BASIS OF ANALYSIS

PRIEST LAKE WATER MANAGEMENT STUDY

September 29, 2017

Preliminary

10/05/2017 4:38:12 PM

BASIS OF ANALYSIS
Priest Lake Water Management Study, Priest Lake, Idaho

1. Study Background

The Priest Lake Water Management Study was initiated by the Idaho Water Resource Board (IWRB) to evaluate opportunities for improving operation of the Priest Lake and Priest River system in order to meet long-term management objectives. The study includes several action items:

- Evaluate alternatives for maintaining required lake levels and for maintaining current minimum discharge requirements of 60 cfs downstream from the dam.
- Assess potential structural and operational modifications to the Priest Lake Outlet Dam.
- Analyze options to improve access and navigable conditions for the Priest Lake Thorofare.

The goal of the study is to develop a range of feasible alternatives in consultation with stakeholders and the public for improving Priest Lake Water Management.

2. Project Study Area Description

Lower Priest Lake (hereafter referred to as Priest Lake) is approximately 18 miles long, has a maximum depth greater than 300 feet, and has active storage space of approximately 760,000 acre-feet. It is connected to Upper Priest Lake (which is approximately 3.3 miles long) by a three-mile long channel known as the "Thorofare" which has long been used by the public for recreation and access to the upper lake. A 1,400-foot-long timber breakwater at the north end of Priest Lake is intended to manage sediment from the upper lake, while providing wave and erosion protection to landowners at the north end of the Priest Lake.

The original Priest Lake Outlet Dam was constructed in 1951. The current dam was constructed in 1978 to replace the deteriorating original dam. The dam was constructed to maintain lake level in Priest Lake and manage downstream flows into Priest River. The dam is owned by IDWR and operated by a contractor on behalf of IDWR. The dam is approximately 12 feet high with gates that regulate discharge. It does not have an emergency spillway.

Water levels in the lake are measured at the USGS outlet gage (#12393000). Lake level begins to rise in April and May during the spring runoff, reaching a maximum level of 3 to 5 ft (outlet gage level) in early June. The level recedes to roughly 3 ft in July and this level is maintained through the summer recreational season. Storage releases commonly start during the second week of October, but have started as early as October 4th and as late as October 16th. Storage releases normally end sometime in November. The gates remain open through the fall, winter, and early spring season to allow natural passage of flows through Priest Lake.

3. Brief History

Priest Lake is located in the northern Idaho Panhandle. It is a significant draw for tourism and recreation, both of which add to the economic benefit to Bonner County. The area is known for the pristine variety of wildlife, clear and clean water, and recreational opportunities. In 2015, limited water supply and drought conditions in northern Idaho made maintaining the required summer lake levels and downstream flow in the river very difficult. This situation, coupled with concerns about the breakwater structure and Thorofare access issues, increased interest in developing both operational and engineered improvements to the entire system.

In response to area stakeholders' concerns, the IWRB authorized funding to perform an evaluation of strategies and options that could meet the long-term water management solutions for the Priest Lake system.

4. Study Criteria

The purpose of the study is to conduct a feasibility assessment to evaluate operational improvements for the Priest Lake system with respect to various criteria. These criteria include the following:

- Lake Level Management (maintaining a 3-ft level at the outlet gage (#12393000) for recreational season and developing operational strategies that improve habitat and minimize shoreline impacts) in accordance with Idaho Statutes § 70-507;
- Maintain current minimum discharge flow requirements downstream of dam (60 cfs); and,
- Provide sustainability for the Thorofare (promoting self-sustaining improvements to improve Thorofare access, navigability, and water quality).

5. Engineering Standards

The following standards and guidelines will be used to conduct the study and corresponding assessment work.

- Outlet Structure
  - U.S. Bureau of Reclamation. Design of Small Dams, 1987.
  - Idaho Administrative Procedures Act (IDAPA). 37.03.06; Safety of Dams Rules.
  - U.S. Army Corps of Engineers (USACE). Gravity Dam Design; EM 1110-2-2200; 30 June 1995.
  - U.S. Army Corps of Engineers (USACE). Stability Analysis of Concrete Structures; EM 1110-2-2100, 1 December 2005.
- Thorofare
  - U.S. Army Corps of Engineers. (USACE). Coastal Engineering Manual, EM 1110-2-1100, 30 April 2006.
  - U.S. Army Corps of Engineers (USACE). Design of Breakwaters & Jetties, EM 1110-2-2904; 8 August 1986.

6. Property Ownership

The study will focus on an assessment of water management change benefits and impacts to the entire Priest Lake. Improvement alternatives (modification of structures, dredging, new structures, etc.) will be focused on government-owned property within the following areas:

- Outlet Dam: The outlet dam is located on Idaho Department of Water Resources property.
- Thorofare: Breakwater and Thorofare is located on Idaho Department of Lands property.

Parcel information for the project study areas will be obtained from the Bonner County GIS database.

7. Hydrographic/Topographic Data & Datums

Topographic and hydrographic data for the project is summarized below:

Data Set Name	Topographic/Hydrographic	Source	Year
Light Detection and Ranging (LiDAR)	Topographic	Watershed Sciences collected for University of Idaho	2012
Priest Lake Survey	Hydrographic	Idaho DEQ	1995
Thorofare Survey	Hydrographic	Delphis for Mott MacDonald	2017

The vertical datum will be: Lake Datum 0.0 ft = 2434.64 ft NGVD29 at USGS outlet gage (#12393000).

