96,555 acre-feet could be expected to occur and may occur for all years during the restriction.

Table 2. Anderson Ranch Reservoir space holders and the amount of space owned, percent of space owned (excluding power head), and the potential maximum shortfall volumes under two different pool elevation restrictions.

Space Holder	**Space Owned** ***acre-ft***	**Percent of Total Space** ***%***	**Shortfall Volume for 4,174 ft Restriction** ***acre-ft/year***	**Shortfall Volume for 4,184 ft Restriction** ***acre-ft/year***
Trinity Springs	800	0.19%	187.00	105.99
New York	351,554	85.11%	82,174.86	46,576.39
Surprise Valley/Micron	3,000	0.73%	701.24	397.46
Ridenbaugh	14,785	3.58%	34,55.96	1,958.82
Bubb	531	0.13%	124.12	70.35
Suez Water	1,000	0.24%	233.75	132.49
Settlers	5,675	1.37%	1,326.52	751.86
Farmers Union	5,593	1.35%	1,307.35	741.00
Boise Valley	939	0.23%	219.49	124.41
Capitol View	449	0.11%	104.95	59.49
New Dry Creek	1,266	0.31%	295.92	167.73
Ballentyne	367	0.09%	85.79	48.62
Phyllis	24,986	6.05%	5,840.41	3,310.32
Little Pioneer	2,123	0.51%	496.25	281.27
Uncontracted	6	0.00%	1.40	0.79
TOTAL	413,074	100%	96,555	54,727

The restriction median streamflow (red line) at the South Fork Boise River below Anderson Ranch Dam shows that flows are slightly higher than the No-Action Alternative starting in late March when the reservoir begins FRM operations but by late July are similar (Figure 10). The maximum flows (orange dashed line) indicate higher peak flows (approximate increase of 1,000 cfs as compared to No-Action Alternative) during the late April through July due to the reduced storage available for the restriction scenario. Minimum flows in the restriction scenario are very similar to the No-Action Alternative. Additional more in-depth analysis on peak flows below Anderson Ranch Dam for the restriction scenario can be found in Appendix G.

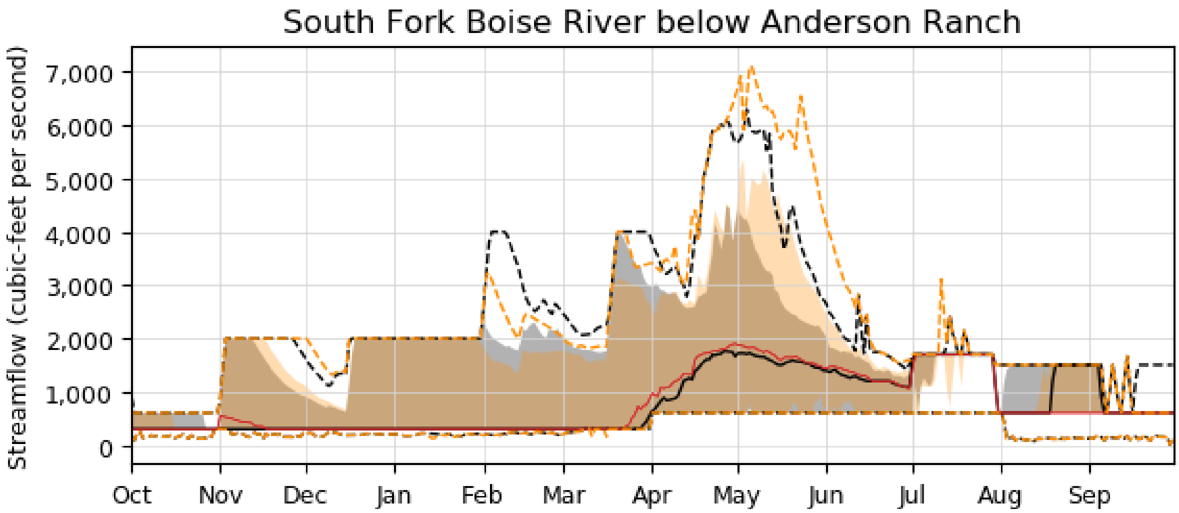

Figure 10. South Fork Boise River below Anderson Ranch Dam streamflow hydrograph depicting the daily median range for the restriction (red line) and No-Action Alternative (black line). The shaded orange region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by the restriction and the No-Action Alternative, respectively.

Median modeling results for the restriction (red line) indicate an earlier refill of Arrowrock Reservoir as compared to the No-Action Alternative (Figure 11)). Median results for the restriction scenario also show a delay when Arrowrock Reservoir begins to draft in mid-July. Median storage for the restriction begins to refill in early September, which is very similar to when the No-Action alternative begins to refill. In general, during the restriction, Arrowrock Reservoir storage is higher than what is shown in the No-Action Alternative.

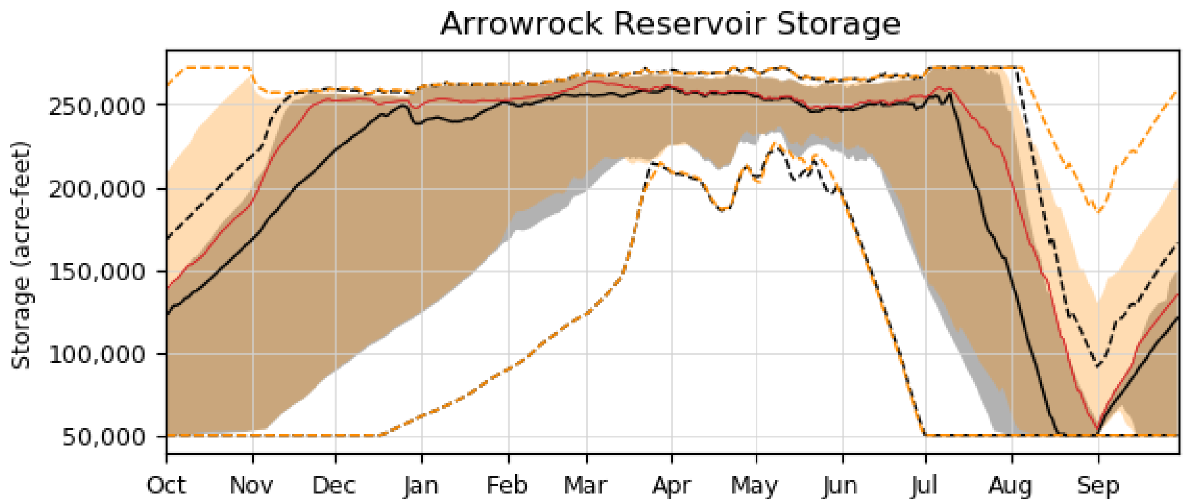

Figure 11. Arrowrock Reservoir storage hydrograph depicting the daily median storage content range for the Restriction (red line) and the No-Action Alternative (black line). The shaded orange region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by the restriction and the No-Action Alternative, respectively.

Median modeling results for the restriction show higher Lucky Peak Reservoir storage during the October through March period (Figure 12). Due to Anderson Ranch Reservoir staying below the restriction elevation of 4174 feet, water is moved downstream and is held within Arrowrock and Lucky Peak reservoirs. Therefore, maintaining the elk pool elevation during the restriction may be harder to accomplish during the restriction period. In real-time operations, there may be more flexibility (by drafting Lucky Peak Reservoir sooner in August to reduce pool elevation) than what is modeled but it is acknowledged that the target elk pool may not be maintained as frequently during the restriction period. For impact of flows downstream of Lucky Peak Reservoir at the Boise River at Glenwood Bridge, refer to the section titled *Streamflow at Boise River at Glenwood* above and Appendix G.

