RECLAMATION
Managing Water in the West

Boise Feasibility Study

Preliminary Hydrologic Evaluation

Technical Memorandum

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Regional Office

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U.S. Department of the Interior

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Bureau of Reclamation

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EXECUTIVE SUMMARY

This study evaluated the potential storage benefit associated with a six-foot raise of Anderson Ranch Dam, a ten-foot raise of Arrowrock Dam, and a four-foot raise of Lucky Peak Dam. Such increases in dam height correspond to an estimated 29,000 acre-feet of additional storage in Anderson Ranch Reservoir, 20,000 acre-feet of additional storage in Arrowrock Reservoir, and 10,000 acre-feet of additional storage in Lucky Peak Reservoir. These storage increases were evaluated under two different storage scenarios: 1) increases at all three reservoirs (59,000 acre-feet or a 6% increase in system storage capacity), and 2) increases at only Anderson Ranch Reservoir and Arrowrock Reservoir (49,000 acre-feet or a 5% increase in system storage capacity).

The evaluation was conducted using the Boise Planning Model to estimate frequency of fill of the expanded storage space given historical hydrology and future 2080s climate change flows. The results of this study suggest: 1) the probability of filling the expanded storage space is roughly equivalent to the probability of filling the existing storage space under both hydrology scenarios, and 2) larger runoff peaks in the 2080s Median scenario increases the probability of fill.

Table 0-1 and 0-2 summarize the results of this analysis in terms of the percent of years that a particular storage volume is equaled or exceeded over the 28-year simulation period under historical hydrology and future 2080s Median hydrology. As shown in the table, the system fills completely in 43-46% of years (12-13 out of 28 years) given historical hydrologic conditions and in 64% of years (18 out of 28 years) given future 2080s Median Climate Change hydrologic conditions. Results also suggest that the increased operational flexibility provided by the expanded space increases the volume of fill in drier years as a result of the reservoirs not needing to draft as deeply to provide space for flood control. It should be noted however that this analysis assumed no-change in current flood control rule curves going into the future.

Table 0-1. Summary of simulated system fill under historical hydrology for the Baseline Scenario (current storage condition), the BOR Reservoirs Only Scenario (increased storage at Anderson Ranch and Arrowrock reservoirs only), and the All Reservoirs Scenario in terms of the percent of years that a particular fill volume (or fill percent) is equaled or exceeded over the 28-year simulation period (1982 through 2009).

	Historical Hydrology					
	Baseline Scenario		BOR Reservoirs Only Scenario		All Reservoirs Scenario	
% of Years	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill
4%	984,242	104%	1,034,140	104%	1,046,744	104%
7%	979,415	103%	1,032,224	103%	1,045,020	104%
11%	978,730	103%	1,031,472	103%	1,043,378	103%
14%	975,684	103%	1,031,418	103%	1,042,625	103%
18%	972,750	102%	1,030,289	103%	1,041,979	103%
21%	970,485	102%	1,027,795	103%	1,040,931	103%
25%	968,927	102%	1,023,506	102%	1,034,637	103%
29%	967,991	102%	1,021,422	102%	1,028,181	102%
32%	965,420	102%	1,018,058	102%	1,022,460	101%
36%	964,039	102%	1,005,859	101%	1,019,576	101%
39%	962,762	101%	1,002,712	100%	1,013,390	100%
43%	949,283	100%	999,825	100%	1,011,703	100%
46%	931,932	98%	991,962	99%	1,004,009	100%
50%	924,497	97%	960,048	96%	977,563	97%
54%	917,093	97%	942,864	94%	958,540	95%
57%	896,185	94%	933,924	94%	949,014	94%
61%	883,010	93%	914,275	92%	930,141	92%
64%	874,883	92%	907,560	91%	908,709	90%
68%	853,008	90%	884,712	89%	893,989	89%
71%	790,042	83%	814,340	82%	825,063	82%
75%	778,602	82%	809,588	81%	792,156	79%
79%	765,993	81%	783,306	78%	790,826	78%
82%	695,446	73%	675,063	68%	666,141	66%
86%	624,454	66%	673,876	67%	666,118	66%
89%	593,777	63%	612,654	61%	624,981	62%
93%	516,260	54%	569,310	57%	561,359	56%
96%	442,379	47%	488,551	49%	504,108	50%
100%	425,152	45%	469,075	47%	482,975	48%

Table 0-2. Summary of simulated system fill under future 2080s Median hydrology for the Baseline Scenario (current storage condition), the BOR Reservoirs Only Scenario (increased storage at Anderson Ranch and Arrowrock reservoirs only), and the All Reservoirs Scenario in terms of the percent of years that a particular fill volume (or fill percent) is equaled or exceeded over the 28-year simulation period (1982 through 2009).

