DEPARTMENT OF ECOLOGY
State of Washington

# 2018 Periodic Inspection Report

*Cascade Lake Dam*
*San Juan County, Washington*

March 2019

DSO File SJ 02-0281

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# 2018 Periodic Inspection Report

*Cascade Lake Dam*
*San Juan County, Washington*

The dam safety inspection of Cascade Lake Dam, engineering analyses, and technical material presented in this report were prepared under the supervision and direction of the undersigned professional engineers, in accordance with RCW 43.21A.064(2).




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Geotechnical Engineer
Dam Safety Office
Water Resources Program

March 19, 2019
(date signed)




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March 19, 2019
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# Introduction

In accordance with RCW 43.21a.064(2), the Department of Ecology, Dam Safety Office (DSO) has the responsibility and authority to inspect the construction of all dams and other works related to the use of water, and to require necessary changes in construction or maintenance to reasonably assure safety to life and property. This report has been prepared in accordance with this statute.

The purpose of this report is to present the results of an inspection of the Cascade Lake Dam. The report provides some background information and a description of the project; results of the June 20, 2018 inspection; and remedial actions based on the findings.

The issues and maintenance deficiencies found during the inspection are covered at the end of the report under Required Remedial Actions.

# Project Information

## Background

The Cascade Lake Dam is located on Orcas Island in the Cascade Creek drainage basin, in Section 31, T 37 N, R 1 W, about ¼-mile SW of SW corner of Moran State Park. The property is owned and operated by the Rosario Resort and Spa. The project purpose is to provide non-potable water for fire flow and hydro-electric power to the Rosario Lodge and community near Cascade Bay.

The dam embankment was reportedly constructed before 1910. The major modifications of the concrete arch dam was completed in 1993, bolstered with a rockfill buttress and shotcrete on the downstream face.

## Previous Inspection Summary

2013 Periodic Inspection. The previous periodic inspection was performed on September 24, 2013. The inspection found that the dam is in good condition and well maintained. The inspection notified a few minor deficiencies that should be corrected: the PVC pipe needs to be protected against UV radiation. Further, it was recommended that the current support structure be replaced by a more permanent/stable structure that would eliminate undue stresses on the pipe.

In addition, the Emergency Action Plan (EAP) should be updated and the Operation and Maintenance (O&M) plan should be prepared for this dam.

# Field Inspection

The primary field inspection of the Cascade Lake Dam was performed on June 20, 2018. The Dam Safety inspection team consisted of the following personnel:

| Name | Aspects Covered |
|---|---|
| Jintae Lee, Ph.D., P.E. | Coordinator, Geotechnical |
| Martin Walther, P.E. | Hydraulic/Hydrology |

Scott Kantrud and Shawn Taylor were present as representatives of the Rosario Resort during the inspection.

# Embankment, Abutments, and Foundations

Description. The Cascade Lake Dam is a concrete arch dam with rockfill buttress structure, with a maximum height of about 21 feet and a crest length of 179 feet. The concrete wall was originally constructed 12 inches thick. In 1993, the dam was modified by the addition of a concrete facing (shotcrete and reinforced concrete) and soil buttress on the downstream slope. The concrete is up to 18 inches thick at the base and extends up to about 6 feet below the top of the original concrete arch. The compacted soil buttress has a slope of about 1.5H:1V.

2018 Inspection. An examination of the visible sections of the dam structure revealed that it was in generally good condition. From the results of the inspection, a few minor deficiencies should be corrected to improve the maintenance and operation of the dam. We found several cracks on the downstream face of the concrete dam structure. The cracks should be monitored continuously and repaired as needed before the reinforcing rods are exposed.

The inspection found eroded area below the principal spillway chute splash pad on the downstream face of the dam. The spillway chute needs to be more robust and properly secured to limit the possibility of erosion and compromise of the soil buttress. It is required to investigate the feasibility of providing a splash pad or other erosion protection for the buttress on the downstream face of the concrete dam structure.

# Overflow Spillway

Description. The principal spillway for Cascade Lake Dam is a rectangular orifice cut out of the concrete arch dam (about 6.5 feet wide by 1.8 feet high). It is located in the center of the dam followed by a sheet metal chute sloped down the soil buttress with about a 4-foot final drop. The principal spillway is at overflow elevation 351.1 feet, approximately 4.9 feet below the dam crest elevation. The discharge capacity of the principal spillway is 11 cfs at water level 351.8 feet, and 112 cfs at water level 356.0 feet. The discharge channel is 22 feet long at a slope of 2.44H:1V.