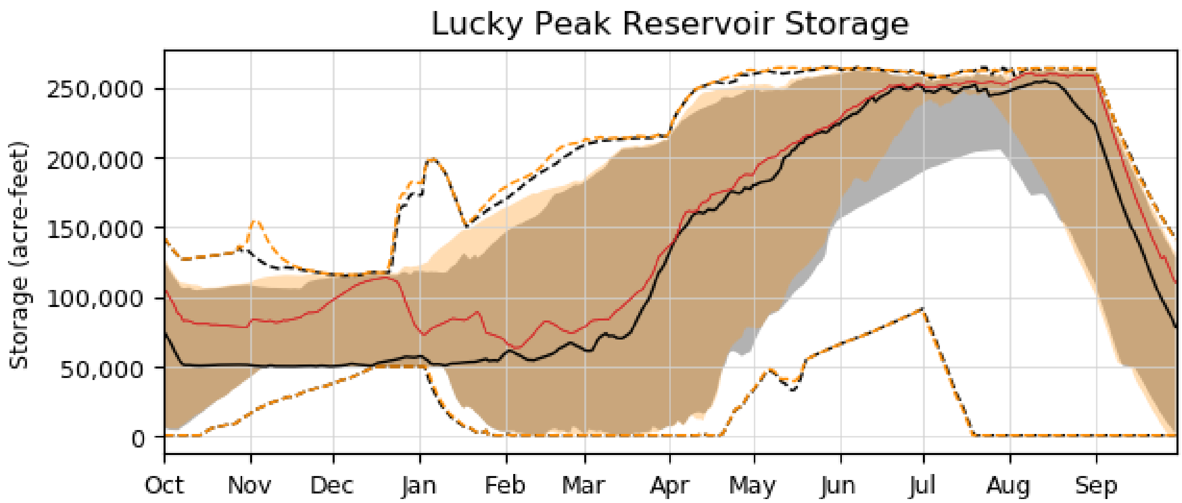

Figure 12. Lucky Peak Reservoir summary storage hydrograph depicting the daily median storage content range for the restriction scenario (red line) and daily median for the baseline condition (black line). The shaded yellow region and shaded gray region represent the 10th-percentile to 90th-percentile range captured by restriction scenario and the baseline condition, respectively. Dashed blue and black lines represent the daily minimum and maximum values.

The Restriction would not have a significant impact to system FRM, a high likelihood of impacting irrigation deliveries, and may reduce the likelihood of staying below the elk pool at Lucky Peak Reservoir.

Description of Operations Post Construction

Four demand scenarios were modeled to portray a range of potential release timings, rates, and durations associated with the increased storage. The scenarios include: 1) no new demand, 2) new early-season demand, 3) new late-season demand, and 4) new municipal and industrial (M&I) demand. Table 3 describes the demand scenarios in more detail. The results of the four demand scenarios described above were used to develop a range of possible flow and reservoir conditions associated with the dam raise referred to as Alternative B. Flood-control operations remained similar to the No-Action Alternative because the new storage space is not anticipated to be used for FRM.

Table 3. Scenario descriptions

Scenario Number	Scenario Name	Description
1	No New Demand	The No New Demand pattern is based on the potential condition where the new space is used to satisfy existing surface water demands in cases where shortage might have otherwise occurred. In this scenario water users above Glenwood have access to the accrued storage on an as-needed basis. The modeling scenarios assumed that if seasonal flow targets during the irrigation season were meet at Glenwood that this would also satisfy irrigation downstream of Glenwood.
2	New Early-Season Demand	The New Early-Season Demand pattern is based on the potential condition where water accrued to the new space might be called upon early in the irrigation season. This is similar to the release of storage for flow augmentation (NOAA Fisheries, 2008) in the spring and early summer. Use of accrued storage in this scenario is limited by flows at Glenwood, where flow augmentation releases occur only when flows at this location are less than 3,000 cfs. As a result of this limitation, water accrued to the new storage account may not be completely exhausted every year.
3	New Late-Season Demand	The New Irrigation Season Demand pattern is based on the condition where water accrued to the new space is delivered during the irrigation season to new users. The water is released at a constant rate from the day the system is full (day of allocation) through October 15; 10% of the water accrued to the new account is reserved for flow augmentation deliveries.
4	New M&I Demand	The New M&I Demand pattern is based on the potential condition where water accrued to the new space is delivered for M&I purposes. The water is released at a rate that changes depending on the time of year, similar to current M&I groundwater deliveries (SPF Water Engineering, 2016 – Table 13) from day the system is full (day of allocation) through March 15 of the following year; 10% of the water accrued to the new account is reserved for flow augmentation deliveries.

Modeling Results

The figures and tables below summarize the results of this modeling effort. In the figures (see Figure 13 for an example), the median daily value of the No-Action Alternative is represented by the solid thin black line. The bounds of the median daily values of Alternative B are represented by the red band (range of demand scenarios 1–4 described in Table 3). Modeling results show 10th- and 90th-percentile ranges to illustrate the predicted operational ranges. The 10th- and 90th-percentile values of the No-Action Alternative scenario are represented by light grey shading. The 10th- and 90th- percentile values of Alternative B are represented by light blue shading. When the 10th- percentile and 90th- percentile values of the No-Action Alternative and Alternative B overlap, the shading is darker blue. When they do not overlap, only the light blue shading or light grey shading appears (see shading on Figure 13 for March 1). The dashed black and blue lines represent the absolute maximum and minimum values of the No-Action Alternative and Alternative B, respectively.

System Storage

Median modeling results for Alternative B (red band) indicate a potential for increased system storage relative to the No-Action Alternative (solid black line) as shown in Figure 13. The average median monthly system content of Alternative B scenario was found to be anywhere from approximately 400 acre-feet to 29,000 acre-feet higher. Similarly, the maximum value of system content (blue dashed line) increased to approximately 29,000 acre-feet for all months of the year and represents the demand scenario 1 when the new storage was not used but carried over to the next year. Minimum system content of Alternative B was nearly identical to the No-Action Alternative with very little, if any, difference. The general shape of system content refill and draft of Alternative B was also very similar to No-Action Alternative.

Alternative B had system storage values that exceeded the No-Action Alternative for most times of the year by various amounts dependent on the demand scenario. Although the increased amount was minimal in relation to the total system content, Alternative B would not have a significant impact on system FRM, meeting existing water deliveries, and meeting ecological constraints.

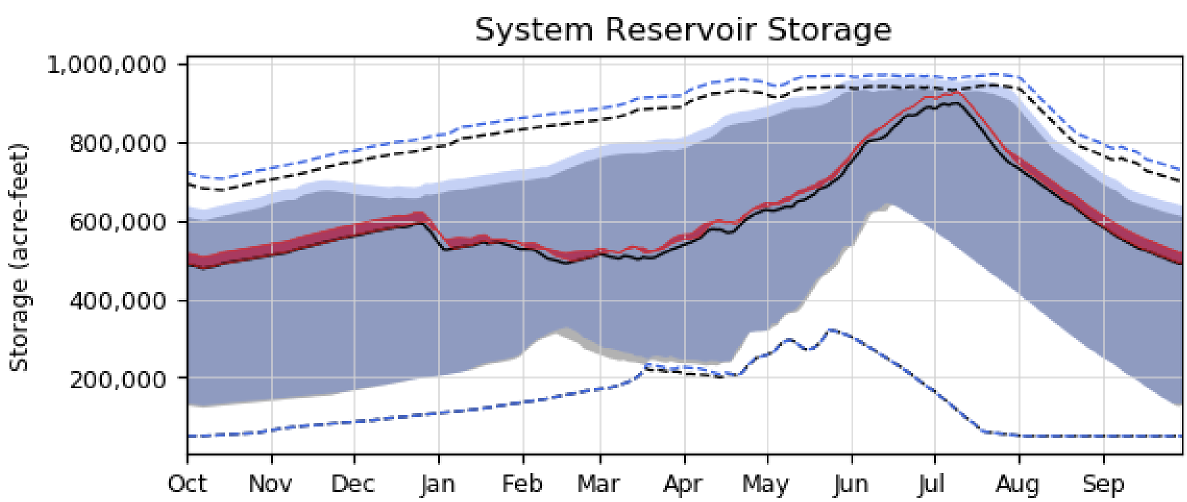

Figure 13. Boise reservoir system storage hydrograph depicting the daily median storage content range for Alternative B (red region) and the No-Action Alternative (black line). The shaded blue region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative B and the No-Action Alternative, respectively. System storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Anderson Ranch Reservoir Storage and Water Surface Elevation

Median modeling results for Alternative B (red band) indicate a potential for increased storage in Anderson Ranch Reservoir relative to the No-Action Alternative (solid black line) as shown in Figure 14. The median monthly content of Alternative B was found to be anywhere from approximately 9000 acre-feet (in March) to 28,000 acre-feet (in April) higher when compared to the No-Action Alternative. Similarly, the maximum value of content (blue dashed line) increased up to approximately 29,000 acre-feet for all months of the year and represents when the new storage was not needed to meet downstream objectives and was carried over to the next year. Due to increased storage values over the No-Action Alternative, Anderson Ranch Reservoir median pool elevations for Alternative B were found to range anywhere from 3 feet to 10 feet higher depending on the time of year. Minimum content of Alternative B was identical to the No-Action Alternative with no difference. The general shape of Anderson Ranch Reservoir content refill and draft of Alternative B was also very similar to the No-Action Alternative.