	2080s Median Hydrology					
	Baseline Scenario		BOR Reservoirs Only Scenario		All Reservoirs Scenario	
% of Years	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill
4%	990,503	104%	1,042,345	104%	1,052,204	104%
7%	989,872	104%	1,041,051	104%	1,050,434	104%
11%	982,953	104%	1,038,467	104%	1,050,040	104%
14%	982,003	103%	1,035,474	104%	1,048,670	104%
18%	981,719	103%	1,034,428	104%	1,046,601	104%
21%	980,359	103%	1,034,389	104%	1,046,339	104%
25%	980,291	103%	1,034,194	104%	1,045,541	104%
29%	978,220	103%	1,033,662	104%	1,043,203	103%
32%	975,786	103%	1,030,048	103%	1,042,292	103%
36%	973,075	102%	1,027,540	103%	1,041,381	103%
39%	967,495	102%	1,025,466	103%	1,036,649	103%
43%	967,452	102%	1,024,179	103%	1,036,453	103%
46%	967,215	102%	1,023,051	102%	1,034,879	103%
50%	965,303	102%	1,019,912	102%	1,032,253	102%
54%	959,892	101%	1,018,932	102%	1,028,645	102%
57%	959,310	101%	1,015,635	102%	1,024,696	102%
61%	958,033	101%	1,012,016	101%	1,018,330	101%
64%	957,946	101%	1,005,784	101%	1,017,381	101%
68%	940,902	99%	945,260	95%	949,516	94%
71%	916,945	97%	936,474	94%	945,543	94%
75%	897,844	95%	915,667	92%	929,568	92%
79%	879,020	93%	898,280	90%	913,203	91%
82%	816,551	86%	840,824	84%	849,443	84%
86%	802,409	84%	838,162	84%	848,943	84%
89%	791,218	83%	837,339	84%	844,523	84%
93%	788,380	83%	810,504	81%	815,566	81%
96%	751,833	79%	784,214	79%	793,486	79%
100%	628,727	66%	643,899	64%	648,679	64%

1 PROJECT OVERVIEW

The objective of this project is to evaluate the storage benefit associated with a six-foot raise of Anderson Ranch Dam, a ten-foot raise of Arrowrock Dam, and a four-foot raise of Lucky Peak Dam. Such increases in dam height correspond to an estimated 29,000 acre-feet of additional storage in Anderson Ranch Reservoir, 20,000 acre-feet of additional storage in Arrowrock Reservoir, and 10,000 acre-feet of additional storage in Lucky Peak Reservoir. These storage increases were evaluated under two different storage scenarios: 1) increases at all three reservoirs (59,000 acre-feet or a 6% increase in system storage capacity), and 2) increases at only Anderson Ranch Reservoir and Arrowrock Reservoir (49,000 acre-feet or a 5% increase in system storage capacity). The evaluation was conducted using the Boise Planning Model to simulate the frequency of fill of the expanded storage space given historical hydrology and future 2080s climate change flows.

2 BOISE PLANNING MODEL DESCRIPTION

The Boise Planning Model was developed using RiverWare and includes logic to simulate all of the competing water demands in the system while adhering to legal water right and physical constraints. Competing water demands include irrigation, flood control, minimum-flow requirements, ecological flow releases, and ecological storage constraints. This model runs at a daily time-step (October 1, 1982 through September 30, 2009) and was updated with new operational logic and recalibrated for this investigation. Figure 2-1 illustrates simulated and observed storage in the Boise Reservoir System. While the model performs well in simulating physical operations of the reservoir system (particularly with respect to the simulation of annual maximum fill), in its current formulation it is not possible to precisely track ownership of water between the three reservoirs. Therefore analysis in this study is based on fill to the system as a whole, rather than for individual reservoirs.

It is important to note that operational objectives have changed over the course of the simulation period (1982 – 2009) and that the model has been calibrated to more closely simulate current operational objectives. These include 1) maintaining a minimum storage volume in Arrowrock Reservoir of 50,000 acre-feet, 2) keeping Lucky Peak Reservoir above 264,000 acre-feet from May 31st through September 1st , and 3) managing peak flows at Glenwood gage to be less than 7,000 cfs. In order to meet these more stringent objectives, Anderson Ranch Reservoir (Figure 2-2) is drafted lower in the simulation than it is in the observed record. As shown in Figure 2-3 and Figure 2-4, these instances often coincide with periods where simulated storage in Arrowrock Reservoir and Lucky Peak Reservoir is higher than historical observations and is more closely meeting minimum storage objectives.

