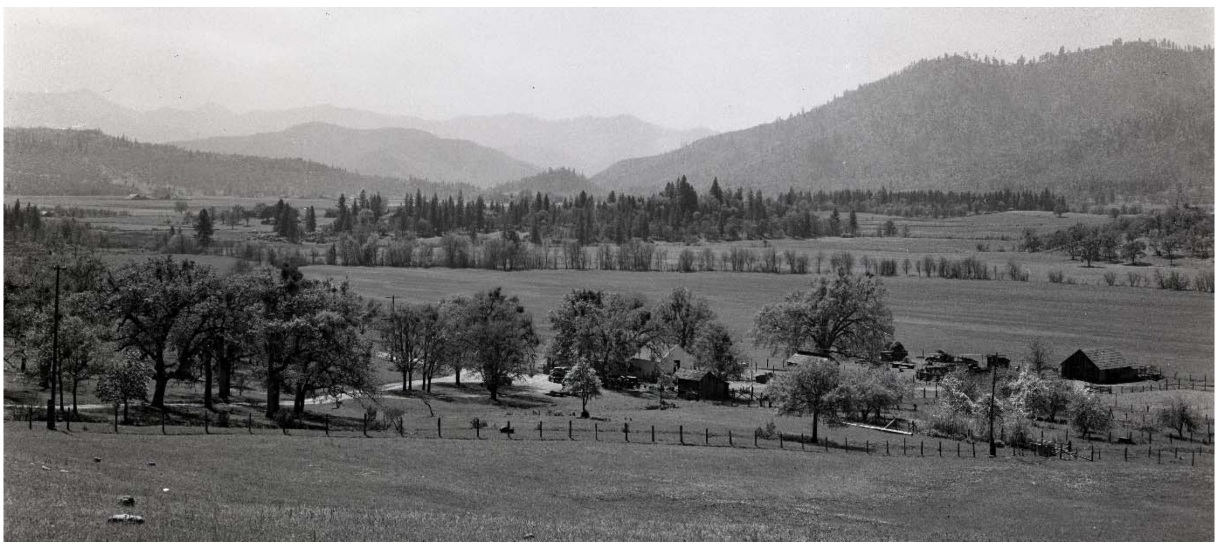
RECLAMATION

Managing Water in the West

Hydrologic Evaluation of Reeder Reservoir to Increase January and February Flows to Ashland Creek

Technical Memorandum



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

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Photograph on front cover: View of farmland near Ashland, Oregon. Contact Reclamation Photographer Dave Walsh for information. April 23, 1946.

Technical Memorandum

Hydrologic Evaluation of Reeder Reservoir to Increase January and February Flows to Ashland Creek

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Peer Review:
The results, findings, and recommendations provided in this technical memorandum are technically sound and consistent with current professional practice. The independent reviewers provided a version of the draft report with comments and suggested revisions in track changes to the study author. Comments were discussed by the study author and reviewers, and the agreed upon resolutions were incorporated into this final version of the technical memorandum.

Kenneth C Nowak	11-28-16
Kenneth Nowak, Bureau of Reclamation	**Date**
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1.0 PROJECT OVERVIEW

The objective of this work is to evaluate the refill probability of Reeder Reservoir under a range of potential increased releases to Ashland Creek in January and February. Potential increased releases would augment Ashland Creek flows and improve the ability of the Bureau of Reclamation (Reclamation) to meet 2012 Rogue River Biological Opinion (BiOp) habitat uplift obligations (National Marine Fisheries Service, 2012). The evaluation was conducted with hydrologic and reservoir historical data from water years 2005-2015.

2.0 REEDER RESERVOIR BACKGROUND

The City of Ashland (City) owns and operates Reeder Reservoir on Ashland Creek. Impounded by the Hosler Dam, Reeder Reservoir is fed by the West and East Forks of Ashland Creek. Reeder Reservoir is the primary source of drinking water for Ashland residents and also provides irrigation water (Carollo Engineers, 2012). Reeder Reservoir has a capacity of 850 acre-feet (AF) and a surface area of 20 acres when full (Bear Creek Watershed Council, 2001). Measured historical hydrologic data for Reeder Reservoir and Ashland Creek is limited.