Alternative B indicates Anderson Ranch Reservoir storage and pool elevations that were higher than the No-Action Alternative for most times of the year by various amounts depend on the demand scenario. Although the amount was minimal in relation to the total reservoir content, Alternative B would not have a significant impact on FRM systems, meeting existing water deliveries, and meeting ecological constraints. The new storage could be used to meet new irrigation deliveries, existing water demand during years of shortage, or ecological constraints.

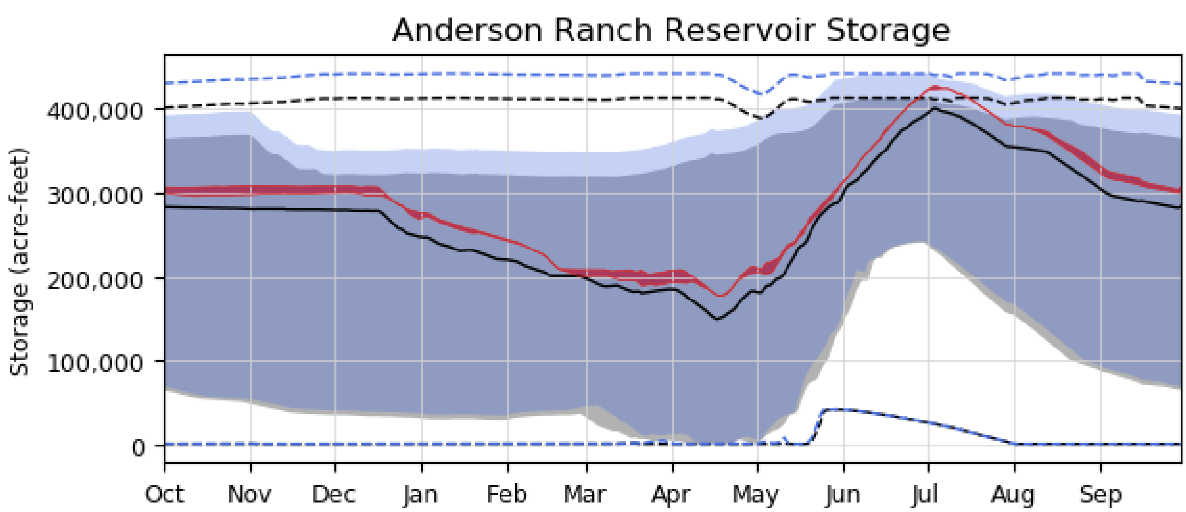

Figure 14. Anderson Ranch Reservoir storage hydrograph depicting the daily median storage content range for Alternative B (red region) and the No-Action Alternative (black line). The shaded blue region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative B and the No-Action Alternative, respectively. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Streamflow in the South Fork Boise River below Anderson Ranch Dam

Alternative B median streamflow (red band) in the South Fork Boise River below Anderson Ranch Dam changed very little from the No-Action Alternative (solid black line) as shown in Figure 15. The largest difference can be seen in the 10th percentile and maximum streamflow that occurs in late spring (May–June) for the highest flow conditions where streamflow was reduced slightly. Differences in maximum streamflow can be seen during March where Alternative B streamflow is more than the No-Action Alternative. Further analysis into the model results show that this was due to the model using different balancing of system space during FRM operations while in real-time operations this would not occur. Differences in streamflow also occur in the middle of August when median flows of Alternative B increase slightly earlier than the No-Action Alternative. As stated Section 3.2.1, the reduction in flow in August and subsequent increase in flow in mid-August is a result of modeling limitations, and in real-time, flows would be shaped to a more constant rate near powerplant capacity (approximately 1,600 cfs) during August. To provide context to the duration of time to release the new storage, Table 4 provides a range of the additional days at the powerplant flow for various demand volumes. For Alternative B, up to an additional 9.1 days of flow at the powerplant would be expected. After this time, flows would gradually decrease to either 600 cfs or 300 cfs depending on the target minimum flow at that time.

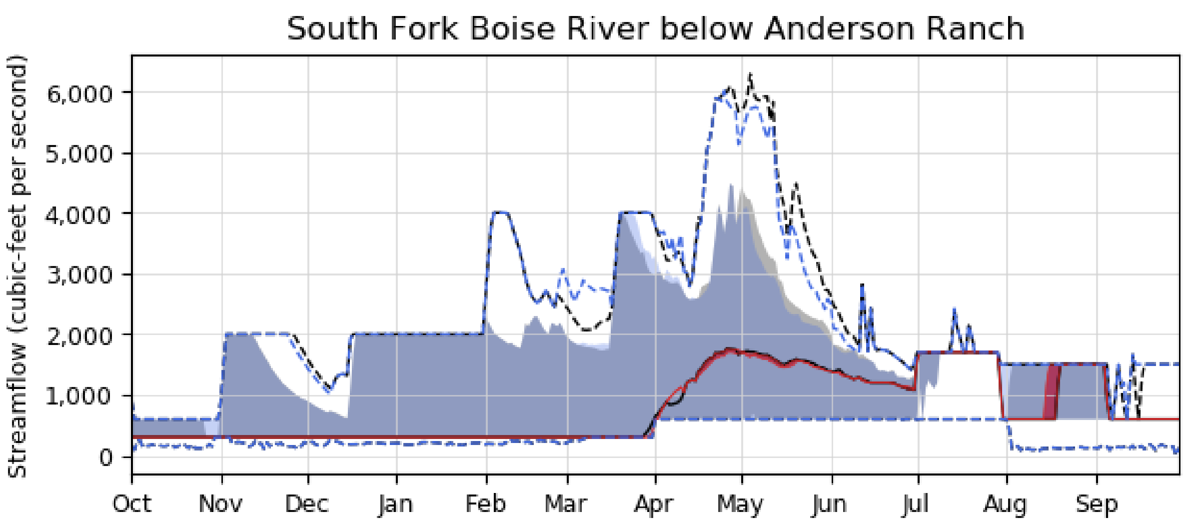

Figure 15. South Fork Boise River below Anderson Ranch Reservoir streamflow hydrograph depicting the daily median range for Alternative B (red region) and the No-Action Alternative (black line). The shaded blue region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative B and the No-Action Alternative, respectively.

Table 4. Number of additional days at power plant capacity (approximately 1,600 cfs, depending on reservoir head) for various additional demand volumes

Additional Demand (acre-feet)	Number of Additional Days at 1,600 cfs During Late Summer
5,000	1.6
10,000	3.2
15,000	4.7
20,000	6.3
25,000	7.9
29,000	9.1

The largest difference in annual peak flow in the South Fork Boise River below Anderson Ranch Reservoir was found to be 710 cfs less during April when compared to the No-Action Alternative. This reduction in peak outflows occurred for high-volume water years when the additional space provided by the dam raise provided a short duration (1–7 days) reduction in peak flows. This reduction in peak flows occur in 8 years of the 50 years modeled, with a 400 cfs–700 cfs reduction in peak flows occurring for 5 years and a 400 cfs or less reduction occurring for the remaining 3 years. For the 8 years where a reduction in peak flows was identified, the peak flows of Alternative B ranged from approximately 4,400 cfs to 5,900 cfs illustrating that these occurred for large runoff volume water years.

Alternative B increased early spring flows and decreased the peak flows for high-volume water years. Late summer flows would also be maintained at higher levels near powerplant capacity (approximately 1,600 cfs) as the new storage water delivered downstream. The changes in South Fork Boise River streamflow would not significantly affect the system FRM, meeting existing water deliveries, or meeting ecological requirements but may provide more recreational boating (rafting and drift boat) flows.

Anderson Ranch Dam Spillway

Modeling results indicate no increase in the use of the spillway at Anderson Ranch Dam for Alternative B. Using the spillway was identified as times when reservoir pool elevations were more than than 4174 feet (bottom of spillway) and Anderson Ranch Dam discharge was more than 10,000 cfs (combined capacity of the powerplant and outlet works). There is no change between Alternative B and the No-Action Alternative, so there would be no significant impact to system FRM, meeting existing water deliveries, or meeting ecological requirements.

Arrowrock Reservoir Storage and Water Surface Elevation

The general shape of Arrowrock median storage in Alternative B was very similar to the No-Action Alternative (Figure 16). Median results did show a slightly slower refill of Arrowrock Reservoir from October through December when storage was up to approximately 19,000 acre-feet less (approximately 8 feet lower pool elevation) for Alternative B. Similar to the No-Action Alternative, Alternative B indicated Arrowrock Reservoir storage remained near full from January through the first part of July after which point the reservoir begins to release water to meet irrigation demand. Both Alternative B and the No-Action Alternative result in Arrowrock Reservoir reaching the target minimum pool in mid-August with refill commencing in early September. Both minimum and maximum content values for the reservoir were similar across both Alternative B and the No-Action Alternative.