8. Climate Change Considerations

It is anticipated that frequency of low summer flow and drought conditions or intensity thereof could increase as a result of climate change. Considerations for climate change should be part of the improvement alternative evaluation. This would include evaluation of drought conditions similar to 2001 and 2005 and a backcheck of water management concepts relative to 1977 and 2015 low water years.

9. Water Levels & Discharge

Water level and discharge data for the project is measured at the gages summarized below:

Gage Name	Measurement	USGS Number	Record Available	Measurement Increment	Source
Priest Lake at outlet NR Coolin, ID	Lake height	12393000	1928-present	daily	USGS website
Priest River NR Coolin, ID	Discharge	12394000	1948-2006	daily	USGS website
Priest River at Falk Ranch NR Priest River, ID	Discharge	12394500	1911-1912	daily	USGS website
Priest River NR Priest River, ID	Discharge Gage height	12395000	1903-present 1910-1911	daily	USGS website
Priest River at Outlet of Priest Lake NR Coolin ID	Discharge	12393500	1912-1948	daily	USGS website
Priest R Outflow NR Coolin, ID	Discharge	12393501	2016-present	15 minutes	USGS website
Upper West Branch Near Dickensheet Junction, ID	N/A	12394100	N/A	N/A	N/A
Staff gage at Marina	N/A	N/A	N/A	N/A	N/A
Staff gage at Dam	N/A	N/A	N/A	N/A	N/A
Thorofare	Discharge	N/A	1994-1995	27 measurements	IDEQ (IDEQ 1997)

- Lake levels are managed at the outlet structure and measured at the outlet gage (#12393000). Levels are required to be no less than 0.1 ft on the gage during the winter and at 3.0 ft during the summer recreational season.
- Average daily water levels are given in Figure 1 below based on data from the outlet gage (#12393000).

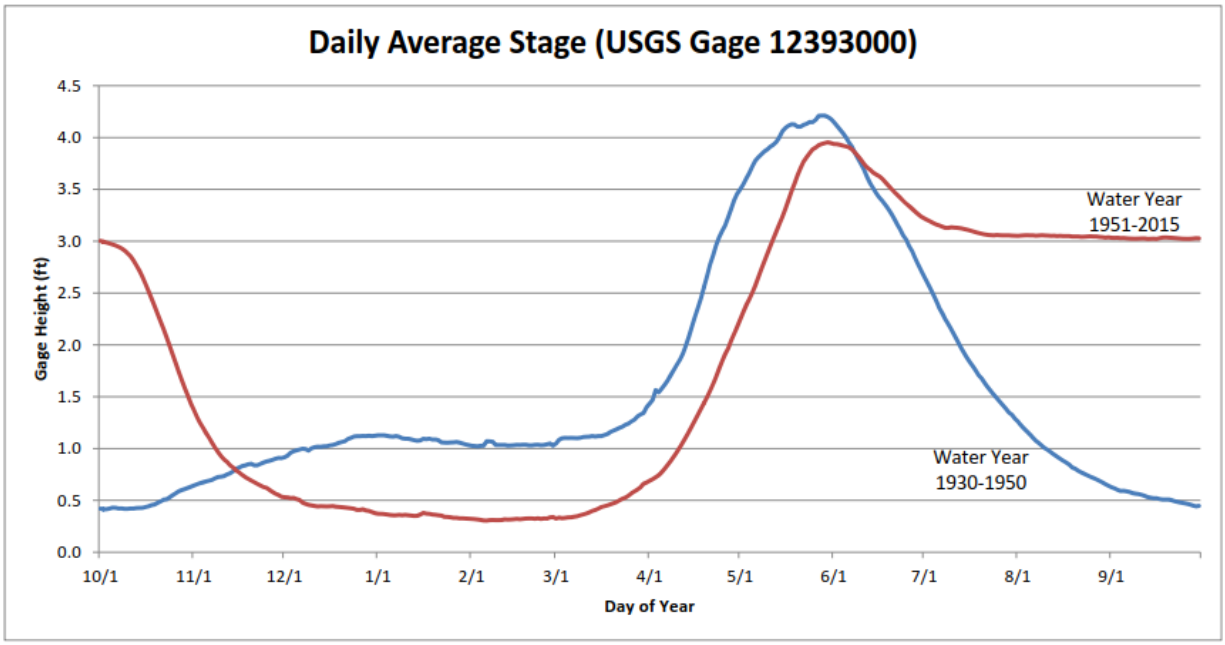

Figure 1: Daily Water Level at USGS Outlet Gage (#12393000).

10. Wind

- Data Sources: Wind data for purposes of wind-wave growth analysis will be obtained from the Western Regional Climate Center Priest Lake Remote Automated Weather Station (RAWS) station. The wind data is collected on an hourly basis with a data record from October 2001 to present.
- Background: The dominant daytime wind direction is from the south shifting to a dominant wind direction from the north at night.
- Wind Conditions: Evaluation of wind-waves for the purpose of conducting impact assessments will utilize a 2-year return period wind speed. Wind-waves for evaluating structure design requirements will utilize a minimum 50-year return period wind speed.

11. Water Management State Code Requirements (Idaho Statutes 70-507)

- Legislature authorized the Priest Lake Outlet dam facility to stabilize summer lake levels of Priest Lake for recreation.
- Code provides explicit requirements for the water surface levels in Priest Lake.
    - Lake level is allowed to exceed 3.0 ft on the outlet gage (#12393000) during spring runoff.
    - After the spring runoff period, the lake level must be at least 3.0 ft until the close of the recreational season as determined by the director of IDWR.
    - At other times of the year, the lake level must be maintained between 0.1 and 3.0 ft on the outlet gage (#12393000).