The City operates Reeder Reservoir to fill by May 31st each year for two reasons. First, May 31st is after flood releases in their historical hydrology and is typically when demands start. Second, the City begins releases out of Reeder Reservoir in June to mitigate temperature impacts for operations at the waste water treatment plant. The Reeder Reservoir storage on May 31st is an important metric in this evaluation.

2.1 Study Period

Due to available data for the reservoir and tributaries, the Reeder Reservoir evaluation spans water years 2005-2015. A comparison of 2005-2015 to a longer historical record was conducted determine if the range is representative of historical flows. The BioOp Technical Memorandum “Regulation model of Bear and Little Butte Creeks and modeled scenarios” describes a method for classifying periods with respect to the hydrologic record (National Marine Fisheries Service, 2012). The tech memo analyzed data from 1963-2011 for inflows into Howard Prairie Reservoir. This method was extended through June 2015 in work by in further analysis of Little Butte Creek (U.S. Bureau of Reclamation, 2015). Howard Prairie Reservoir is about 25 miles north east of Reeder Reservoir. Table 2.1 below shows that the period of record from water year 2005-2014 had two high, three average, and five low flow years; 2015 was an average year through June 30th.

Table 2.1: Water-years 1963 through 2011 annual inflow to Howard Prairie Reservoir sorted by probability of exceedance from the Rogue River Biological Opinion "Regulation model of Bear and Little Butte Creeks and modeled scenarios" technical memorandum (National Marine Fisheries Service, 2012); this work was expanded to 2015 (U.S. Bureau of Reclamation, 2015). Volumes greater than the 30% exceedance volume were defined as wet, volumes less than the 70% exceedance volume as dry, and the remaining years were considered average. Years highlighted in blue were included in the analysis for the Reeder Reservoir.

High Flow Years			Average Flow Years			Low Flow Years		
WY	Annual Volume (1000 AF)	Exceedance	WY	Annual Volume (1000 AF)	Exceedance	WY	Annual Volume (1000 AF)	Exceedance
1995	51.3	2%	1975	38.9	32%	1999	25.4	70%
1971	49.5	4%	1996	38.8	34%	2013	25.2	72%
1982	49.4	6%	1997	38.0	36%	1990	23.0	74%
1974	48.9	8%	1970	36.3	38%	2005	22.7	75%
1969	47.7	9%	2004	36.1	40%	1973	22.5	77%
1993	47.5	11%	1983	35.5	42%	2012	22.2	79%
1979	46.9	13%	1976	33.0	43%	2010	21.4	81%
1963	45.5	15%	1980	32.3	45%	1988	20.7	83%
1972	45.3	17%	1986	31.6	47%	1966	20.5	85%
2006	44.9	19%	2003	31.3	49%	1987	19.0	87%
1978	44.6	21%	*2015	*31.0	51%	1981	16.5	89%
1984	43.7	23%	2008	30.8	53%	1968	12.4	91%
1965	41.6	25%	1991	30.5	55%	2014	12.3	92%
1967	40.6	26%	2002	30.4	57%	2001	11.3	94%
2011	40.4	28%	2009	29.5	58%	1992	10.4	96%
1989	40.2	30%	1985	29.2	60%	1994	10.0	98%
			1964	29.1	62%	1977	9.5	100%
			2000	28.3	64%			
			1998	27.3	66%			
			2007	27.1	68%			

* Incomplete data, calculated through 6/30/2015.

An even distribution of wet, average, and dry years would have indicated that the evaluation period was representative of historical hydrologic conditions (i.e., 3 wet, 5 average, and 3 dry years). The evaluation period was skewed toward dry years with five of the eleven being classified as dry. Having more dry years than average or wet years included in the Reeder Reservoir evaluation period leads to results that are likely to be conservative.