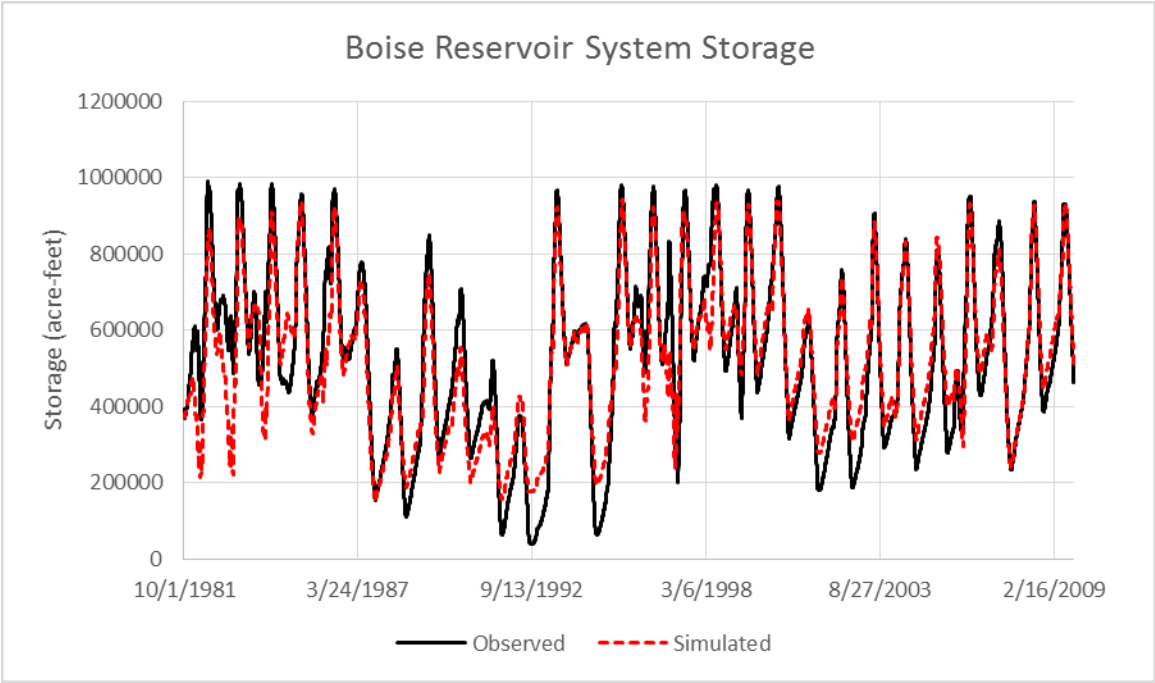

Figure 2-1. Simulated storage (red dashed line) and observed storage (black solid line) in the Boise Reservoir System for the 1982 through 2009 water years.

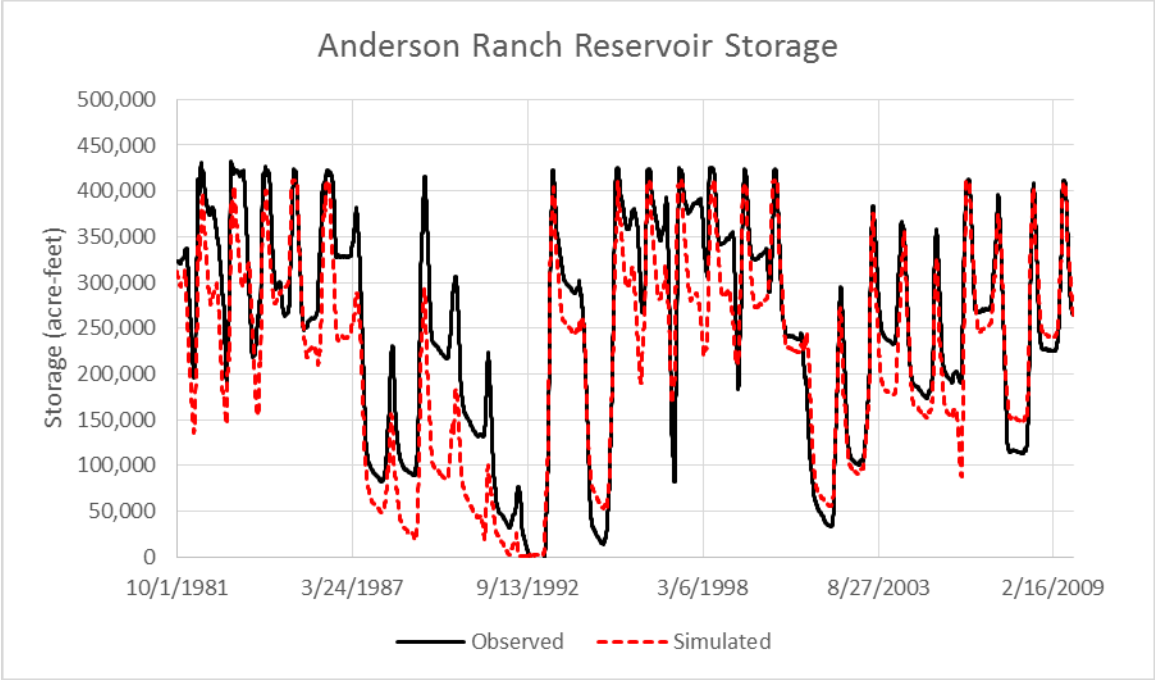

Figure 2-2. Simulated storage (red dashed line) and observed storage (black solid line) in Anderson Ranch Reservoir for the 1982 through 2009 water years.