12. Recreational Season

The recreational season for Priest Lake for the purpose of this study was defined to be the following:

- Definition
    - As determined by the Director of IDWR.

- Timeframe
    - Historical: Typically July 1 to first weekend after 1st full week of October.
    - Study Definition: July 1 to October 8.

12.1. Vessel Type & Size Class

Vessel types and sizes that utilize Priest Lake and those that will be utilized for the study and assessment of Thorofare navigation sustainability are outlined herein.

- Recreational Vessels.
    - Thorofare - Recreational. Vessels that will utilize the Thorofare and their characteristics were assumed to be the following:

Vessel Type	Example	Beam (ft)	Draft (ft)	Length (ft)
Water Sports Boats (includes wake boards & ski boats w inboard/outboard motors)	Chaparral SSX Surf	8.5	3	25
Fishing Boats with outboards	North River Seahawk	8.5	2.5	25
Pontoon Boats with outboards	Crestliner Rally DX Pontoon	8.5	2	25

    - Lake - Recreational. Vessels utilizing the lake but not the Thorofare were assumed to be the following:

Vessel Type	Example	Beam (ft)	Draft (ft)	Length (ft)
Cabin Cruisers	Carver Cabin Cruiser	14	4	38
Sail Boats	Hunter 26'/SL	8.5	2 to 6	26

- Non-Recreational.
    - Work Barge. U.S. Forest Service work barge and landing craft. These vessels may utilize the Thorofare under special circumstances but will not be the basis for the analysis.

13. Thorofare Navigation

It is desired to provide sustainable navigable access in the Thorofare from Priest Lake into upper Priest Lake for the specified class of vessel (Thorofare – Recreational). The following will be criteria for the navigation and Thorofare improvements evaluation:

- Channel. Navigation in the Thorofare will be through the naturally-formed channel alignment (marked with navigation buoys) and will not be a straight channel to promote sustainability and reduce maintenance dredging needs.
- Navigation Depth. The minimum water depth at summer recreational period (when lake level is at 3.0 ft outlet gage (#12393000)) is desired to be 4 ft. An alternative for 5 ft of water depth will be evaluated.
- Width. A minimum width at the navigable depth is needed for vessels to transit the Thorofare and is a function of the width (beam) of the vessel. The minimum width depends on one-way

versus two-way traffic for the size of vessels being evaluated. Minimum width requirements will be evaluated as a part of conducting the study.

- Navigation Aids. Historically, the County has installed navigation buoys along the entrance to the Thorofare. The practice of navigation aid buoys will continue for any alternative being evaluated. The need for additional buoys will be assessed during the evaluation of alternatives.

14. Species Considerations

Based on conversations with the state and federal regulatory agencies, the following is a summary of considerations for species of concern within Priest Lake and the Thorofare.

- Bull Trout:
  - Migration period mid-May through November. Typically, in spawning streams by November.
  - Adjusted lake levels do not result in restricted access to tributary streams.
- Kokanee:
  - Spawning in November, December, in nearshore gravels. No presence within sand substrate for spawning.
  - Lake level to be returned to natural, non-regulated conditions by November 1; start of potential Kokanee spawning.

15. Regulatory Considerations

Based on conversations with the state and federal regulatory agencies, the following is a summary of requirements that will likely apply to any proposed in-water construction work:

- Work Window
  - Year around will likely be allowed for the Thorofare and Outlet Dam, assuming no full blockage to fish and fish can escape from work area. Additional restrictions or limitations will likely apply for protection of summer recreational season and winter ice conditions.
- Water Quality
  - Protection of water quality during construction in accordance with Section 401 Permit issued by Idaho Department of Environmental Quality (DEQ).
- Construction Materials
  - Pressure treated timber materials above or in contact with waters of Priest Lake are not allowed per Priest Lake Management Plan, IDL (1990).
  - In-water disposal of dredged materials will require further investigation from regulatory agencies on requirements and limitations if some form of in-water disposal or beneficial reuse were proposed.

16. Dam Operations

The following is a summary of existing and historical dam operations as determined from the IDWR records, water rights and discussions with the dam operator.

- Discharge & Operational Requirements
  - Gage Level:
    - 3.0 ft outlet gage (#12393000) water level during summer recreational period.
  - Minimum Discharge:

        - Flow: 60 cfs min.
        - Timing: Entire calendar year.
    - Fall Discharge:
        - Flows
            - Not greater than 2,500 cfs during fall discharge.
            - No greater than 1,200 cfs increase in 24-hour period (Avista 2002 operating scheme).
        - Timing
            - Start drawdown not prior to October 1.
            - Historically started on the first Sunday of October.
            - Complete drawdown prior to November 1.
    - Spring Discharge:
        - Gate Closure.
            - Gates operated to capture runoff in June to achieve a 3.0' outlet gage (#12393000) level by July 1.
            - Gate closure subject to opening restrictions to limit effect of hydraulic jump and corresponding risk of downstream apron scouring which could destabilize the dam structure.
    - Notification made 2 weeks prior to the start of drawdown Maximum Discharge: Not regulated by outlet dam (gates fully open during spring runoff). Peak discharge during fall discharge is limited to minimize erosional effects from hydraulic jump.
- Manually Controlled Gates
    - The radial gates are manually controlled by the Dam operator utilizing an electric powered torque wrench.
    - Gate opening is determined based on observations of water levels at a marina staff gage and historical flow records.
    - Dam operator rules of thumb – 3" opening = 30 cfs/gate.
    - Discharge Rating Curve relative to marina staff gage was developed.
    - Discharge distributed across all bays due to hydraulic jump/scour. Concerns for hydraulic jump exist primarily during the spring runoff gate operations and not during the fall discharges for lake level reduction.
- Water Levels
    - Primarily monitored at the marina staff gage in the morning before gate adjustment.
    - Variations from local atmospheric pressure and wind events (seiche) effect the water levels at the dam and are taken into consideration during gate operations. Up to 6 to 8-inches of variation within 8 to 10 hours' time has been observed due to this phenomenon.
    - There is a water level difference between the marina staff gage and the staff gage at the dam.
- Historical Records
    - Records of each day gate opening and lake level are available.