2.2 Physical Description and Limitations

Inflows. Gaged daily flow data for the West and East Forks of Ashland Creek (14353000 and 14353500, respectively) are available from the United State Geological Survey (USGS) for the following time periods: 10/1/1924-1/31/1933, 12/1/1974-9/30/1982, and 10/1/2002-present (United States Geological Survey, 2016). The West and East Fork USGS gages are located roughly 1,000 feet upstream from Reeder Reservoir. In addition, the City maintains and gages a Cipoletti weir on each fork roughly 300 feet upstream of the reservoir. Weir data from the City was supplied from 2005 through 2015.

The two inflow data sources were used together to create the inflow data set for the analysis. Due to weir and instrumentation capacities, the Cipoletti data is only valid up to 18.6 cubic feet per second (cfs). The West and East Forks had 579 days and 556 days, respectively, out of the 3901 days of the study period where flow was above 18.6 cfs, which equates to about 14% of the time. Generally, the higher flow rates occurred between November and June. For flow greater than 18.6 cfs, data from the USGS gages was used. Since the weirs are downstream of the gages and there are no diversions between them, it would be expected that the flow in the weirs would be greater than or equal to the flows measured at the gages. However, inspection of the measured data revealed that this was not always the case, so the assumption was made to use the maximum value reported by each gage/weir pair. The distance between the two measurement points on each inflow and the distance between these measurements and the reservoir leave the possibility of additional inflow that is not accounted for in this data.

Storage. There is a gage at the reservoir for the water surface elevation which is converted into a storage volume. Bathymetry surveys conducted by the City in 2007 and 2016 did not show substantial changes to the reservoir.

Outflows. There is no gage on Ashland Creek downstream of Reeder Reservoir to measure total outflows from the reservoir.

Water leaves Reeder Reservoir via either the spillway or the outlet works; only a portion of the outlet works outflow is measured. The spillway weir is not currently used as a measurement device nor is it calibrated to be used as such. When the spill gates are closed, maximum storage in Reeder Reservoir is 850 AF (Reeder's full capacity). If the spill gates are lowered into a down position, Reeder can only store roughly 93% (790 AF) of its total capacity before spilling.

After being released through the outlet works, outflow can follow many possible paths (Figure 2.1). The City maintains a generator with measured inflow data. The City’s water treatment plant is downstream of the generator. There is a generator bypass link to Ashland Creek. An energy dissipation vault between the reservoir and the generator can also bypass the outlet works to Ashland Creek. Water that flows through the generator is the only measured outflow from Reeder Reservoir.

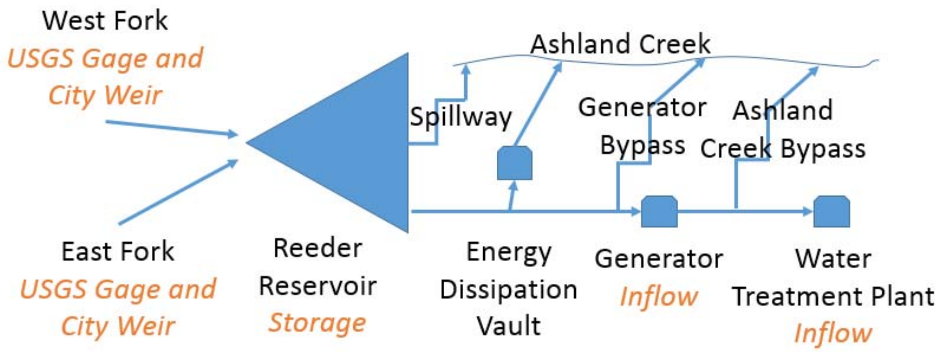

Figure 2.1. Diagram (not to scale) of Reeder Reservoir. Orange text indicates that data is available.

The four potential paths for flow through the outlet works are 1) all water goes through the City’s generators and then is released in combination to the City’s water treatment plant for drinking water or to the Ashland Creek Bypass, 2) water is divided between an energy dissipation vault which flows to Ashland Creek and the generator, 3) all water is sent through the energy dissipation vault, and 4) all water is sent through the generator bypass. Release options 2, 3, and 4 have outflow from the reservoir that is not measured. Those options are used during time of generator maintenance, big storm events, or when the reservoir is filling very quickly.