Overall, Alternative B had Arrowrock Reservoir storage and pool elevations that were similar to the No-Action Alternative except during October through December when median pool elevation may be up to 8 feet lower. Although this is a change from the No-Action Alternative during the October-through-December period, Alternative B would have no significant to system FRM, meeting existing water deliveries, and meeting ecological requirements.

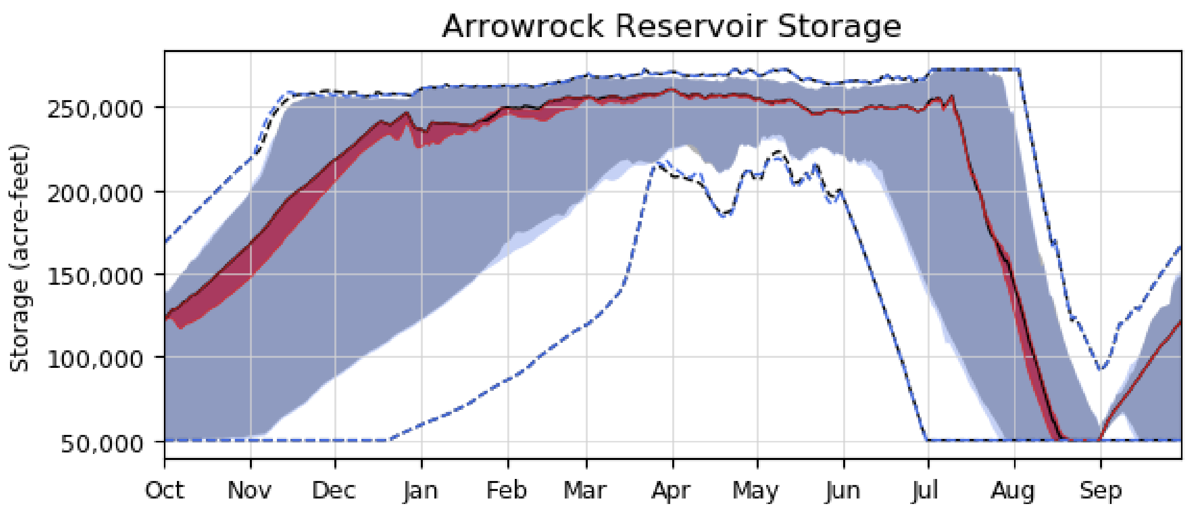

Figure 16. Arrowrock Reservoir storage hydrograph depicting the daily median storage content range for Alternative B (red region) and the No-Action Alternative (black line). The shaded blue region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative B and No-Action Alternative, respectively.

Lucky Peak Reservoir Storage and Water Surface Elevation

Lucky Peak Reservoir median content for Alternative B changed very little from the No-Action Alternative (Figure 17). The most notable changes in median content were found at the end of the irrigation season where, depending on the demand pattern, Lucky Peak Reservoir content decreased slightly earlier in the model. Median pool elevation differences between Alternative B and the No-Action Alternative ranged from 0.3 foot to approximately 5 feet from October through August, and up to 7 feet lower in September. During the peak water recreation season from May through August, Lucky Peak Reservoir pool elevations were within approximately 2 feet of pool elevation as compared to the No-Action Alternative. Due to the ability to move water as needed within the system reservoirs to meet irrigation demand, in real-time operations, it is anticipated that fewer changes between Alternative B and the No-Action Alternative would be experienced. The 90th-percentile values of Alternative B were found to be lower during the May through July period and correlated to very dry water years. Similar to the No-Action Alternative, median values for Alternative B show no change in the ability to meet the target elk pool elevation during the winter. Minimum and maximum content values were found to be very similar between Alternative B and the No-Action Alternative.

Overall, Alternative B had very similar Lucky Peak Reservoir content when compared to the No-Action Alternative. There were differences found in the 90thpercentile and late season pool elevations but this would either be a rare occurrence due to very dry water supply conditions or the flexibility of real-time operations would minimize this difference. Additionally, results showed there would be no significant impact to system FRM, meeting existing water deliveries, and meeting ecological requirements.

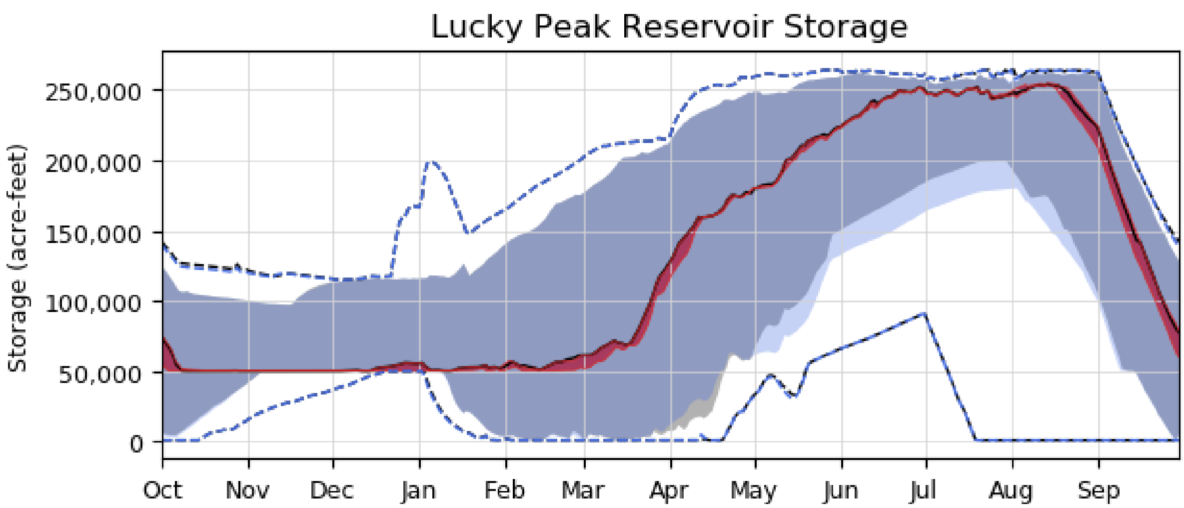

Figure 17. Lucky Peak Reservoir summary storage hydrograph depicting the daily median storage content range for Alternative B (red region) and the No-Action Alternative (black line). The shaded blue region and shaded gray region represent the 10th-percentile to 90th-percentile range captured by Alternative B and the No-Action Alternative, respectively. Dashed blue and black lines represent the daily minimum and maximum values.

Streamflow at Boise River at Glenwood

As stated earlier, although the modeling assumptions may not capture all the complexities of real-time operations for FRM, it does provide a method to compare the results of two different scenarios: Alternative B versus the No-Action Alternative.

Alternative B median streamflow (red band) in the Boise River at Glenwood changed very little from the No-Action Alternative (solid black line) as shown in Figure 18. The median streamflow during late July show a slight variation in flow for Alternative B where streamflow remains elevated at approximately 2,000 cfs for longer. Minimum flows for Alternative B show no change as compared to the No-Action Alternative and maximum streamflow showed streamflow remaining at approximately 3,000 cfs slightly longer in August. This variation in August streamflow is also shown in the 10th-percentile values and relates to the demand scenario 2 that uses the new space to deliver water such as for flow augmentation. As noted in the No-Action Alternative model results section, the model limitations result in flow augmentation releases beginning only after the DOA (the date in water rights accounting where storage accounts have reached their maximum accrual) and results in extending the release of flow augmentation longer than would occur in real-time operations. No benefits to FRM were shown because both Alternative B and the No-Action Alternative have very similar 10th-percentile and maximum streamflow which is consistent with the assumption that the new space would not be authorized for FRM operations.

The Alternative B scenario had minimal changes in streamflow in the Boise River at Glenwood location. There were changes noted in late July median flows and maximum and 10th-percentile streamflow staying higher longer into August, although these were relatively small compared to the No-Action Alternative. Although there were some changes to streamflow in the Boise River at Glenwood with Alternative B, the changes we relatively small and would not significantly impact the system FRM, meeting existing water deliveries and meeting ecological constraints.