17. Lake Water Management Evaluation Scenarios

Water management operational alternatives for evaluation will be developed in coordination with IDWR. Appendix A provides a detailed summary of the scenarios to be evaluated. The following will be considered in the water management alternatives:

1. Timeframe
    a. July 1 to October 8.
2. Water Levels (outlet gage (#12393000) datum)
    a. Variations from 2.75 ft to 3.5 ft.
3. Outlet Dam Discharges
    a. Current Minimum Requirement of 60 cfs.
    b. Review of Water Right #97-07380 minimum instream flows.
4. Water Years
    a. Drought years
        i. 2001 and 2005 as the basis for analysis.
        ii. 1977 and 2015 as backcheck years.
    b. Wet Years
        i. Not Evaluated
    c. Typical Average Year
        i. Use as a backcheck for a drought year condition for comparison.
5. Gate Operational Procedures
    a. Evaluate timing for gate operations to capture runoff during drought or near drought years to ensure water level and discharge criteria are met throughout the summer recreational period.
    b. Determine earliest time period in year to capture storage to meet study criteria.

Additional details on water management alternatives will be provided under a separate technical memorandum (see Appendix A).

18. Pool Raise Considerations

For evaluation of pool raise alternatives, an assessment of potential for impacts will be conducted on the following shoreline features and infrastructure:

- Basement Flooding
- Beach Erosion
- Recreational Beach
    - Loss of Use.
    - Fire Pits.
    - Benches.
    - Beach Width.
- Boat Cover
- Ecosystem (wetlands, riparian)
- Piers

- Boat Launch

19. Outlet Dam Stability Assessment

19.1. General Criteria

The Priest Lake Outlet Dam is classified as a large dam under IDAPA 37.03.06 Safety of Dams Rules due to its storage capacity exceeding 4,000 acre-ft and it is in the Significant Hazard Category of IDAPA 37.03.06. Any proposed modifications to the outlet Dam will be in conformance with IDAPA 37.03.06 requirements, supplemented with Federal design guidelines for dams and hydraulic structures— including applicable technical guidelines and engineering manuals from the Bureau of Reclamation and the U.S. Army Corps of Engineers. The following category and classification applies to the Priest Lake Outlet Dam:

- Dam size classification per IDAPA 37.03.06: Large
- Dam hazard category per IDAPA 37.03-06: Significant

19.2. Geotechnical Criteria

The stability against sliding and foundation stability shall satisfy the safety levels indicated in Table 1, per USACE EM 1110-2-2200 *Gravity Dam Design.*

Table 1. Dam stability criteria per EM 1110-2-2200 Gravity Dam Design

Load Condition	Resultant location at base	Minimum Sliding FS	Foundation Bearing Pressure
Usual	Middle 1/3	2.0	≤ allowable
Unusual	Middle 1/2	1.7	≤ allowable
Extreme	Within base	1.3	≤ 1.33 x allowable

19.3. Structural

The structural assessment will provide evaluation in accordance with ACI 318-14 and AISC Steel Construction Manual for concrete and steel components of the dam, respectively. Supplement with other structural codes and design guides to determine loads and load combinations, listed under *Applicable Codes and References.*

19.4. Seismic Criteria

If the dam stability analysis for the pool raise indicates a factor of safety of less than 2.0 thereby necessitating an upgrade/modification, seismic analysis and upgrades to meet current code would be required.

IDWR requires seismic evaluation since Priest Lake Dam is classified as a large dam per IDAPA 37.03.06 Section 040. The horizontal acceleration (seismic coefficient) of 0.156 is what has been applied for this area for pseudo-static analysis.

19.5. Hydraulic Criteria

Hydraulic criteria for use in evaluating dam stability will include the following:

- Summer Recreation Period (Static Load on Radial Gates):
    - Headwater Priest Lake level = 3.5 ft outlet gage (#12393000).

- Tailwater level based on discharge Flows = 60 cfs.

20. References

American Concrete Institute (ACI). Building Code Requirements for Structure Concrete. 318-14. 2014.

American Institute of Steel Construction (AISC). Steel Construction Manual. 2011.

Idaho Administrative Procedures Act 37.03.06; Safety of Dams Rules.

Idaho Administrative Procedures Act 37-03-06.

Idaho Department of Water Resources (IDWR). Water Right Number 97-07380.

Idaho Department of Lands (IDL). Response to permit for replacement of Thorofare Breakwater. Permit No. L-97-S-891.

Idaho Division of Environmental Quality (IDEQ). Phase 1 Diagnostic Analysis Priest Lake. 1997.

Idaho Statues 70-507.

U.S. Army Corps of Engineers (USACE). Gravity Dam Design; EM 1110-2-2200; 30 June 1995.

U.S. Army Corps of Engineers (USACE). Stability Analysis of Concrete Structures; EM 1110-2-2100, 1 December 2005.

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U.S. Army Corps of Engineers (USACE). Design of Breakwaters & Jetties, EM 1110-2-2904; 8 August 1986.

U.S. Bureau of Reclamation. (USBR). Design of Small Dams, 1977.