There are many factors contributing to uncertainty in the reservoir mass balance equation for Reeder Reservoir. These include unmeasured outflow paths from Reeder Reservoir, lack of information on spillway gate position over the study period, potential for unaccounted for inflows over the distance between the inflow measurements and the reservoir, undefined groundwater influences (contributing or reducing), and gage errors. Evaporation from the 20-acre reservoir is also ignored.

3.0 DATA DEVELOPMENT

3.1 Historical Outflow

A spreadsheet was developed with a daily timestep to determine the impact on Reeder Reservoir storage of releasing additional flows in January and February to help satisfy BiOp requirements. As explained in Section 2, the available total outflow data is incomplete. Therefore, the total outflow was calculated daily using the measured storage and estimated inflow (described in section 2.2) with Equation 1, where the subscripts t and t-1 denote the current and previous time steps, respectively.

$$\boldsymbol{Inflow_t - (Storage_t - Storage_{t-1}) = Total\ Outflow} \qquad (1)$$

An estimate of unmeasured outflow, referred to as spill, was calculated by subtracting the known component of outflow, inflow to the generator, from the calculated total outflow. Using the estimated inflows and generator data described in section 2.2 directly in this calculation resulted in some negative spill values. This suggests that there may be additional inflow to the reservoir that is not measured by the gages used in this study. To account for this, the estimated inflows were adjusted so that any negative calculated spill values became zero. During the 3901 days of the study record, inflows were adjusted 657 days (17% of the time); the average adjustment increased the inflow 3.0 cfs with a standard deviation of 4.5 cfs. The maximum adjustment was 41.9 cfs. Figure 3.1 shows the calculated total outflows, measured outflow through the generator, and spill once the inflows were adjusted.

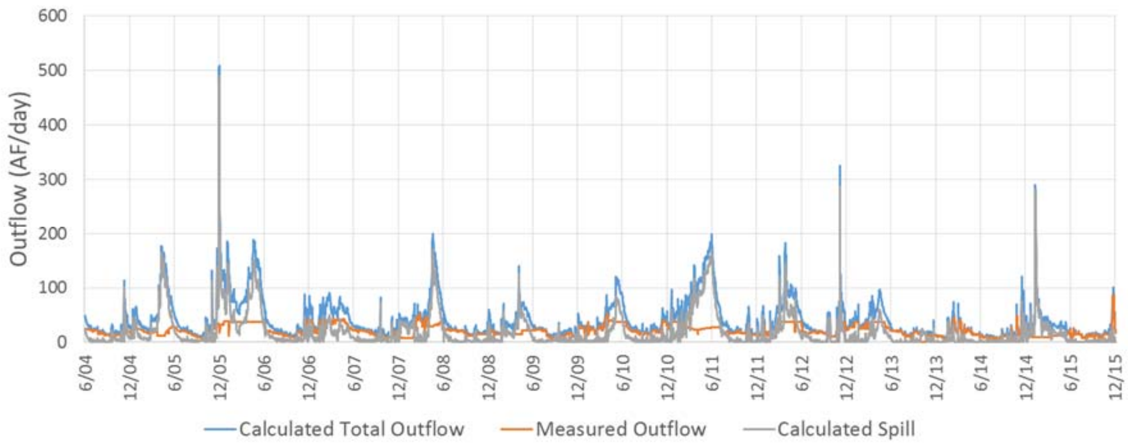

Figure 3.1. Outflows for Reeder Reservoir: calculated total outflow (blue), measured outflow through the generator (orange), and calculated spill (gray) after inflow adjustments.

3.2 Developing BiOp Scenario Simulation

Two types of scenarios were defined for this study: a no-action scenario and a range of potential flow scenarios. The range of flows were chosen based on flow needs identified in the BiOp; a maximum of 10 cfs could be used to augment Ashland and Bear Creek flows.

To simulate the scenarios, a minimum outflow time series was developed. This study assumed that BiOp releases were additional releases above and beyond what has historically been released from the reservoir during the months of January and February. Based on this, the minimum outflow time series was developed such that a) minimum outflow during January and February equals the measured flow through the generator plus the calculated spill and b) minimum outflow during the remainder of the year equals the generator flow. This assumption depends on generator flow being sufficient to meet downstream water rights requirements. These definitions of minimum outflow allow flows after February to be less than historical flows because reservoir releases above the generator inflow were not maintained.