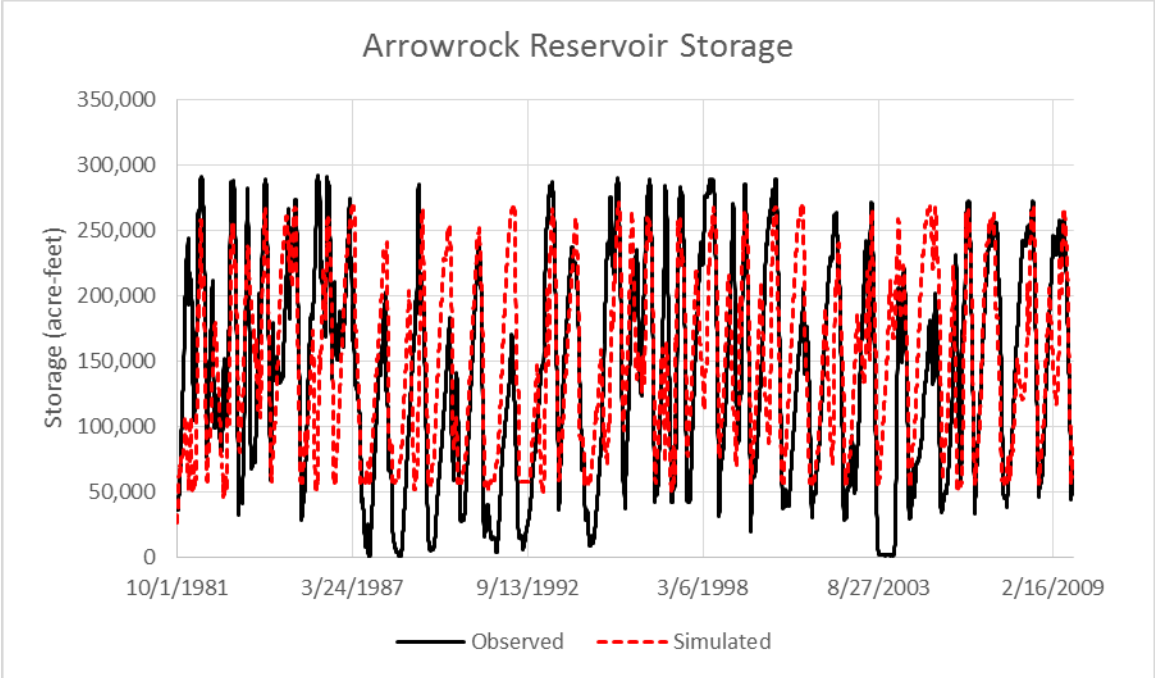

Figure 2-3. Simulated storage (red dashed line) and observed storage (black solid line) in Arrowrock Reservoir for the 1982 through 2009 water years.

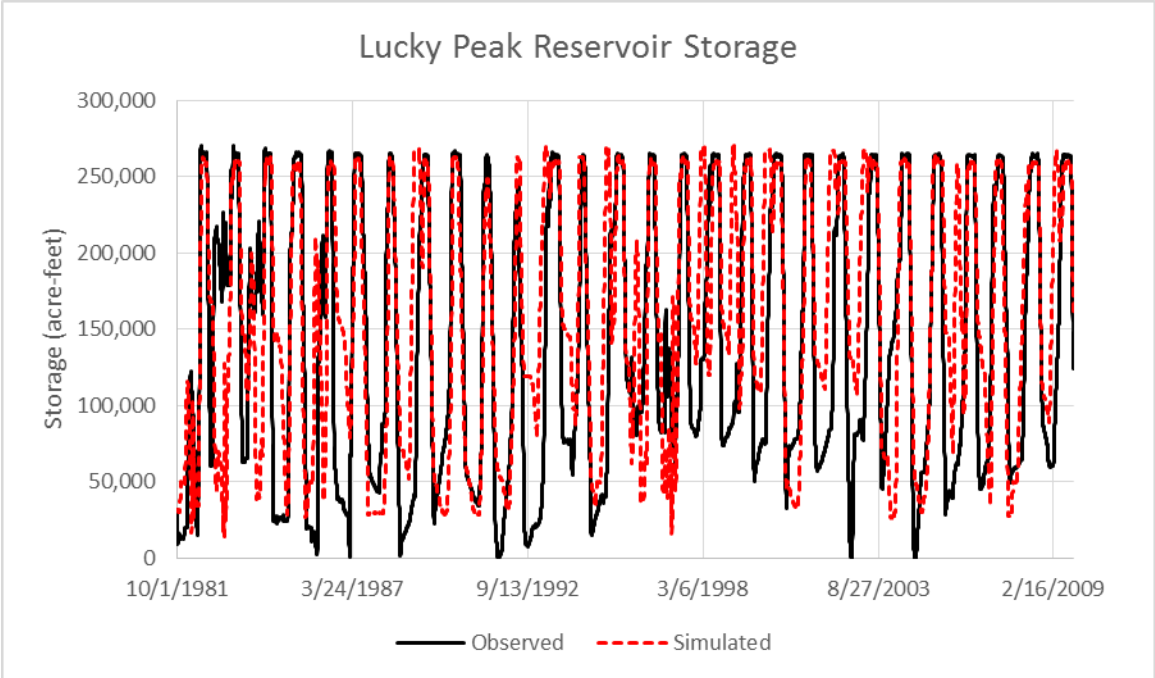

Figure 2-4. Simulated storage (red dashed line) and observed storage (black solid line) in Lucky Peak Reservoir for the 1982 through 2009 water years.