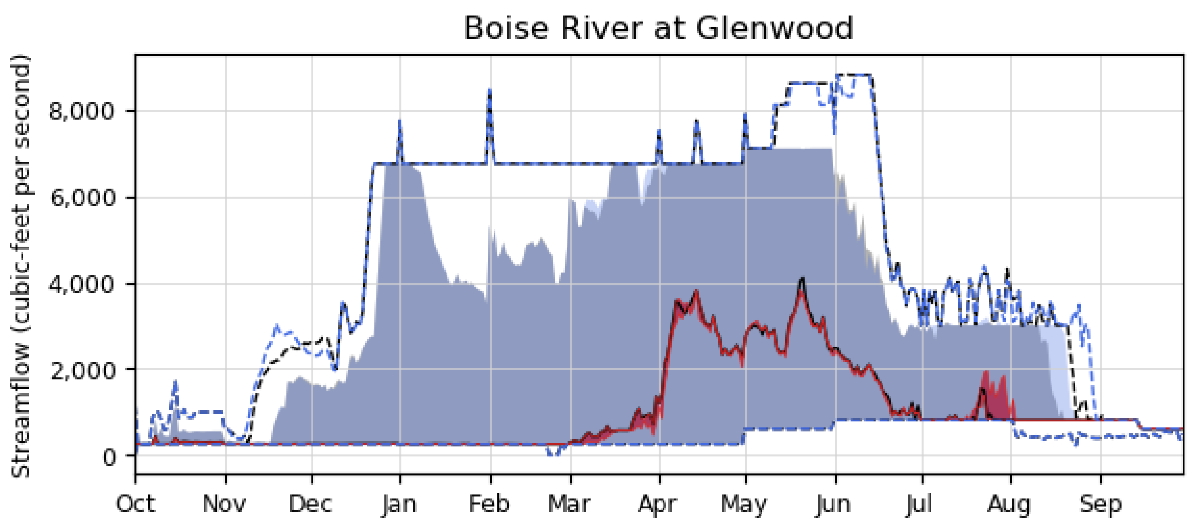

Figure 18. Boise River at Glenwood summary streamflow hydrograph depicting the daily median streamflow range for Alternative B (red region) and the No-Action Alternative (black line). The shaded blue region and shaded gray region represent the 10th-percentile to 90th-percentile range captured by Alternative B and the No-Action Alternative, respectively. Dashed blue and black lines represent the daily minimum and maximum values.

Flow Augmentation

Reservoir space, including both uncontracted and contracted space, used to meet flow augmentation requirements would fill before any new reservoir space, including that created by a raise at Anderson Ranch Dam.

Therefore, no change to the flow augmentation volumes of Alternative B as compared to the No-Action Alternative are anticipated.

As part of this analysis, Reclamation assessed potential changes to flow at Lower Granite Dam on the Lower Snake River for Alternative B. Generally, there is a slight difference in flows ranging from -1.3% to 0.7% at Lower Granite Dam for certain years due to more water being stored in the Boise River system. The largest percent change in flow was -1.3% in 1985 where there is a shift in timing in the delivery from June to July as the system filled earlier and released flow augmentation earlier but flow augmentation is coordinated in real time and therefore this large of change would not likely occur. The largest change due to filling the new storage space would be no more than 1%, and would likely occur in April, May, or June. For additional information on the analysis completed for impacts to flow augmentation due to Alternative B refer to Appendix F.

3.2.3 Alternative C – 3-ft Dam Raise with Associated Projects

Alternative C would raise Anderson Ranch Dam 3 feet and include associated projects (e.g., Cow Creek Road realignment and regrading, reducing road curvature near the approach of the dam). This raise increases the storage capacity of Anderson Ranch Reservoir by approximately 14,400 acre-feet for an active capacity of approximately 427,474 acre-feet.

The dam raise equates to a 3% increase in the active capacity of Anderson Ranch Reservoir and a 1% increase in the Anderson Ranch, Arrowrock, and Lucky Peak reservoir system.

Construction Phase

Construction activities associated with the 3-foot dam raise would require the same pool restriction (elevation 4174 feet) of Anderson Ranch Reservoir and installing a coffer dam as stated in Alternative B. The discussion of Alternative B in Section 3.2.1 provides details on how the project would impact the restriction during the construction phase. Alternative C construction is expected to take approximately 44 months (See 3-foot Engineering Summary in Appendix D).

The restriction would have no significant impact on system FRM, a high likelihood of impacting irrigation deliveries, and may reduce the likelihood of staying below the elk pool at Lucky Peak Reservoir.

Description of Operations Post Construction

Similar to Alternative B, four demand scenarios (Table 3) were modeled to portray a range of potential release timings, rates, and durations associated with Alternative C. The results of the four scenarios were used to develop a range of possible flow and reservoir conditions associated with Alternative C.

Modeling Results

In Figure 19 the median daily value of the No-Action Alternative is represented by the solid thin black line. The bounds of the median daily values of Alternative C scenario is represented by the red band (range of demand scenarios 1–4). Modeling results show 10th- and 90th-percentile ranges to illustrate the predicted operational ranges. The 10th- and 90th-percentile values of the No-Action Alternative scenario are represented by light grey shading. The 10th- and 90th- percentile values of Alternative C are represented by light green shading. When the 10th- percentile and 90th-percentile values of the No-Action Alternative and Alternative C overlap, the shading is darker green. When they do not overlap, only the light green shading or light grey shading appears (see March 1 shading on shading on Figure 19). The dashed black and green lines represent the absolute maximum and minimum values of the No-Action Alternative and Alternative C, respectively.

System Storage

Median modeling results for Alternative C (red band) indicate a potential for increased system storage relative to the No-Action Alternative (solid black line on Figure 19). The average median monthly system content of Alternative C scenario was found to be anywhere from approximately 600 acre-feet less to approximately 16,400 acre-feet more. Similarly, the maximum value of system content (blue dashed line) increased up to approximately 14,400 for all months of the year when compared to the No-Action Alternative and represents the demand scenario 1 when the new storage was not used but carried over to the next year. Minimum system content of Alternative B was nearly identical to the No-Action Alternative with very little if any difference. The general shape of system content refill and draft of Alternative C was also very similar to the No-Action Alternative.

Alternative C had system storage values that exceeded the No-Action Alternative for most times of the year by various amounts dependent on the demand scenario. Although the amount was minimal in relation to the total system content, Alternative C would not significantly affect system FRM, meeting existing water deliveries, and meeting ecological constraints.

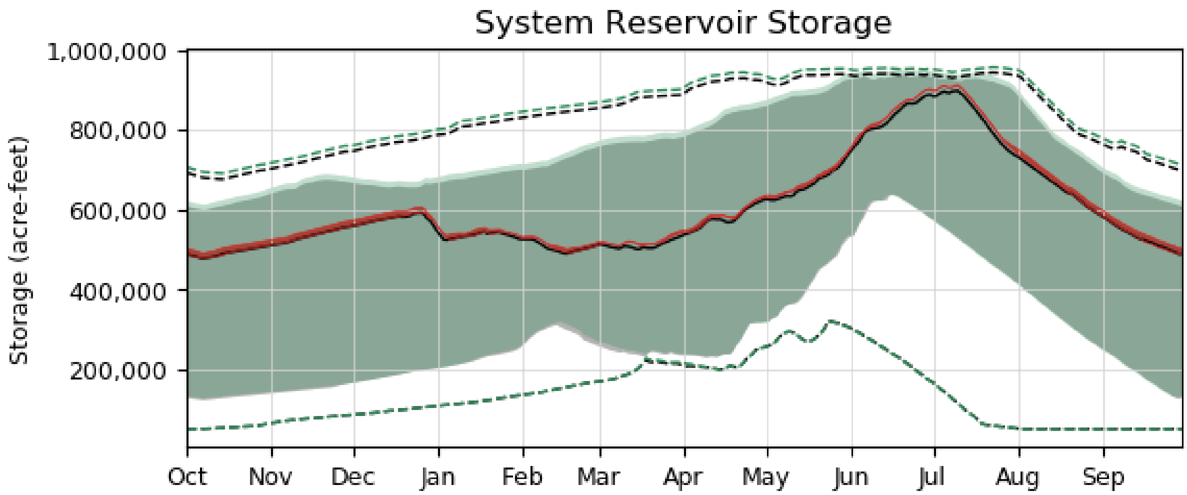

Figure 19. Boise reservoir system storage hydrograph depicting the daily median storage content range for Alternative C (red region) and daily median for the No-Action Alternative (black line). The shaded green region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative C and the No-Action Alternative, respectively. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Anderson Ranch Reservoir Storage and Water Surface Elevation

Median modeling results for Alternative C (red band) indicate a potential for increased Anderson Ranch Reservoir storage relative to the No-Action Alternative (solid black line) as shown in Figure 20. The median monthly Anderson Ranch Reservoir content of Alternative C was found to be anywhere from approximately 5,000 acre-feet (in March); 14,000 acre-feet (in April); and approximately 16,000 acre-feet (in September) higher when compared to the No-Action Alternative. Similarly, the maximum value of Anderson Ranch Reservoir content (blue dashed line) increased up to approximately 14,400 for all months of the year and represents the demand scenario 1 where the new storage was not used but carried over to the next year. Due to increased storage values over the No-Action Alternative, Anderson Ranch Reservoir median pool elevations for Alternative C were found to range anywhere from 2 feet to 5 feet higher. Minimum Anderson Ranch Reservoir content of Alternative C was identical to the No-Action Alternative. The general shape of Anderson Ranch Reservoir storage increase and decrease of Alternative C was very similar to No-Action Alternative.