BiOp release scenarios were evaluated in the 0 cfs (no-action) to 10 cfs range per day for January and February. The scenarios were simulated as follows, for each daily timestep

1) Calculate the amount of water available (supply) to satisfy downstream demands as inflow plus current storage (starting storage for the timestep).
2) Subtract the minimum outflow from the available supply to determine the supply remaining for BiOp release.

3) Subtract the BiOp release from the remaining supply and calculate the resulting storage. If there is insufficient available supply to meet the BiOp release, release what is available. If there is no available supply, set the BiOp release to 0 AF/day.
4) If the resulting storage is greater than the reservoir storage capacity, calculate the spill required. If not, set to spill to 0 AF/day and carry the resulting storage to step 5.
5) Recalculate the resulting storage (ending storage for the timestep). This becomes the starting storage for the next timestep.

4.0 SIMULATION RESULTS

The datasets and methods described in Section 3.0 were used to analyze the potential impact of additional flows to the existing outflows during January and February.

4.1 No-Action Scenario (0 cfs)

The first scenario simulated a flow of 0 cfs to represent a no-action scenario. The resulting storage from the no-action scenario served as a comparison to the historical measured storage values. The no-action storage values are always equal to or larger than the measured values (Figure 4.1). This is due to two things: the assumptions made to conduct simulation calculations and the limited available information on the operational activities that occur at the reservoir. First, the calculations for simulation do not maintain spill for months other than in January and February. The outflows in the remaining months for the calculated no-action scenario only meet the minimum flow as defined in Section 3.2

Second, the input data has limitations and non-repeatable operations. For example, in periods where the gaged storage hovers around 800 AF (e.g., January to July 2006), the spillway gates were in the lower position so the reservoir capacity was reduced to roughly 93%. There was no information that could be used in the calculation to determine when the spillway gates were in the lower position; it was assumed that they were always in the higher position, allowing the reservoir to fill to maximum capacity when it may not have historically. Another example is the limited information regarding when releases were made through the energy dissipation vault. Since it could not be determined when these releases would be made at any given time, the resulting calculated storage was larger than measured. The calculation method presented did not consider any operations to reduce the rate of refill other than operations that may have been accounted for in the minimum flow series for January and February.

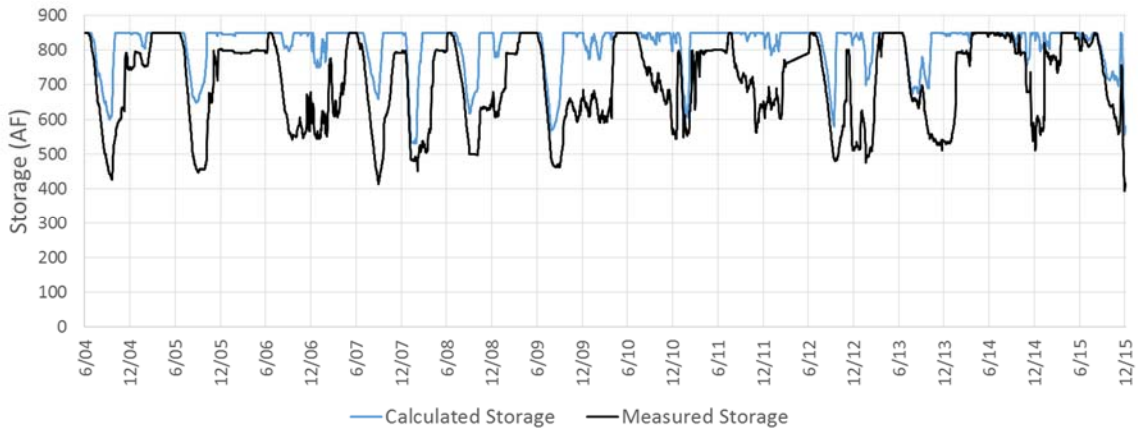

Figure 4.1. Simulated no-action scenario, 0 cfs BiOp flow, storage (blue) and measured (black) storage for Reeder Reservoir.