The auxiliary spillway is a 21-inch diameter steel pipe located in the center of the dam. The auxiliary spillway is at overflow elevation 351.8 feet, 0.7 feet above principal spillway invert. This pipe would flow only during high reservoir levels. It drops several feet and flows unobstructed directly into the culvert entrance. The discharge capacity the auxiliary spillway is

13 cfs at water level 354.0 feet, and 21 cfs at water level 356.0 feet. The discharge conduit is 22-feet long without a slope.

2018 Inspection. Our inspection of the visible sections of the spillway revealed the principal spillway is made of sheet metal and appears flimsy. It is not much wider than the cutout opening in the concrete arch, has only about 8 inches of side control and is not firmly attached to the soil buttress. Since the soil buttress is integral to the structural stability of the dam, this potential erosion could be a serious safety issue. To this end, a more permanent and stable spillway chute is needed below the notch to protect the soil buttress.

The inspection found that there was no debris barrier for the spillway entrance. To reduce the potential for large logs and other floating debris to obstruct the spillway entrance, we recommend that a log boom or other debris barrier be installed in front of the spillway entrance. A log boom extending to each side from a single post out in front of the spillway would be acceptable to Dam Safety.

Our inspection noticed a partially blocked culvert just downstream from Palisades Drive. The 42-inch culvert just below the dam beneath Palisades Drive was clear, but the next culvert downstream was partially blocked. In order to maintain free drainage of spillway flows away from the dam, we recommend that the debris in front of this downstream culvert be removed.

## Outlet Works

Description. There is a 10-inch diameter plastic low-level outlet pipe in the center of the dam. The low-level outlet penstock is connected to a pressure line that feeds non-potable fire flow and supplies water to a DC turbine at the Rosario Resort area.

2018 Inspection. The low-level outlet pipe section that passes through the concrete dam is showing its obvious age with extensive corrosion. However, we did not see any signs that the pipe may be leaking, as there was not any seepage. The operator reported that the outlet pipe and control valve is operated frequently and no problems have been observed.

# Evaluation and Analysis

Based on observations made during the inspection, the condition assessment of the dam is considered to be **Fair.** This condition assessment is in line with the system used by the National Inventory of Dams (USACE 2008)[1] to classify dams with no existing dam safety deficiencies recognized for normal loading conditions.

## Downstream Hazard Assessment

A downstream hazard classification of Hazard Class 2D, *Significant* downstream hazard potential is assigned to the Cascade Lake Dam.

[1] USACE. National Inventory of Dams, US Army Corps of Engineers, Washington DC. Version 4.0, Page 16. April 2008.

Prior to the 2018 inspection, the setting downstream from the Cascade Lake Dam was classified as having a *Significant* hazard potential, Hazard Class 2. As part of the inspection, the downstream hazard potential was reassessed. This involved a visual inspection of the downstream area and review of topographic maps and ortho-photo images of the site and downstream area. Our assessment revealed that no new structures have been built downstream of the dam since the previous assessment of downstream hazard. The open area is the site of the Rosario Resort. There are two access roads, several buildings for Resort guests and other activity areas near the possible inundation area, should the dam fail. One Resort building appears to be close to the stream path. The warning time is expected to be very short. Based on these findings, the hazard classification for the Cascade Lake Dam should be at *Significant*, Hazard Class 2D.

## Hydrology and Spillway Adequacy

The spillway for Cascade Lake Dam can pass the runoff from a Design Step 4 dam safety storm. This event has an annual exceedance probability of 1 in 10,000, and an exceedance probability of 1 in 100 over a 100 year period. The Long high intensity storm was found to be the controlling event. The spillway can pass the dam safety inflow design flood of 130 cfs with 0.2 feet of freeboard remaining on the concrete arch dam.

The details of the hydrologic analysis are described in the inflow design flood study compiled by Dam Safety (Johnson, 1991), and other calculations in Dam Safety's electronic files.

## Operation and Maintenance

Procedures and responsibilities for normal operation of the facility, monitoring and inspection of the dam, and for scheduled maintenance and unscheduled repairs of the dam and related facilities and equipment are described in the Operation and Maintenance (O&M) manual. A written O&M manual for the dam has been prepared and a copy provided to the DSO.

The O&M manual dated 1994 is on file with DSO. The O&M manual needs to be updated with any changes and additional information. If you need any assistance, contact Charlotte Lattimore at (360) 407-6066 or by e-mail at charlotte.lattimore@ecy.wa.gov.