U.S. Geological Survey (USGS). Water Data for the Nation. Priest Lake at Outlet NR Coolin ID, 12393000. <https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=12393000&agency_cd=USGS>

APPENDIX A

MOTT MACDONALD

Preliminary
10/05/2017 4:41:54 PM

Memorandum

Subject: Priest Lake Water Management Project, Water Management Operational Alternatives Discussion

To: IDWR & Bonner County

From: Mott MacDonald & GeoEngineers

Date: June 15, 2017

Table 1 was assembled as a starting point for the analysis of potential water management operational alternatives to be considered for meeting the criteria and objectives of the study (as outlined in the Basis of Analysis Memorandum).

Table 1. Priest Lake Water Management for Existing Operations (Exist) and Alternatives (Alt) for Dry-Year Types and a Normal Type Year Check

Alternative	Water-year Type	Recreation Lake Level			Priest River Discharge (Q)			Inflow Calendar Year	Commentary
		Stage (ft)	Start Date	End Date	Q (cfs)	Start Date	End Date		
Exist-D1	Dry	3.0	July 1	Oct 8	60 (min)	July 1	Oct 8	2001	Base, run 1st to understand time periods for lack of water to better refine alternatives for timing of increased water level and drawdowns of the additional storage.
Exist-D2	Dry	3.0	July 1	Oct 8	60 (min)	July 1	Oct 8	2005	Base
Exist-N	Normal	3.0	July 1	Oct 8	60 (min)	July 1	Oct 8	2002	Base
Alt 1	Dry	3.5	July 1	Aug 30	60 (min)	July 1	Oct 8	2001	Basic Low Flow
		3.5 to 3.0	Sept 1	Oct 8	2,000 (max)	Oct 9	Oct 31		
Alt 2	Dry	3.5	July 1	Aug 30	60 (min)	July 1	Oct 8	2005	Basic Low Flow
		3.5 to 3.0	Sept 1	Oct 8	2,000 (max)	Oct 9	Oct 31		
Alt 2N	Normal	3.5	July 1	Aug 30	60 (min)	July 1	Oct 8	2002	Run normal year after completing dry condition alternatives; so water level range could be different than that described.
		3.5 to 3.0	Sept 1	Oct 8	2,000 (max)	Oct 9	Oct 31		

Alternative	Water-year Type	Recreation Lake Level			Priest River Discharge (Q)			Inflow Calendar Year	Commentary
		Stage (ft)	Start Date	End Date	Q (cfs)	Start Date	End Date		
Alt 3	Dry	3.25	July 1	Aug 30	60 (min)	July 1	Sept 30	2001	Lower water level in Sept.
		3.25 to 2.75	Sept 1	Sept 30	2,000 (max)	Oct 1	Oct 31		
Alt 4	Dry	3.5	July 1	Aug 15	60 (min)	July 1	Sept 30	2001	Variation in timing of water levels.
		3.5 to 3.0	Aug 16	Sep 15	2,000 (max)	Oct 1	Oct 31		
		3 to 2.75	Sept 16	Oct 8					
Alt 5	Dry	3.25	July 1	Aug 30	60 (min)	July 1	Oct 8	2001	Variation in timing of water levels.
		3.25 to 3.0	Sept 1	Oct 8	2,000 (max)	Oct 9	Oct 31		
Alt 6	Dry	TBD	July 1	TBD	60 (min)	July 1	Oct 8	TBD	To be determined after running dry alternatives.
Alt 7	Dry	TBD	July 1 to TBD	TBD	550 (min)	July 1	July 1	TBD	To be determined after running dry alternatives.
					250 (min)	Aug 1	Oct 8		

Footnote:

1. TBD = To be determined

Footnotes on Scenarios, Assumptions & Criteria for Water Management Alternatives:

- Additional detail on data and approach for conducting the analysis is outlined in the attached June 15, 2017 GeoEngineers Approach to Water Management Modeling Memorandum.
- In accordance with IDWR approved criteria, the water management analysis is focused on dry and drought year lake system water management operational changes. Therefore, wet year simulations will not be conducted as those operations will remain unchanged from historical conditions. No modeling of wet water-year types included.
- Flows (Q) are minimums and maximums for the stated time periods.
- August 15 date to be adjusted based on refinement of low water availability and time period for storage required to meet the minimum 60 cfs stream flow.
- Maximum discharge in October of 2,000 cfs (no more than 1,200 cfs increase in 24-hour period) assumed to be the limited flow condition in October based on review of historical operations. Discharge curve to mimic a prior year discharge and gate operation pattern (such as 1979, per IDWR documentation).
- Water Right 97-07380 as measured at the confluence with the East River is converted to outlet dam discharge values in accordance with information provided by IDWR (Personnel communication, Matt Anders, June 2017). Those conversion values are as follows:
    - 700 cfs at East River = 550 cfs at outlet dam
    - 300 cfs at East River = 250 cfs at outlet dam
- Starting time for gate operation to achieve revised higher pool level by July 1 (or summer recreational period) will be evaluated. It is assumed that gate operations can be modified to meet any new operational needs and requirements. As part of the outlet dam assessment work, an evaluation of the gate operations will be conducted.
- Drought and dry years of 2001 and 2005 were selected due to their full data record and being representative of current dam operations. Other dry/drought years (such as 1977 and 2015) will be backchecked once the analysis is completed for 2001 and 2005.
- Priest Lake inflows calculated by IDWR will be used for the calendar years identified in Table 1.