4.2 Other Flow Scenarios

Figure 4.2 shows the storage volume that results for a range of additional outflows (3 cfs, 5 cfs, and 10 cfs) in January and February. The reservoir reaches its maximum capacity at some point each water year with each flow alternative. Under the 5 cfs and 10 cfs alternatives, storage in the reservoir declines to the point that water is not available to sustain the additional flows throughout January and February. The reservoir completely empties under the 10 cfs each year and 5 cfs scenarios 1 time before the end of the BiOp flow period.

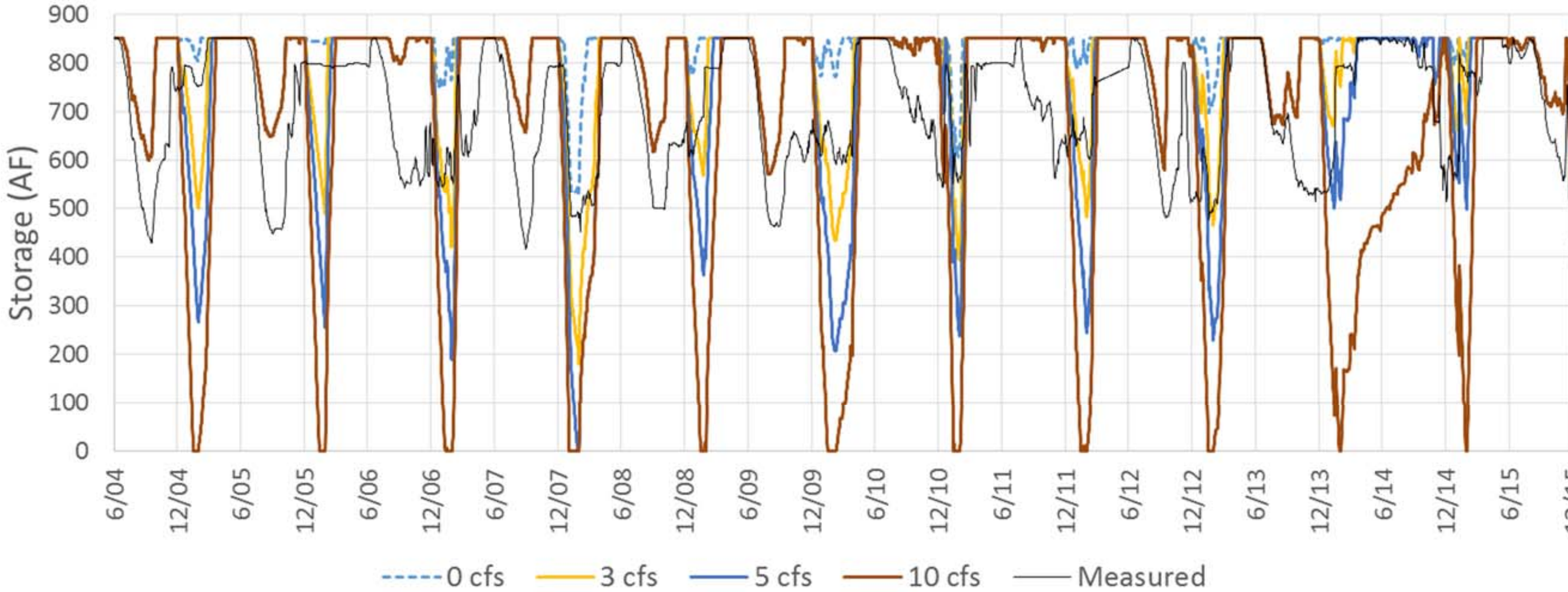

Figure 4.2. Comparison of the historical gaged storage (black) and the calculated storage for a range of potential additional releases in January and February to help meet BiOp requirements.