3 HISTORICAL REFILL PROBABILITY

Analysis of water right accounting records from the Idaho Department of Water Resources (IDWR), dating back to 1988 and summarized in Appendix Table 9-1, indicates that maximum accrual (excluding accrual to uncontracted space) was achieved in 55% of years for Anderson Ranch Reservoir, 91% of years for Arrowrock Reservoir, and 55% of years for Lucky Peak Reservoir, with all three reservoirs reaching maximum accrual together in only 41% of years. In terms of system fill, IDWR accounting data also suggests that the Boise Reservoir System reached or exceeded the volume of system contracted space (949,668 acre-feet) in 50% of years during the period spanning 1988 through 2009[1]. Simulated results suggest a similar refill probability with the system reaching 949,668 acre-feet in approximately 48% of years for the 1988 through 2009 period and in approximately 46% of years for the full simulation period (1982 through 2009). Results for the full simulation period are summarized in Table 4-1.

4 NEW STORAGE SCENARIOS

The Boise Planning Model was used to evaluate the probability of filling an additional 29,000 acre-feet of storage (corresponding to a proposed 6-ft dam raise) in Anderson Ranch Reservoir, an additional 20,000 acre-feet of storage (10-ft raise) in Arrowrock Reservoir, and an additional 10,000 acre-feet of storage (4-ft raise) in Lucky Peak Reservoir. These proposed storage increases were evaluated using two different new storage scenarios:

1) BOR Reservoir Only Scenario - simulating storage increases at Anderson Ranch and Arrowrock reservoirs only
2) All Reservoirs Scenario - simulating storage increases at all three reservoirs.

These scenarios were created by updating the model to include new physical space in the appropriate reservoirs, creating new storage accounts with the most junior water right priority dates in the basin, and updating the model logic to utilize the new space.

In order to conservatively evaluate the probability of completely refilling the additional space each year, this evaluation assumed that demand for the new stored water is large enough that all water accrued to the new account is used each year, leaving no carryover.

[1] Storage accounting records were not available prior to 1988. Water rights accounting was first implemented in Water District 63 in 1986, however records for 1986 and 1987 did not include values for Anderson Ranch fill. Per conversation with IDWR staff, prior to 1986 allocations were typically based on maximum physical fill of the reservoirs with storage being allocated first to Arrowrock, second to Anderson, and last to Lucky Peak.

This condition was simulated through the addition of new water users within the model that call on any water available in the new storage accounts. Given the limitations of the current model configuration in tracking ownership or "paper fill" between the reservoirs, fill benefits are evaluated in terms of total system fill.

Table 4-1 shows the simulated results for each storage scenario (Baseline, BOR Reservoirs Only, and All Reservoirs) under historical hydrologic conditions. As seen in the table, the expanded storage space fills completely with the same probability as the Baseline scenario, suggesting that in years where there is enough water to fill the existing storage space, there is likely enough additional water available to fill 5% more space (49,000 acre-feet) under the "BOR Reservoir Only Scenario" or 6% more space (59,000 acre-feet) under the "All Reservoir Scenario".

Table 4-1. Summary of simulated fill in terms of the percent of years a particular fill volume (or fill percent) is equaled or exceeded over the 28-year simulation period (1982 through 2009).

	Historical Hydrology					
	Baseline Scenario		BOR Reservoirs Only Scenario		All Reservoirs Scenario	
% of Years	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill
4%	984,242	104%	1,034,140	104%	1,046,744	104%
7%	979,415	103%	1,032,224	103%	1,045,020	104%
11%	978,730	103%	1,031,472	103%	1,043,378	103%
14%	975,684	103%	1,031,418	103%	1,042,625	103%
18%	972,750	102%	1,030,289	103%	1,041,979	103%
21%	970,485	102%	1,027,795	103%	1,040,931	103%
25%	968,927	102%	1,023,506	102%	1,034,637	103%
29%	967,991	102%	1,021,422	102%	1,028,181	102%
32%	965,420	102%	1,018,058	102%	1,022,460	101%
36%	964,039	102%	1,005,859	101%	1,019,576	101%
39%	962,762	101%	1,002,712	100%	1,013,390	100%
43%	949,283	100%	999,825	100%	1,011,703	100%
46%	931,932	98%	991,962	99%	1,004,009	100%
50%	924,497	97%	960,048	96%	977,563	97%
54%	917,093	97%	942,864	94%	958,540	95%
57%	896,185	94%	933,924	94%	949,014	94%
61%	883,010	93%	914,275	92%	930,141	92%
64%	874,883	92%	907,560	91%	908,709	90%
68%	853,008	90%	884,712	89%	893,989	89%
71%	790,042	83%	814,340	82%	825,063	82%
75%	778,602	82%	809,588	81%	792,156	79%
79%	765,993	81%	783,306	78%	790,826	78%
82%	695,446	73%	675,063	68%	666,141	66%
86%	624,454	66%	673,876	67%	666,118	66%
89%	593,777	63%	612,654	61%	624,981	62%
93%	516,260	54%	569,310	57%	561,359	56%
96%	442,379	47%	488,551	49%	504,108	50%
100%	425,152	45%	469,075	47%	482,975	48%