## Emergency Preparedness

The Emergency Action Plan (EAP) identifies potential emergency conditions at the dam, prescribes procedures to be followed to minimize loss of life and property damage, and provides a list of actions that may be taken to prevent or slow down failure of the dam. An EAP dated 2013 is on file with DSO, some of the contacts and phone numbers are out of date.

Considering the foregoing, the EAP needs to be updated in accordance with the DSO guidelines. The dam owner or their agent responsible for inspecting, operating, and maintaining the dam needs to complete their review of the EAP to confirm its appropriateness and accuracy, and to add any missing information. Responsible parties need to be familiar with the plan, and aware of their responsibilities in an emergency. For further EAP assistance, please feel free to contact

Charlotte Lattimore by electronic mail at charlotte.lattimore@ecy.wa.gov or by telephone at (360) 407-6066.

## Annual Inspections

A periodic inspection of the dam on an annual basis should be conducted by the dam owner/operator, and the findings recorded on an inspection form included in the O&M manual. A copy of the completed annual inspection documentation should be submitted to the DSO. Dam Safety has not received the completed annual inspection documentation for the past five years.

## Remedial Actions Required

This inspection found that the Cascade Lake Dam is in fair condition. The physical condition of the concrete dam structure and overflow spillway appears to be similar to previous dam safety inspections. Our investigation turned up the following maintenance which will need to be addressed. Please respond with a schedule for completing the tasks listed below within 60 days of the receipt of this report.

1. Cracks in concrete structure. The cracks in the concrete dam structure should be monitored with a view toward eventual repair as needed.
2. Principal spillway. A more permanent and stable spillway chute is needed below the notch to protect the soil buttress from a potential erosion.
3. Debris barrier. A log boom or other debris barrier should be installed in front of the spillway entrance to reduce the potential for large logs and other floating debris to obstruct the spillway entrance.
4. Blocked culvert. The debris in front of this downstream culvert should be removed to maintain free drainage of spillway flows away from the dam.
5. Update the O&M manual. Please provide any necessary updates for the current O&M document for this dam. **The manual should be completed and a copy submitted to the Dam Safety Office within 180 days of this report.**
6. Update the EAP. Please provide an EAP document with current contacts and any other changes that have been applied. For more detail, please refer to the Emergency Preparedness sections above.
7. Annual Inspections. Yearly inspections of the dam should be performed and copies of the documentation should be submitted to DSO in accordance the O&M manual and EAP.

# References

USACE. ***National Inventory of Dams***, US Army Corps of Engineers, Washington DC. Version 4.0, Page 16. April 2008.

David Cummings (2000). ***Cascade Lake Dam, Second Periodic Inspection,*** File No.: SJ02-0281. Water Resource Program, Washington State Department of Ecology.

John Blacklaw and Doug Johnson (2008). ***Periodic Inspection Report, Cascade Lake Dam,*** File No.: SJ02-0281. Water Resource Program, Washington State Department of Ecology.

Gustavo Ordonez (2014). ***2013 Periodic Inspection of the Cascade Lake Dam Preliminary Results,*** Dam Safety File No.: SJ02-0281. Dam Safety Office, Washington State Department of Ecology.

**Additional Resource Materials**

David Cummings and Doug Johnson (1991). ***Periodic Dam Safety Inspection Report, Cascade Lake Dam***. Washington State Department of Ecology Publication No. 91-7.

David Cummings (1991). ***Structural Analysis, Cascade Lake Dam***. Washington State Department of Ecology, Water Resources Program, Open File Technical Report OFTR 91-2.

Doug Johnson (1991). ***Cascade Lake Dam Inflow Design Flood Study***. Washington State Department of Ecology, Water Resources Program, Open File Technical Report OFTR 91-1.

Water Resources Program, Dam Safety Section. ***Dam Safety Guidelines, Part III: An Owner's Guidance Manual***. Washington State Department of Ecology Publication No. 92-55C. July 1992.