Alternative C indicated Anderson Ranch Reservoir storage and pool elevations higher than the No-Action Alternative for most times of the year by various amounts dependent on the demand scenario. Although the amount was minimal in relation to the total Anderson Ranch Reservoir storage, Alternative C would not have a significant impact on system FRM, meeting existing water deliveries, and meeting ecological requirements. The new storage would help meet new irrigation deliveries and for demand scenarios where the water was not delivered in a particular year, in general, meeting ecological constraints may be easier.

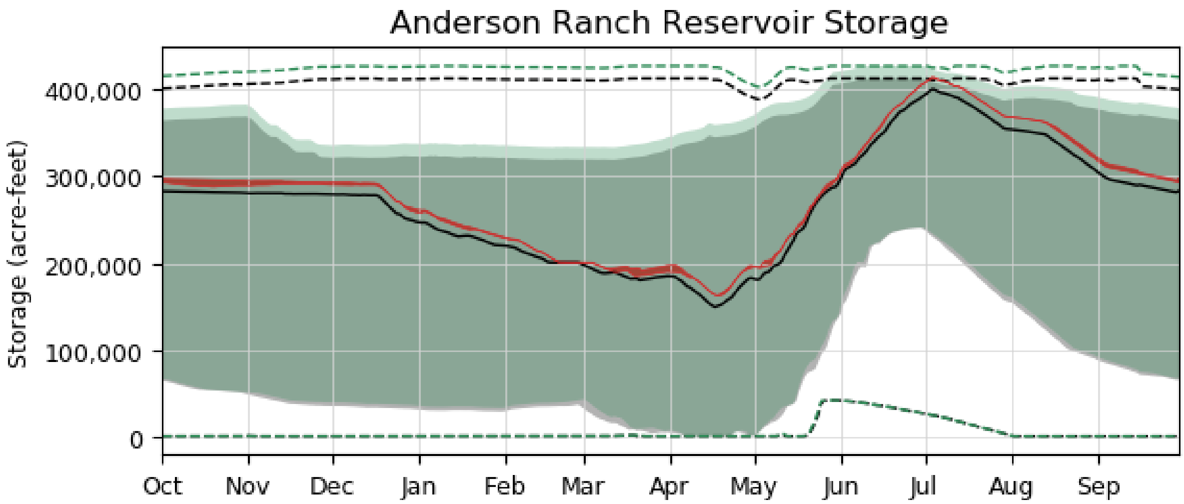

Figure 20. Anderson Ranch Reservoir storage hydrograph depicting the daily median storage content range for Alternative C (red region) and daily median for the No-Action Alternative (black line). The shaded green region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative C and No-Action Alternative, respectively. Storage values do not include 36,956 acre-feet of inactive powerhead space in Anderson Ranch Reservoir.

Streamflow in the South Fork Boise River below Anderson Ranch Dam

Alternative C median streamflow (red band) in the South Fork Boise River below Anderson Ranch Dam changed very little from the No-Action Alternative (solid black line) as shown in Figure 21. The largest difference can be seen in the 10th percentile and maximum streamflow that occurs in late spring (May–June) for the highest flow conditions where streamflow was reduced slightly. Differences in maximum streamflow can be seen during March where Alternative C streamflow is larger than the No-Action Alternative. Further analysis into the model results show that this was due to the model using different balancing of system space during FRM operations while in real-time operations this would not occur. Differences in streamflow also occur in the middle of August when median flows of Alternative C increase slightly earlier than the No-Action Alternative. As stated in Section 3.2.1, the No-Action Alternative the reduction in flow in August and subsequent increase in flow in mid-August is a result of limitation of modeling and in real-time operations flow would be shaped to a more constant rate near powerplant capacity (approximately 1,600 cfs) through this period. To provide context to time to release the new storage, Table 5 provides a range of the additional days at the powerplant flow for various demand volumes. For Alternative C, up to an additional 4.5 days of flow at the powerplant flow would be expected. After this, flows would ramp down to either 600 cfs or 300 cfs depending on the target minimum flow at that time.

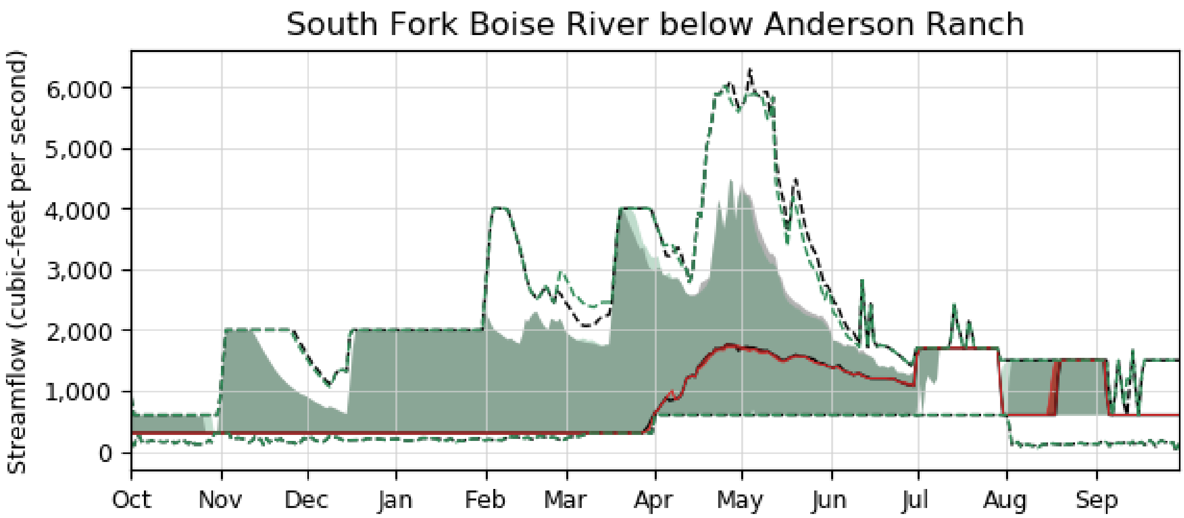

Figure 21. South Fork Boise River below Anderson Ranch Reservoir streamflow hydrograph depicting the daily median range for Alternative C (red region) and daily median for the No-Action Alternative (black line). The shaded green region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative C and the No-Action Alternative, respectively.

Table 5. Number of additional days at power plant capacity (approximately 1600 cfs) for various additional demand volumes

Additional Demand (acre-feet)	Number of Additional Days at 1,600 cfs During Late Summer
5,000	1.6
10,000	3.2
14,400	4.5

The largest difference in annual peak flow in the South Fork Boise River below Anderson Ranch Reservoir was found to be 380 cfs less during April when compared to the No-Action Alternative. This reduction in peak outflows occurred for heavy water years when the additional space provided by the dam raise provided a short duration (1–5 days) reduction in peak flows. This reduction in peak flows occur in 6 years of the 50 years modeled, with a 200 cfs–400 cfs reduction in peak flows occurring for 3 years and a less than 200 cfs reduction occurring for the remaining 3 years. For the 6 years where a reduction in peak flows was identified, the peak flows of Alternative B ranged from approximately 4,900 cfs to 6,000 cfs illustrating that these occurred for heavy runoff volume water years.

Alternative B increased early spring flows and decreased the peak flows for heavy water years. Late summer flows would also be maintained at higher levels near powerplant capacity (approximately 1,600 cfs) as the new storage water delivered downstream. The changes in South Fork Boise River streamflow would not have a significant impact on system FRM, meeting existing water deliveries, or meeting ecological requirements but may provide more recreational boating (rafting and drift boat) flows.