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To:	Younes Nouri and Shane Phillips (Mott MacDonald)
From:	Tim Hanrahan
Date:	15 June 2017
File:	22593-001-00, Priest Lake Water Management Study
Subject:	Approach to Water Management Modeling

I am writing this memorandum in response to the discussion between Younes and myself today concerning:

1. Our approach to water management modeling

2. Identifying any outstanding data issues that need to be addressed before the modeling can proceed further

The modeling approach is summarized in the following narrative. There remains one outstanding issue that needs to be finalized by the project team and IWRB/IDWR. This issue concerns the Priest Lake outlet dam stage-discharge curve to be used for modeling. A description of this issue is described in the following section "Outlet Dam Physical Data."

Approach to Water Management Modeling

Water management alternatives for Priest Lake will be modeled with the reservoir simulation model HEC-ResSim (USACE, 2013). The software is commonly used as a decision support tool for evaluating reservoir operations for a variety of operational goals and constraints. For the Priest Lake system, HEC-ResSim will be used to model the operational goal of a prescribed lake level (e.g., recreation season level of 3.0 feet from July 1 to October 8) under corresponding constraints of prescribed discharges at the Priest Lake outlet dam, and total inflow to Priest Lake. Each water management alternative to be modeled will include a unique combination of, 1) lake level goal during the calendar year, 2) discharge constraints during the calendar year, and 3) total calculated inflow to Priest Lake during the calendar year. Each alternative will be modeled at a daily time step over the duration of selected calendar years.

Completion of the water management simulations in HEC-ResSim requires data for the physical characteristics of Priest Lake, the physical characteristics of the Priest Lake outlet dam, and the inflow hydrology to Priest Lake.

Priest Lake Physical Data

The relationship between lake level and lake volume (level-volume rating curve) is required for the simulation modeling. These data are available in the form of a rating table for USGS gage 12393000, which was provided by IDWR (Matt Anders, personal communication) in the spreadsheet "12393000_2015.xlsx." This spreadsheet lists the gage height (feet) and corresponding lake volume capacity (acre-feet) for gage heights ranging from 0.0 feet to 6.69 feet. The elevation datum of the gage is 2,434.64 feet (NGVD29), and this elevation will be used in the modeling to simulate lake levels relative to the geodetic datum.

The lake-volume rating curve was extrapolated at the upper and lower bounds. USGS water year summary reports for gage 12393000 indicate a minimum lake level of -0.46 feet occurred in 1977 and 2001, with a

corresponding lake volume of 37,500 acre-feet. Accordingly, the rating curve was extended to -0.46 feet by using the linear fit between lake level and lake volume. Similarly, the rating curve was extended to 7.5 feet by using a linear fit equation. Extending the data to 7.5 feet of lake level was done to use these data with the available stage-discharge rating curve for the outlet dam.

Outlet Dam Physical Data

The relationship between lake level and Priest Lake discharge (stage-discharge rating curve) is required for the simulation modeling. The lake level must be in the same vertical datum as USGS gage 12393000. These data are available in the form of a rating curve developed by IDWR (1977, Figure 1). Data points from this curve were entered into a spreadsheet and used to develop a polynomial fit between lake stage and discharge. The upper and lower bounds of this rating curve were extended by using the polynomial fit. Extending the rating curve was done to use these data with the available level-volume rating curve for Priest Lake.

A second stage-discharge rating curve is also available from IDWR (date unknown, Figure 2). Data points from this curve were entered into a spreadsheet and used to develop a polynomial fit between lake stage and discharge. Neither the date nor source of this curve is known, and thus the provenance of the data described by the curve are unknown.

The stage-discharge curves of Figure 1 and Figure 2 differ slightly (Figure 3). However, small differences in lake level can be manifested into large differences in lake volume and discharge. For example, in the Priest Lake system, a one-day 0.1 feet of lake level change corresponds to approximately 2,360 acre-feet of lake volume or 1,190 cubic feet per second (cfs) discharge.

The stage-discharge curve to be used for modeling remains to be finalized by the project team and IWRB/IDWR.

Priest Lake Inflow Hydrology

Total daily inflow to Priest Lake is required for the simulation modeling. These data are available from IDWR (Matt Anders, personal communication) in the spreadsheet “Calc Inflow.xlsx.” Because the tributary streams to Priest Lake are ungauged, the total daily inflow was calculated from a water balance based on measured change in lake volume, discharge from Priest Lake into Priest River measured at USGS gage 1234000, and calculated lake evaporation.

The calculated daily inflow is available for the selected calendar years to be modeled (2001, 2002, 2005).

References

Idaho Department of Water Resources (IDWR). 1977. Priest Lake Outlet, Phase 1, Construction of Sheet Pile Cutoff Wall. Plans, Specifications, and Contract Documents. Section 5, Plans and Drawings. Idaho Department of Water Resources, Boise, Idaho.

U.S. Army Corps of Engineers (USACE). 2013. HEC-ResSim Reservoir System Simulation User’s Manual, version 3.1. USACE Institute for Water Resources, Hydrologic Engineering Center, Davis, California.