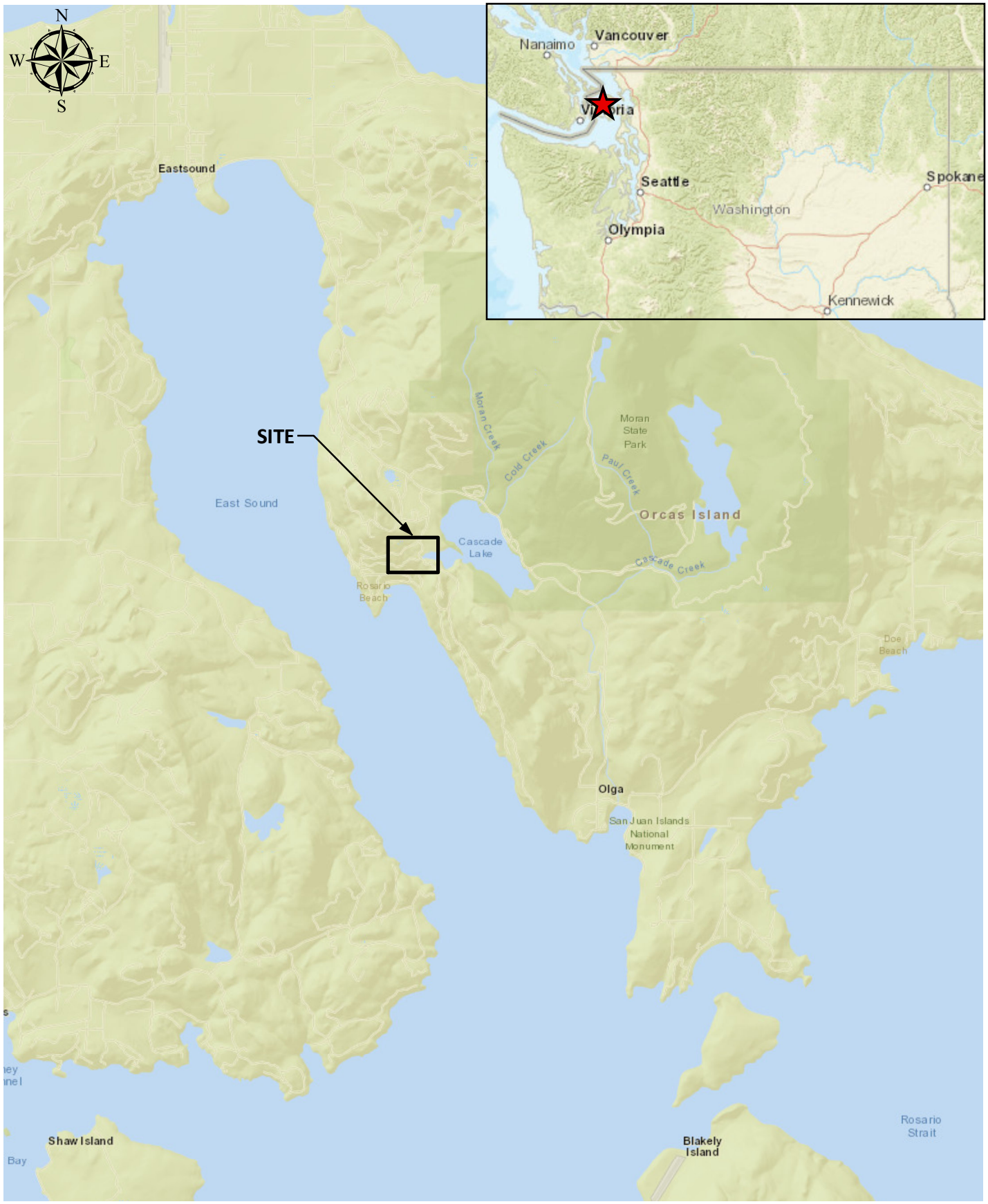
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Water Resources Program, Dam Safety Section. ***Dam Safety Guidelines, Part IV: Dam Design and Construction***. Washington State Department of Ecology Publication No. 92-55D. July 1993.




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VICINITY MAP

Figure: 1

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N

W E

S

Rosario Rd

Palisades Dr

Orcas Island

io Rd

C a

Orcas Island

Cascade Lake

Main Dam Crest

Palisades Dr

Cascade Way

Rosario Rd

Way

Palisades Dr

bing

150 0 150 300 450 600

Feet

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SITE PLAN

Figure:

2

# Appendix A: Project Data Sheet

## General

| | |
|---|---|
| State I.D. Nos. | SJ02-0281 |
| Owner and Operator | Rosario Resort |
| Location | T 37 N, R 1 W, Section 31, Orcas Island East<br>¼ mile SW of SW corner of Moran State Park |
| Construction Completed | Before 1910 |
| Major Modifications | 1993 (shotcrete d/s face; rockfill buttress) |
| Purpose | Water supply; hydroelectric power |
| Public Water System WFI No. | 74270J |
| NID Condition Assessment | Fair (inspection date: June 20, 2018) |
| Downstream Hazard Potential | Significant, Hazard Class 2D |
| Downstream Flood Path | Unnamed creek to Cascade Bay/East Sound |