Within the 0 to 10 cfs range, flows were identified that 1) could be sustained 100% of the time for the analysis period and 2) could be supported without the reservoir dropping below the historical minimum of 393 AF. These flows were found to be 4.6 cfs and 1.2 cfs, respectively (Figure 4.3). First, a flow rate of 4.6 cfs is the highest flow rate that can be maintained throughout the BiOp flow period of January and February. The calculations assumed that historical operations would be adjusted so that spill is reduced and the reservoir is allowed to fill every year. If operations are not adjusted, the highest allowable release would be less than 4.6 cfs. In the simulation, a flow of 4.6 cfs during January and February caused the storage to drop below the historical minimum of 393 AF eight of the eleven years with one year (2007) going to zero storage. Second, a flow rate of 1.2 cfs is the highest flow at which the storage does not go below the historical measured minimum storage value of 393 AF at any time. There is no established minimum storage level for Reeder Reservoir. In reality, the reservoir does have water quality issues when storage levels get too low.

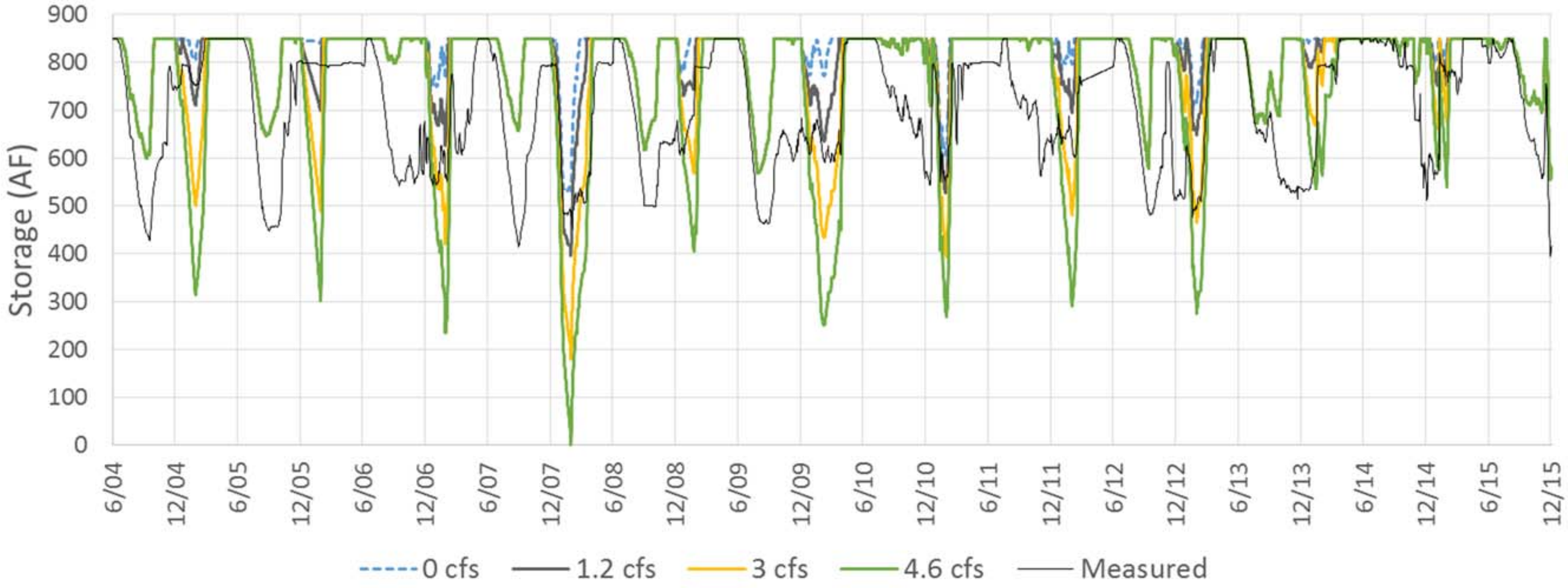

Figure 4.3. Comparison of the historical gaged storage (black) and the calculated storage for a range of potential additional releases in January and February to help meet BiOp requirements.

May 31st reservoir refill was evaluated for each year of the period of record (2005-2015). The measured storage had five years where 850 acre-feet was not reached by May 31st but was reached at a later date; three of those years (2006, 2008, and 2011) are due to the spillway gate position and one year (2007) due to releases though energy dissipation vault to prepare for large inflows. BiOp flow releases of 5 cfs or less resulted in the reservoir being full by May 31st in all years. In 2014, the 10 cfs alternative storage was 461 AF on May 31st and storage did not return to full until the 2015 water year.