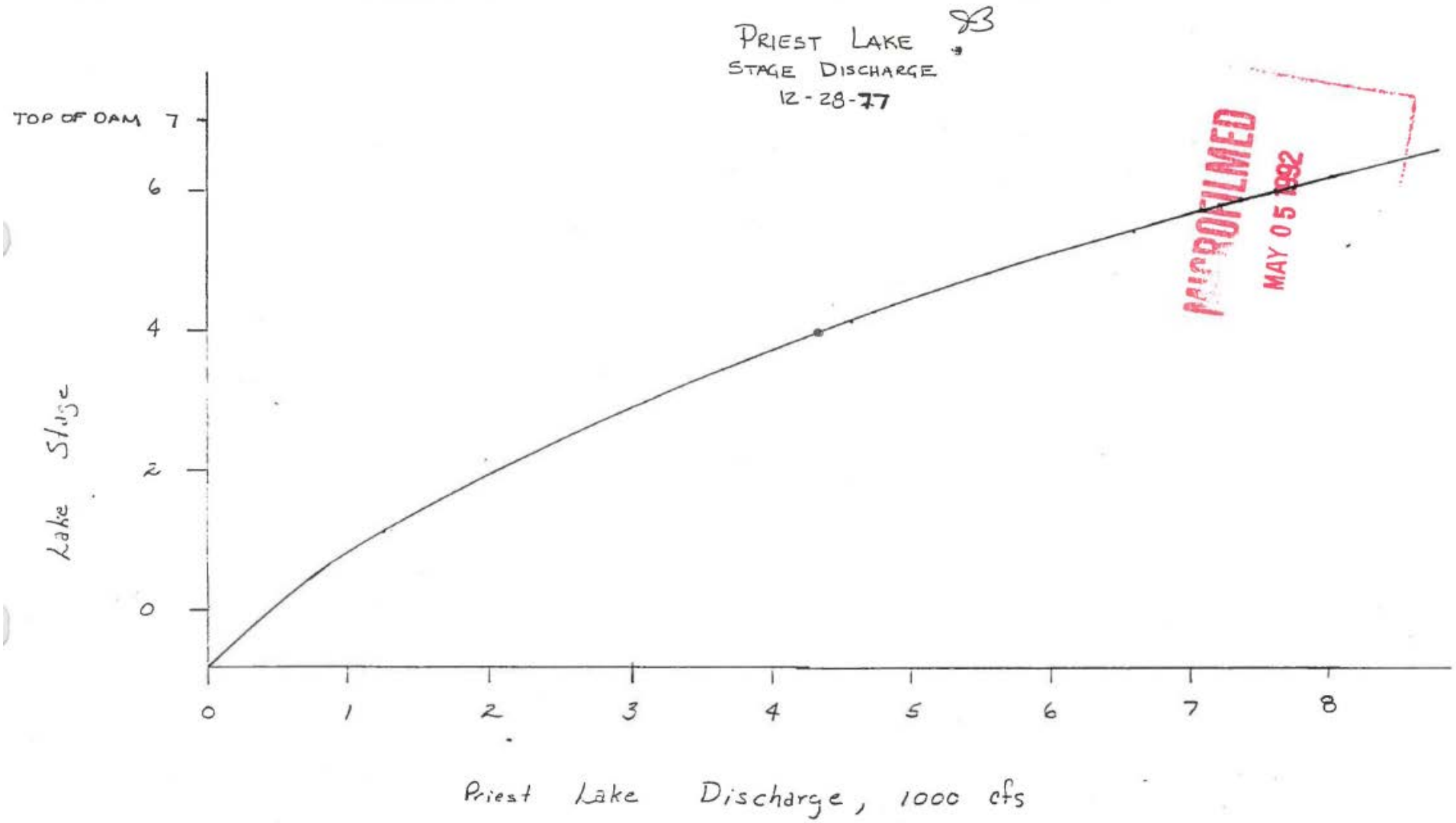

Figure 1. Priest Lake outlet stage-discharge curve (IDWR, 1977).