## Reservoir

| | |
|---|---|
| Watershed | Moran Creek |
| Drainage Area | 3.42 square miles |
| Spillway Overflow Elevation | 351.1 feet |
| Surface Area at Spillway Overflow | 170 acres |
| Active Storage at Spillway Overflow | 1770 acre-feet |
| Dam Crest Elevation | 356.0 feet |
| Surface Area at Dam Crest | 190 acres |
| Active Storage at Dam Crest | 2670 acre-feet |

## Dam Structure

| | |
|---|---|
| Type | Concrete arch dam with rockfill buttress |
| Structural Height | 21 feet |
| Hydraulic Height | 17 feet |
| Crest Elevation | 356.0 feet |

| | |
|---|---|
| Elevation Datum | Principal Spillway invert = 351.1 feet |
| Crest Length | 179 feet |
| Crest Width | 1.0 feet |
| Upstream Slope | -0-H:1V |
| Downstream Slope | -0-H:1V |

## Principal Spillway

| | |
|---|---|
| Type | Rectangular orifice |
| Location | Center of dam |
| Discharge Capacity | 11 cfs at water level 351.8 feet<br>79 cfs at water level 354.0 feet<br>110 cfs at water level 355.8 feet<br>112 cfs at water level 356.0 feet |
| Overflow Elevation | 351.1 feet |
| Overflow Control Section | Base 6.5 feet, vertical sides, 1.8 feet deep |
| Discharge Channel - section | Base 7.0 feet, vertical sides, 0.5 feet deep |
| Discharge Channel - profile | 22 feet long at slope 0.41 ft/ft (2.44H:1V) |

## Auxiliary Spillway

| | |
|---|---|
| Type | 21 inch diameter steel pipe |
| Location | Center of dam |
| Discharge Capacity | 13 cfs at water level 354.0 feet<br>20 cfs at water level 355.8 feet<br>21 cfs at water level 356.0 feet |
| Overflow Elevation | 351.8 feet |
| Discharge Conduit - section | 21-inch diameter steel pipe |
| Discharge Conduit - profile | 22-feet long at slope -0-ft/ft |
| Inflow Design Flood - Discharge | 130 cfs |
| Inflow Design Flood - Storm | Step 4, 71% PMP; Long, high intensity |
| Inflow Design Flood - Precipitation | 24 hr = 7.1 inches, 72 hr = 8.5 inches<br>(as calculated per Technical Note 3, 1993) |

## Low Outlet Drain

| | |
|---|---|
| Type | 21-inch diameter steel pipe |
| Location | Center of dam |
| Discharge Capacity | 25 cfs at water level 351.0 feet |
| | 15 cfs at water level 348.0 feet |
| Flow Controls | Upstream – butterfly valve |
| | Downstream – none |
| Intake Elevation | 345.3 feet (pipe invert) |
| Outlet Conduit - profile | 22 feet long, slope -0- ft/ft |
| Drawdown Capacity | 3.5 inches/day at water level 351.0 feet |
| (max drawdown at minimal inflow) | 2.0 inches/day at water level 348.0 feet |

## Low Outlet Penstock

| | |
|---|---|
| Type | 10-inch diameter plastic pipe |
| Location | Center of dam |
| Discharge Capacity | 9 cfs at water level 351.0 feet |
| | 8 cfs at water level 348.0 feet |
| | 6 cfs at water level 345.0 feet |
| Intake Elevation | 338.8 feet (pipe invert) |
| Drawdown Capacity | 1.2 inches/day at water level 351.0 feet |
| (max drawdown at minimal inflow) | 1.1 inches/day at water level 348.0 feet |
| | 1.0 inches/day at water level 345.0 feet |

# Appendix B: Photographs

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Photo 1: View of Cascade Lake




Photo 2: View of Cascade Lake Dam

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Photo 3: View of concrete arch dam crest




Photo 4: Downstream slope face of dam




Photo 5: View of principal spillway and auxiliary spillway




Photo 6: Erosion below principal spillway splash pad

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Photo 7: Cracks on downstream face of concrete dam




Photo 8: 10-inch diameter low-level outlet pipe

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Photo 9: Lined culvert under roadway




Photo 10: Debris in front of downstream culvert