5 CLIMATE CHANGE SCENARIO

Several climate change scenarios were considered in this evaluation to provide insight into how probability of fill might change in the future. These scenarios were obtained from the recent Columbia River Basin Impact Assessment (Reclamation 2016a) and include a combination of 20th-, 50th-, and 80th-percentile changes in precipitation and temperature (Less Warming/Dry, Less Warming/Wet, Median, More Warming/Dry, and More Warming/Wet) for the 2040 and 2080 periods. More detailed information on the development of these scenarios is available in Reclamation's Columbia River Basin Impact Assessment Technical Memorandum: Climate Change Analysis and Hydrologic Modeling (2016a). Notable changes to Boise System inflows under these climate change scenarios include

- An increase in annual inflow volumes by the end of the century (across all scenarios),
- Increased inflows during the late-winter and spring and decreased inflows during the summer months (across all scenarios),
- And a shift in peak inflows from May to April by the end of the century (More Warming/Wet, More Warming/Dry, and Median scenarios).

As in the recent Boise General Investigation modeling (Reclamation, 2015), this evaluation focused on storage impacts under the 2080s Median climate change scenario. More information on system storage under these more extreme scenarios is available in the Columbia River Basin Impact Assessment Water Resource Modeling Technical Memorandum (Reclamation, 2016b), which modeled system storage using a monthly time-step MODSIM model.

Results of the simulations indicate that the probability of filling the expanded system storage space increases under the 2080s Median climate change scenario. Under the climate change scenario the expanded system space fills in 64% of years, compared to 46% under the historical hydrology scenario. These results are summarized in Table 5-1.

Table 5-1. Summary of simulated fill in terms of the percent of years a particular fill volume (or fill percent) is equaled or exceeded over the 28-year simulation period (1982 through 2009).

	2080s Median Hydrology					
	Baseline Scenario		BOR Reservoirs Only Scenario		All Reservoirs Scenario	
% of Years	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill
4%	990,503	104%	1,042,345	104%	1,052,204	104%
7%	989,872	104%	1,041,051	104%	1,050,434	104%
11%	982,953	104%	1,038,467	104%	1,050,040	104%
14%	982,003	103%	1,035,474	104%	1,048,670	104%
18%	981,719	103%	1,034,428	104%	1,046,601	104%
21%	980,359	103%	1,034,389	104%	1,046,339	104%
25%	980,291	103%	1,034,194	104%	1,045,541	104%
29%	978,220	103%	1,033,662	104%	1,043,203	103%
32%	975,786	103%	1,030,048	103%	1,042,292	103%
36%	973,075	102%	1,027,540	103%	1,041,381	103%
39%	967,495	102%	1,025,466	103%	1,036,649	103%
43%	967,452	102%	1,024,179	103%	1,036,453	103%
46%	967,215	102%	1,023,051	102%	1,034,879	103%
50%	965,303	102%	1,019,912	102%	1,032,253	102%
54%	959,892	101%	1,018,932	102%	1,028,645	102%
57%	959,310	101%	1,015,635	102%	1,024,696	102%
61%	958,033	101%	1,012,016	101%	1,018,330	101%
64%	957,946	101%	1,005,784	101%	1,017,381	101%
68%	940,902	99%	945,260	95%	949,516	94%
71%	916,945	97%	936,474	94%	945,543	94%
75%	897,844	95%	915,667	92%	929,568	92%
79%	879,020	93%	898,280	90%	913,203	91%
82%	816,551	86%	840,824	84%	849,443	84%
86%	802,409	84%	838,162	84%	848,943	84%
89%	791,218	83%	837,339	84%	844,523	84%
93%	788,380	83%	810,504	81%	815,566	81%
96%	751,833	79%	784,214	79%	793,486	79%
100%	628,727	66%	643,899	64%	648,679	64%

6 PREVIOUS STUDY COMPARISON

The refill probabilities estimated by this study are lower than the probabilities suggested by modeling results produced for the 2005 report "Hydrologic Analysis of the Refill Probabilities Associated with Increasing the Storage Capacities of Anderson Ranch and Arrowrock Reservoirs" (Reclamation, 2005). This earlier study reported that the additional storage would fill between 60% and 70% of the time under historical hydrologic conditions, while this study suggests that this space would fill closer to 46% of the time.

While a detailed investigation into the differences between the two modelling efforts was not performed, several differences were noted and likely explain the discrepancy in the reported results. These are summarized in Table 6-1.

Table 6-1. Summary of key model differences between this study (2017) and the earlier 2005 study.