Anderson Dam Spillway

Modeling results indicate no increase in the use of the spillway at Anderson Ranch Dam for Alternative C. Spillway use was identified as times when reservoir pool elevations were more than 4174 feet (bottom of spillway) and Anderson Ranch Dam discharge was more than 10,000 cfs (combined capacity of the powerplant and outlet works). There is no change between Alternative C and the No-Action, so there would be no significant impact to system FRM, meeting existing water deliveries, or meeting ecological constraints.

Arrowrock Reservoir Storage and Water Surface Elevation

The general shape of Arrowrock Reservoir median storage and release for Alternative C was similar to the No-Action Alternative (Figure 22). Median results did show a slightly slower refill of Arrowrock Reservoir during the October through December period when content was up to approximately 5800 acre-feet less (approximately 3 feet lower pool elevation) for Alternative C. Similar to the No-Action Alternative, Alternative C had Arrowrock Reservoir content that remained near full from January through the first part of July after which point the reservoir begins to draft to meet irrigation demand. Both Alternative C and the No-Action Alternative result in Arrowrock reaching the target minimum pool in mid-August with refill commencing in early September. Both minimum and maximum content values for the reservoir were very similar across both Alternative C and No-Action Alternative.

Overall, Alternative C had Arrowrock content and pool elevations that were similar to the No-Action Alternative except during October through December when median pool elevation may be up to 3 feet lower. Although this is a change from the No-Action Alternative during October-through-December period, Alternative C would not significantly impact system FRM, meeting existing water deliveries, and meeting ecological constraints.

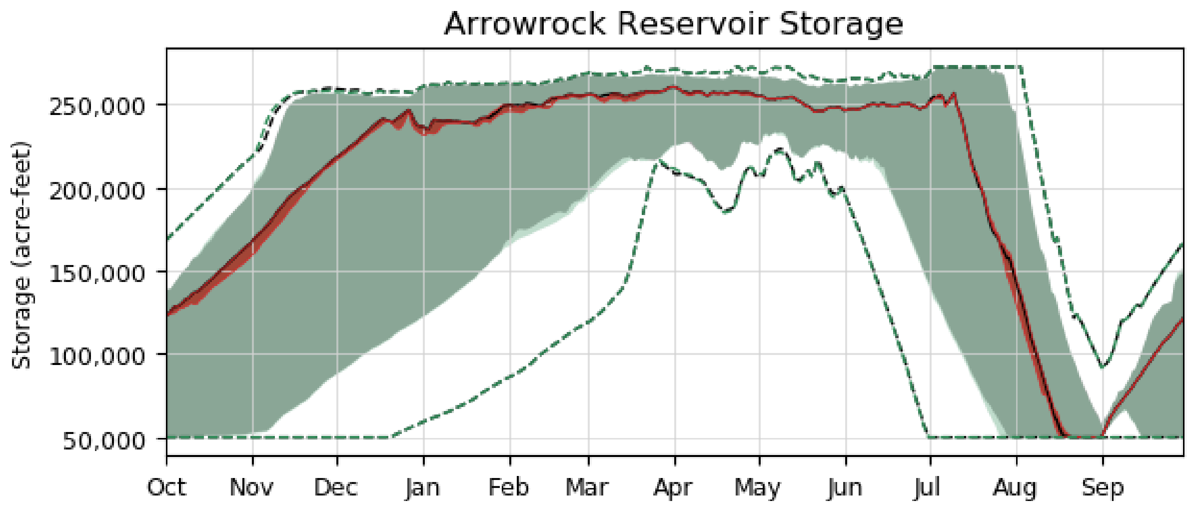

Figure 22. Arrowrock Reservoir storage hydrograph depicting the daily median storage content range for Alternative C (red region) and daily median for the No-Action Alternative (black line). The shaded green region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative C and the No-Action Alternative, respectively.

Lucky Peak Reservoir Storage and Water Surface Elevation

Lucky Peak Reservoir median content for Alternative C changed very little from the No-Action Alternative (Figure 23). The most notable changes in median content we found at the end of the irrigation season where, depending on the demand pattern, Lucky Peak Reservoir drafted slightly earlier in the model. Median pool elevation differences between Alternative C and the No-Action Alternative ranged from 0 feet to approximately 2.1 feet lower from October through August, and up to 3.8 feet lower in September. During the peak water recreation season from May through August, Lucky Peak Reservoir pool elevations were within approximately 0.5 foot of the No-Action Alternative. Because real-time operations move water as needed within the system to meet irrigation demand, it is anticipated that fewer changes, if any, between Alternative C and the No-Action Alternative would be experienced. The 90th-percentile values of Alternative C were found to be lower during the May through July period and correlated to very dry water years. Similar to the No-Action Alternative, median values for Alternative C show no change in the ability to meet the target elk pool elevation during the winter. Minimum and maximum content values were found to be very similar between both Alternative C and the No-Action Alternative.

Overall, Alternative C had very similar Lucky Peak Reservoir content when compared to the No-Action Alternative. There were differences found in the 90th-percentile and late-season-pool elevations but this would either be a rare occurrence due to very dry water conditions or real-time flexibility would minimize this difference. Additionally, results showed there would be no significant impact to system FRM, meeting existing water deliveries, and meeting ecological constraints.

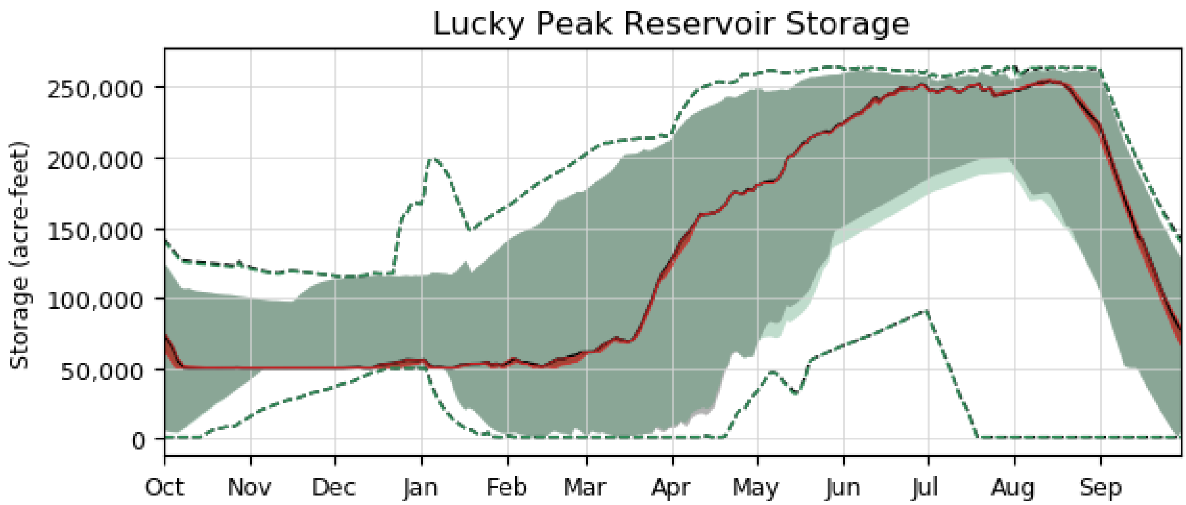

Figure 23. Lucky Peak Reservoir summary storage hydrograph depicting the daily median storage content range for Alternative C (red region) and the No-Action Alternative (black line). The shaded green region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative C and the No-Action Alternative, respectively.

Streamflow at Boise River at Glenwood

As stated earlier, although the modeling assumptions may not capture all the complexities of real-time operations for FRM, it does provide a method to compare the results of two different scenarios (Alternative C versus No-Action Alternative).

Alternative C median streamflow (red band) in the Boise River at Glenwood changed very little from the No-Action Alternative (solid black line) as shown in Figure 24. The median streamflow during the end of July show a slight variation in flow for Alternative C where streamflow remains elevated at approximately 2,000 cfs for longer duration. Minimum flows for Alternative C show minimal, if any, change compared to the No-Action Alternative and maximum flows showed streamflow remaining at approximately 3,000 cfs—slightly longer in August. This variation is also shown in the 10th-percentile streamflow and relates to the demand scenario 2 that uses the new space to deliver water such as for flow augmentation. As noted in the No-Action Alternative model results section, the model limitations result in flow augmentation releases beginning only after the DOA (the date in water rights accounting where storage accounts have reached their maximum accrual) and results in extending out the release of flow augmentation longer than would occur in real-time operations. No benefits to FRM were shown because both Alternative C and the No-Action Alternative have very similar 10^{th}-percentile and maximum streamflow which is consistent with the assumption that the new space would not be authorized for FRM operations.