5.0 CONCLUSIONS

This study evaluated the refill probability under a range of potential increased releases from Reeder Reservoir to Ashland Creek to help Reclamation meet BiOp requirements. Release scenarios evaluated ranged from an additional 0 cfs to 10 cfs. The results of this study suggest that Reeder Reservoir could refill by May 31st each year in the study period with a BiOp release of a constant flow rate of 4.6 cfs in January and February with one year completely emptying the reservoir. BiOp release of 1.2 cfs is the largest flow which would the reservoir storage would remain above the lowest value in the historic measured record of 393 AF. Analysis of the operations and effects to reservoir outflow beyond meeting historic generator demands were outside the scope of this evaluation given the limitations.

5.1 Limitations and Considerations

The length of the available data for the evaluation was from water years 2005-2015. Using a year classification scheme from the BiOp, the evaluation period was not a representative of past hydrologic conditions but rather skewed dry. Analysis in a dry period means that results are likely to be conservative. Climate change projections for the general region show earlier runoff, a decline in snowpack, and less winter precipitation falling as snow. These types of changes may require reevaluation of Reeder Reservoir. Climate change could impact the timing and magnitude Reeder Reservoir refill and the reliability of releases for the BiOp.

Data limitations such as incomplete measurement of outflow and lack of a flood control curve restricted the evaluation process. Access to that type of information may significantly alter the results of this analysis. Real-time operations of the energy dissipation vault for flood control releases and drawdown of the reservoir will be a large factor on the refill timing and the spring/summer spill regime. The inflow data also produced limitations due to the need to a) balance the inconsistencies of the USGS gages and City weir measurements and b) adjust inflows due to negative computed releases. This analysis evaluated the hydrologic conditions to allow the release of BiOp flows during January and February; it did not investigate alternatives for how the spill and storage will need to be managed differently in other times of the year.

Any release to help Reclamation meet BiOp requirements will change the operations of Reeder Reservoir. Releasing water in January and February will reduce spill later in the year and affect the operation of the energy dissipation vault. The reduced Reeder total outflow in spring as it refills from additional winter releases needs to be acknowledged by operators and interests downstream as historical flows in Ashland Creek after the BiOp flow period will change with these additional release.

Figure 4.1 shows how low the storage in Reeder Reservoir may get with additional outflows but potential implications of such conditions are not discussed in depth in the analysis. Water quality in the reservoir as influenced by low storage values may affect how the additional flow rates are chosen. A BiOp flow of 4.6 cfs does draw the reservoir to empty one year and below the historical measured minimum of 393 AF eight years. A simplistic analysis found that a flow rate of 1.2 cfs is the largest flow which would allow the reservoir to keep a storage value of at least the lowest value in the historic measured record.

6.0 LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Bear Creek Watershed Council, 2001	Bear Creek Watershed Council. (2001). Bear Creek watershed assessment: Phase II – Bear Creek tributary assessment. Available at: http://www.rvcog.org/pdf/WR_BCWA_PART2_Mt_Ashland.pdf
Carollo Engineers, 2012	Carollo Engineers. (2012). *Comprehensive water master plan for the City of Ashland.* April 2012. Available at http://www.ashland.or.us/SIB/files/2012%20CWMP-Carollo(1).pdf
National Marine Fisheries Service, 2012	National Marine Fisheries Service. (2012). *Endangered species act biological opinion and Magnuson-Stevens fishery conservation and management act essential fish habitat response for the future operation and maintenance of the Rogue River Basin Project*. April 2012. Available at http://www.usbr.gov/pn/programs/esa/oregon/rogue/biop.pdf
United States Geological Survey, 2016	U.S. Geological Survey. (2016). *National water information system data available on the World Wide Web (USGS Water Data for the Nation)*. Available at waterdata.usgs.gov/nwis
United States Bureau of Reclamation, 2015	U.S. Bureau of Reclamation. (2015). Flow frequency calculations for Little Butte Creek. August 2015.