2017 Study	2005 Study
More recent simulation period (1982-2009)	Longer simulation period (1928-2000)
Modeling performed with RiverWare, a rule-based modeling platform for river and reservoir management simulation (www.riverware.org).	Modeling performed with MODSIM, a network flow optimization modeling platform for river and reservoir management simulation (www.modsim.engr.colostate.edu).
System is partitioned into 5 reaches (or river segments)	System is partitioned into 6+ reaches (or river segments)
Reach gains (or local inflow to a particular river segment) obtained from most recent 2010 Modified Flows effort	Reach gains (or local inflow to a particular river segment) obtained from earlier 2000 Modified Flows effort
Demands are represented by historical observed timeseries	Demands are "patterned" (i.e., represented by a 12-month repeating pattern based on historical demands)

7 CONCLUSIONS

The results of this study suggest that the probability of filling an additional 49,000 acre-feet (BOR Reservoirs Only) or 59,000 acre-feet of storage space is equivalent to the probability of filling the existing system storage space under both hydrology scenarios. The system fills completely in 43-46% of years (12-13 out of 28 years) given historical hydrologic conditions and in 64% of years (18 out of 28 years) given future 2080s Median Climate Change hydrologic conditions.

In addition to providing potential carryover benefits, such space may also increase operational flexibility as a result of larger flood control space and increased storage supply to help meet Arrowrock Reservoir and Lucky Peak Reservoir minimum pool criteria. More detailed investigation is needed to more fully quantify the system benefit provided by the additional space.

It is recommended that future work consider a wider range of climate change projections and that the model logic be further updated to more precisely track ownership of water between the reservoirs.

8 LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Reclamation 2005	Bureau of Reclamation. 2005. Hydrologic Analysis of the Refill Probabilities Associated with Increasing the Storage capacities of Anderson Ranch and Arrowrock Reservoirs. Prepared by the U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. February 2005.
Reclamation 2015	Bureau of Reclamation. 2015. Boise General Investigation: Modeling the Proposed New Arrowrock Storage Alternatives using the Boise RiverWare Planning Model. Prepared by the U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. December 2015.
Reclamation 2016a	Bureau of Reclamation. 2016. Columbia River Basin Impacts Assessment: Climate Change Analysis and Hydrologic Modeling Technical Memorandum. Prepared by the U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. April 2016.
Reclamation 2016b	Bureau of Reclamation. 2016. Columbia River Basin Impacts Assessment: Water Resources Modeling Technical Memorandum. Prepared by the U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. April 2016.

9 APPENDIX

Table 9-1. Summary of Idaho Department of Water Resources water rights accounting data for storage account fill for each year in the data record. Available space reported excludes uncontracted space. Data for storage fill is not available for years prior to 1988.

	Anderson Ranch			Arrowrock			Lucky Peak			System		
Year	Fill (AF)	Space (AF)*	% Fill	Fill (AF)	Space (AF)	% Fill	Fill (AF)	Space (AF)	% Fill	Fill (AF)	Space (AF)	% Fill
1988	151,088	413,074	36.6%	286,600	286,600	100.0%	119,057	264,250	45.1%	556,744	963,924	57.8%
1989	423,200	413,074	102.5%	286,600	286,600	100.0%	137,777	264,250	52.1%	847,577	963,924	87.9%
1990	285,897	413,074	69.2%	286,600	286,600	100.0%	141,468	264,250	53.5%	713,964	963,924	74.1%
1991	190,943	413,074	46.2%	286,600	286,600	100.0%	63,118	264,250	23.9%	540,661	963,924	56.1%
1992	37,006	413,074	9.0%	286,600	286,600	100.0%	66,531	264,250	25.2%	390,137	963,924	40.5%
1993	464,200	413,074	112.4%	286,600	286,600	100.0%	248,879	264,250	94.2%	999,679	963,924	103.7%
1994	303,978	413,074	73.6%	184,854	286,600	64.5%	203,863	264,250	77.1%	692,696	963,924	71.9%
1995	464,200	413,074	112.4%	286,600	286,600	100.0%	264,250	264,250	100.0%	1,015,050	963,924	105.3%
1996	464,200	413,074	112.4%	286,600	286,600	100.0%	264,250	264,250	100.0%	1,015,050	963,924	105.3%
1997	464,200	413,074	112.4%	286,600	286,600	100.0%	264,250	264,250	100.0%	1,015,050	963,924	105.3%
1998	464,200	413,074	112.4%	286,600	286,600	100.0%	264,250	264,250	100.0%	1,015,050	963,924	105.3%
1999	464,200	413,074	112.4%	286,600	286,600	100.0%	257,402	264,370	97.4%	1,008,202	964,044	104.6%
2000	464,200	413,074	112.4%	286,600	286,600	100.0%	264,370	264,370	100.0%	1,015,170	964,044	105.3%
2001	217,658	413,074	52.7%	272,224	272,224	100.0%	183,619	264,370	69.5%	673,502	949,668	70.9%
2002	345,049	413,074	83.5%	272,224	272,224	100.0%	225,624	264,370	85.3%	842,898	949,668	88.8%
2003	413,292	413,074	100.1%	272,224	272,224	100.0%	264,370	264,370	100.0%	949,886	949,668	100.0%
2004	382,027	413,074	92.5%	252,261	272,224	92.7%	264,370	264,370	100.0%	898,658	949,668	94.6%
2005	328,474	413,074	79.5%	272,224	272,224	100.0%	264,370	264,370	100.0%	865,068	949,668	91.1%
2006	450,030	413,074	108.9%	272,224	272,224	100.0%	264,370	264,370	100.0%	986,624	949,668	103.9%
2007	396,490	413,074	96.0%	272,224	272,224	100.0%	264,370	264,370	100.0%	933,084	949,668	98.3%
2008	450,030	413,074	108.9%	272,224	272,224	100.0%	264,370	264,370	100.0%	986,624	949,668	103.9%
2009	450,030	413,074	108.9%	272,224	272,224	100.0%	264,370	264,370	100.0%	986,624	949,668	103.9%