The Alternative C scenario had minimal changes in streamflow in the Boise River at Glenwood location. There were changes noted in late July median flows and maximum and 10th-percentile streamflow staying higher longer into August, although these were relatively small compared to the No-Action Alternative. Although there were some changes to streamflow in the Boise River at Glenwood due to Alternative C, the changes we relatively small and would not be a significant impact to system FRM, meeting existing water deliveries, and meeting ecological constraints.

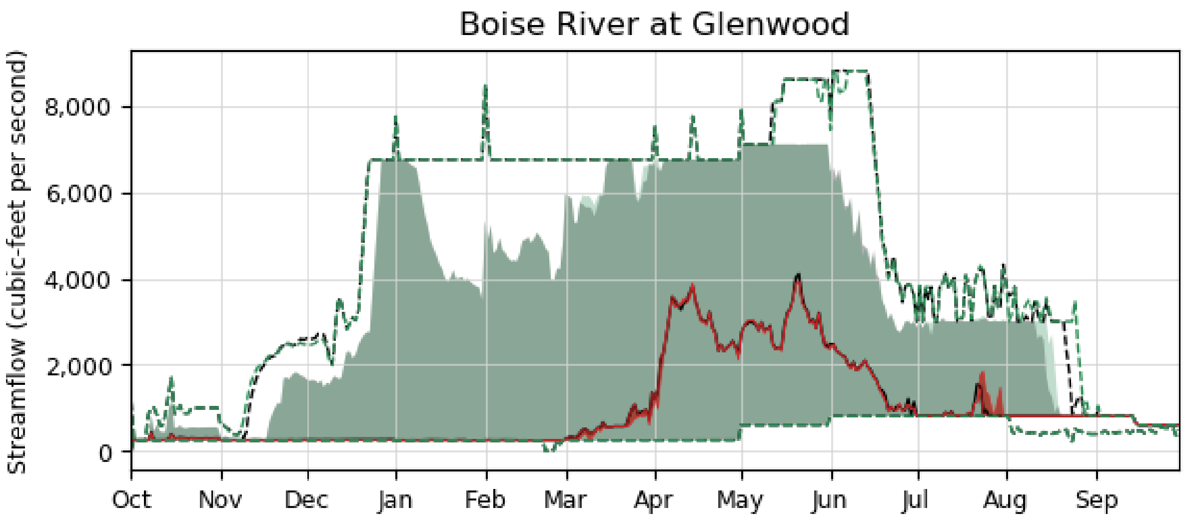

Figure 24. Boise River at Glenwood summary streamflow hydrograph depicting the daily median streamflow range for Alternative C (red region) and the No-Action Alternative (black line). The shaded green region and shaded gray region represent the 10th-percentile to 90th-percentile range while the dashed lines represent the maximum and minimum values captured by Alternative C and the No-Action Alternative, respectively.

Flow Augmentation

Reservoir space, including both uncontracted and contracted space, used to meet flow augmentation requirements would fill before any new reservoir space, including that created by an Anderson Ranch Dam raise. Therefore, no change to the flow augmentation volumes of Alternative C as compared to the No-Action Alternative are anticipated.

As part of this analysis, Reclamation assessed potential changes to flow at Lower Granite Dam on the Lower Snake River for Alternative C. Generally, there is a slight difference in flows ranging from -0.4% to 0% at Lower Granite Dam for certain years due to more water being stored in the Boise River system. The largest percent change in flow was -0.4% in 1985 where there is a shift in timing in the delivery from June to July as the system filled earlier and released flow augmentation earlier but flow augmentation is coordinated in real time and therefore this large of change would not likely occur. The largest change due to filling the new storage space would be no more than 0.4%, and would likely occur in April, May, or June. For additional information on the analysis completed for impacts to flow augmentation due to Alternative B refer to Appendix F.

3.3 Cumulative Effects

Cumulative effects are analyzed for the Alternative B and Alternative C. Cumulative effects are those that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. The cumulative effects analysis considers projects, programs, and policies that are not speculative and are based on known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable. While no present actions are identified, Reclamation has identified two past actions: Pine Bridge at the South Fork Boise River and the 4-foot Anderson Ranch Dam crest raise for security enhancement. Reclamation has also identified two potential future projects to be considered for the cumulative impact analysis: Cat Creek Energy Project and South Fork Boise River Diversion Project. Additional project proposal information for these, as known by Reclamation to date, is provided in Chapter 2 of the EIS.

The Pine Bridge replacement would not have any direct or indirect effects to water operations or hydrology, therefore no cumulative effects. The 4-foot crest raise was for security enhancement and not water retention, having no direct or indirect effects to water operations or hydrology, therefore not cumulative effects.

There is no formal proposal by Cat Creek Energy on details of the proposed drafts or potential downstream delivery to Water District No. 63 users, so it is not possible to perform a cumulative affects analysis at this time. To some extent, the same can be said about the South Fork Boise River Diversion Project. However, multiple conditions must exist for project diversions to occur.

- Minimum of 800 cfs below Anderson Dam
- Minimum of 240 cfs below New York Canal June 16 through February 28 or 29
- Minimum of 1,100 cfs below New York Canal March 1 through May 31
- The system is in flood control.

These requirements assume that water would be diverted during the spring. Depending on either Cat Creek Energy, South Fork Boise River Diversion or if both proposed projects are completed, the probability of refill for Alternative B and Alternative C would change. Modeling completed using the 1959 to 2008 historical period determined a refill probability for Alternative B of 38% to 62% depending on if both or none proposed projects are completed. Results for Alternative C indicate a refill probability of 42% to 64% depending on if both or neither proposed projects are completed. These refill probabilities were found to decrease when a shorter 28-year historical period (1980–2008) and reduce refill probabilities to 29% to 43% for Alternative B and to 36% and 43% for Alternative C depending on if both or neither proposed projects are completed. For additional information about the analysis completed refer to Appendix G.

Due to the conditions listed above for both proposed projects, it is assumed that cumulative effects from other currently proposed projects would not be a significant cumulative impact to system FRM, meeting existing water deliveries, and meeting ecological constraints but may impact refill probabilities of Alternative B and Alternative C.

3.4 Mitigation

Mitigation includes actions taken to avoid, minimize, rectify, reduce, or eliminate over time and compensate for impacts (Council on Economic Quality, 2005). Rectifying an impact can include repair and restoration, while compensation could be done through replacement. Mitigation measures developed for this project were developed to address impacts determined to be significant or potentially significant and include the following.

- Impacts to water deliveries during construction. Potential mitigation activities may include:
    - providing funds to mitigate impacts from reduced water supply and
    - seeking opportunities for water rentals from other space holders.
- Impacts to system FRM during construction. Mitigation activities (outlined in Appendix G) may include the following.
    - Providing the November 1– December 31 space requirement of 300,000 acre-feet (165,000 acre-feet in lower system)
    - Providing the January 1–March 30 minimum space requirement of 300,000 acre-feet to 50,000 acre-feet depending on forecast
    - Providing the dynamic forecast-based system space requirement (January 1–July 15) or draft system to empty, whichever is less.
    - Develop guidance for the percent of total system space that would be required to be held in Anderson Ranch Reservoir based on a local reservoir runoff volume forecast and maximum target discharge.
    - Identify operational triggers where construction would need to be delayed due to severe hydrologic conditions and develop lead times required to demobilize equipment.

Page intentionally left blank.

4. References

Bureau of Reclamation (Reclamation), 2017. Boise Feasibility Study Preliminary Hydrologic Evaluation Technical Memorandum. Prepared by the U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. February.

Reclamation, 2019. *Feasibility Design Report – Anderson Ranch Dam 6-Foot Reservoir Raise, Technical Memorandum No. AND-8313-FEA-2019-1, Boise Project, Idaho, Columbia – Pacific Northwest Region.* Technical Services Center, Denver, Colorado. May.

Council on Economic Quality, 2005.

NOAA Fisheries, 2008. National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2008 Upper Snake Biological Opinion, Consultation for the Operation and Maintenance of 10 Bureau of Reclamation Projects and 2 Related Actions in the Upper Snake River above Brownlee Reservoir.

Regents of the University of Colorado, 2019. RiverWare version 7.5. Boulder, Colorado 80301.

SPF Water Engineering, LLC, 2016. Treasure Valley DCMI Water-Demand Projections (2015–2065). Prepared for the Idaho Water Resource Board and Idaho Department of Water Resources. August.