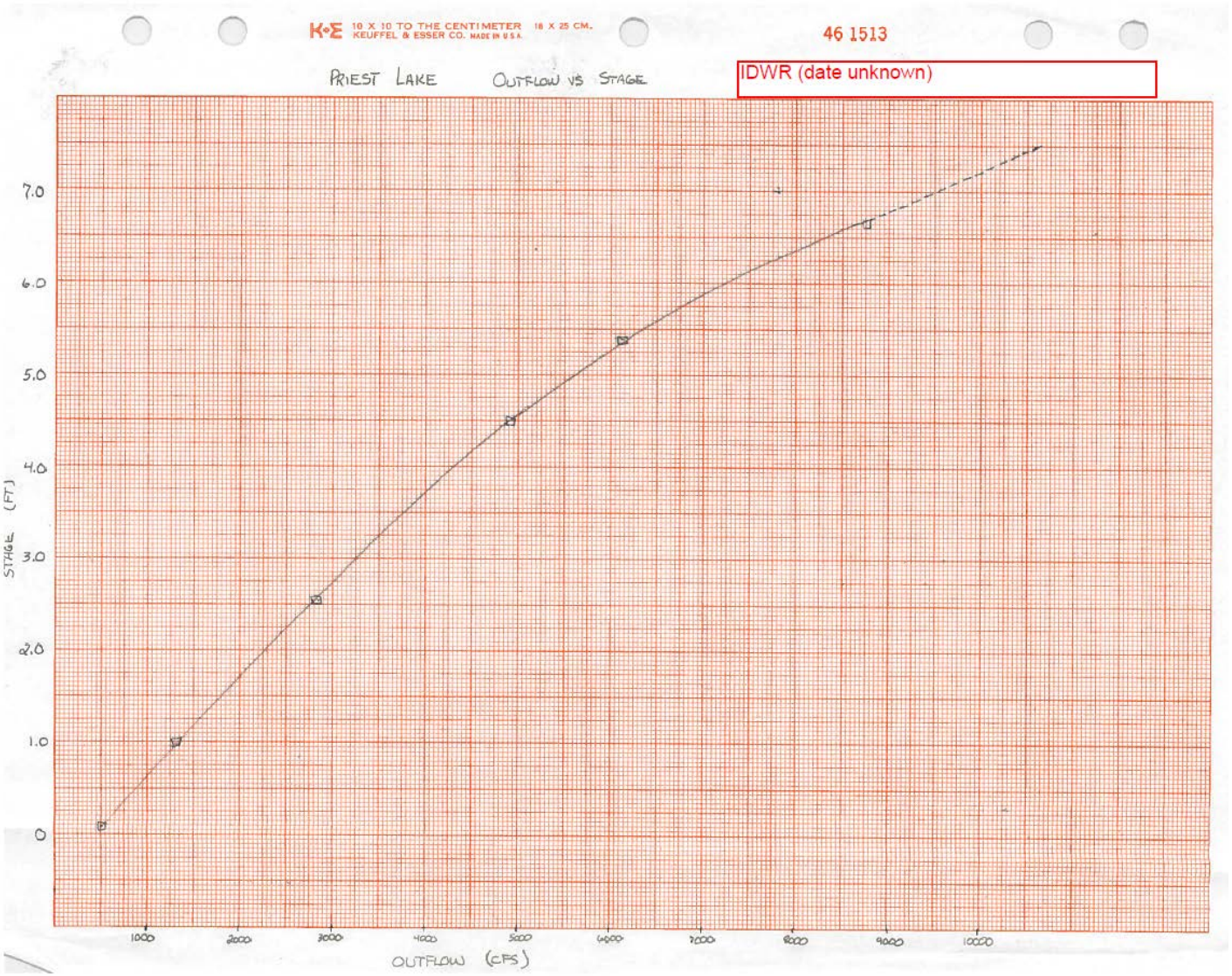

Figure 2. Priest Lake outlet stage-discharge curve (IDWR, Date Unknown).

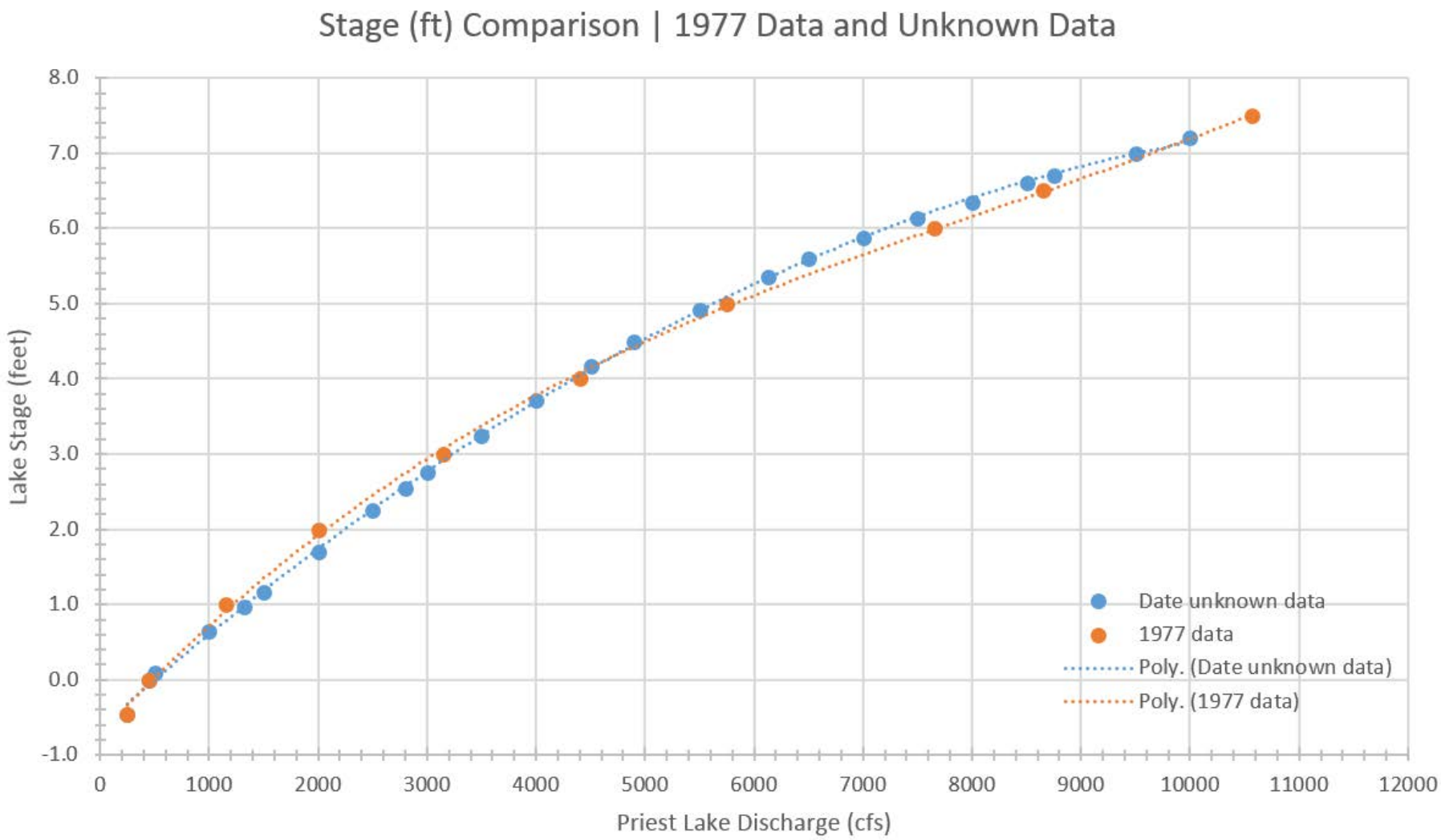

Figure 3. Comparison of available Priest Lake outlet stage-discharge curves.