* Volume of space excludes uncontracted space in Anderson Ranch Reservoir.

Table 9-2. Summary of simulated fill in terms of the percent of years a particular fill volume (or fill percent) is equaled or exceeded over the 28-year simulation period (1982 through 2009).

	Historical Hydrology						2080s Median Hydrology					
	Baseline Scenario		BOR Reservoirs Only Scenario		All Reservoirs Scenario		Baseline Scenario		BOR Reservoirs Only Scenario		All Reservoirs Scenario	
% of Years	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill	Volume (AF)	% Fill
4%	984,242	104%	1,034,140	104%	1,046,744	104%	990,503	104%	1,042,345	104%	1,052,204	104%
7%	979,415	103%	1,032,224	103%	1,045,020	104%	989,872	104%	1,041,051	104%	1,050,434	104%
11%	978,730	103%	1,031,472	103%	1,043,378	103%	982,953	104%	1,038,467	104%	1,050,040	104%
14%	975,684	103%	1,031,418	103%	1,042,625	103%	982,003	103%	1,035,474	104%	1,048,670	104%
18%	972,750	102%	1,030,289	103%	1,041,979	103%	981,719	103%	1,034,428	104%	1,046,601	104%
21%	970,485	102%	1,027,795	103%	1,040,931	103%	980,359	103%	1,034,389	104%	1,046,339	104%
25%	968,927	102%	1,023,506	102%	1,034,637	103%	980,291	103%	1,034,194	104%	1,045,541	104%
29%	967,991	102%	1,021,422	102%	1,028,181	102%	978,220	103%	1,033,662	104%	1,043,203	103%
32%	965,420	102%	1,018,058	102%	1,022,460	101%	975,786	103%	1,030,048	103%	1,042,292	103%
36%	964,039	102%	1,005,859	101%	1,019,576	101%	973,075	102%	1,027,540	103%	1,041,381	103%
39%	962,762	101%	1,002,712	100%	1,013,390	100%	967,495	102%	1,025,466	103%	1,036,649	103%
43%	949,283	100%	999,825	100%	1,011,703	100%	967,452	102%	1,024,179	103%	1,036,453	103%
46%	931,932	98%	991,962	99%	1,004,009	100%	967,215	102%	1,023,051	102%	1,034,879	103%
50%	924,497	97%	960,048	96%	977,563	97%	965,303	102%	1,019,912	102%	1,032,253	102%
54%	917,093	97%	942,864	94%	958,540	95%	959,892	101%	1,018,932	102%	1,028,645	102%
57%	896,185	94%	933,924	94%	949,014	94%	959,310	101%	1,015,635	102%	1,024,696	102%
61%	883,010	93%	914,275	92%	930,141	92%	958,033	101%	1,012,016	101%	1,018,330	101%
64%	874,883	92%	907,560	91%	908,709	90%	957,946	101%	1,005,784	101%	1,017,381	101%
68%	853,008	90%	884,712	89%	893,989	89%	940,902	99%	945,260	95%	949,516	94%
71%	790,042	83%	814,340	82%	825,063	82%	916,945	97%	936,474	94%	945,543	94%
75%	778,602	82%	809,588	81%	792,156	79%	897,844	95%	915,667	92%	929,568	92%
79%	765,993	81%	783,306	78%	790,826	78%	879,020	93%	898,280	90%	913,203	91%
82%	695,446	73%	675,063	68%	666,141	66%	816,551	86%	840,824	84%	849,443	84%
86%	624,454	66%	673,876	67%	666,118	66%	802,409	84%	838,162	84%	848,943	84%
89%	593,777	63%	612,654	61%	624,981	62%	791,218	83%	837,339	84%	844,523	84%
93%	516,260	54%	569,310	57%	561,359	56%	788,380	83%	810,504	81%	815,566	81%
96%	442,379	47%	488,551	49%	504,108	50%	751,833	79%	784,214	79%	793,486	79%
100%	425,152	45%	469,075	47%	482,975	48%	628,727	66%	643,899	64%	648,679	64%