Buoyant Gate for Spada Lake's Spillway

Students: Hongxuan Deng, Rohan Young, Josh Barr, Careu Tapang; Industry Advisors: Scott Spahr, Andrew McDonnell, Adam Lewis;
Faculty Advisors: Prof. Richard Wiebe, Prof. Erkan Istanbulluoglu

Motivation: Energy demands are changing and the Snohomish Public Utility District is responding by evaluating projects to improve their power supply portfolio. Spada Lake's current morning glory spillway limits the lake's maximum elevation, but the addition of a gate would raise the effective maximum height of the spillway. Raising the maximum height would create additional storage volume, and thus additional hydroelectric power generation without compromising the dam's safety.

Generation Revenue Potential: $567,000 per year with the addition of a 5' tall gate.

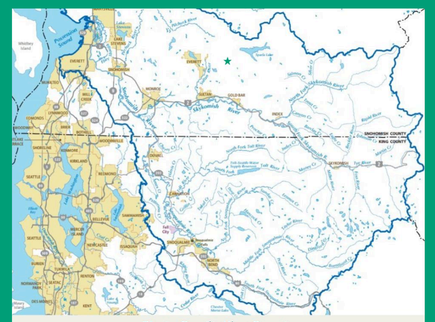


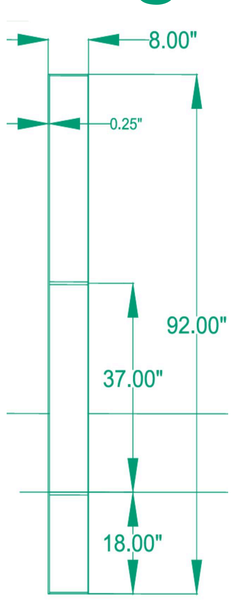
Photo Credit: King County

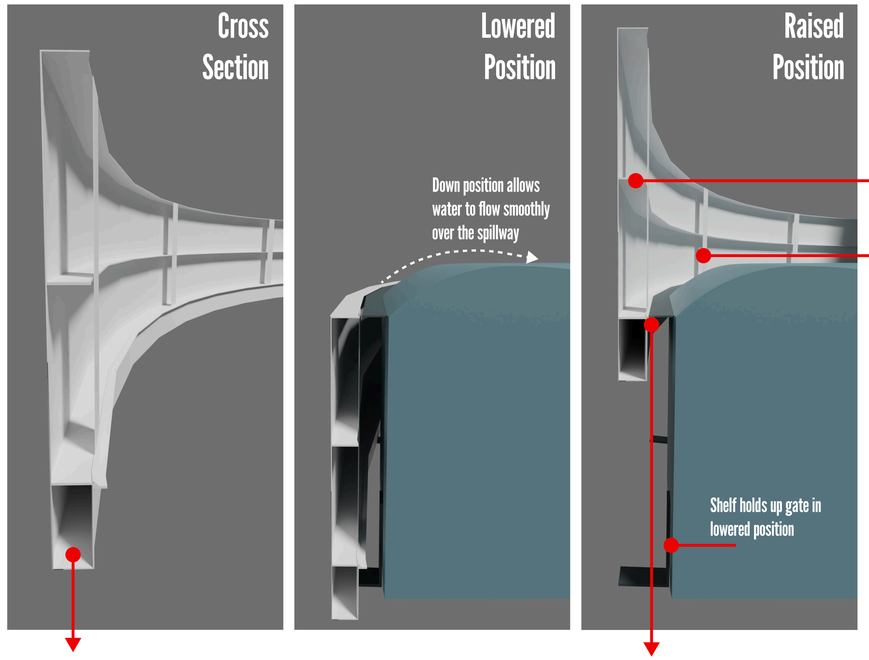
Background: Spada Lake is located on the Sultan River and impounded by the 262' earthen embankment Culmback Dam. It serves an important role as both a drinking water source for the City of Everett and water supply for the Henry M. Jackson Hydroelectric Project which serves approximately 56,000 Snohomish County homes. A key dam safety feature at Spada Lake is the 96' diameter morning glory spillway which drains the lake like a sink drain when the elevation rises above the lip of the spillway.

Gate Design

Primary Design Considerations:

1. Contamination from hydraulic oil
2. Lack of electricity at spillway
3. Preserving existing spillway lip geometry when gate is inactive

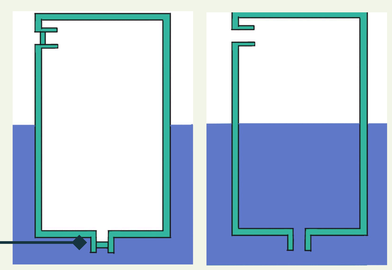




Ballast Tank

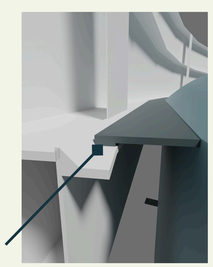
Allows the gate to go up/down by increasing/decreasing buoyancy. valves will be operated manually.

To raise the gate, valves are closed



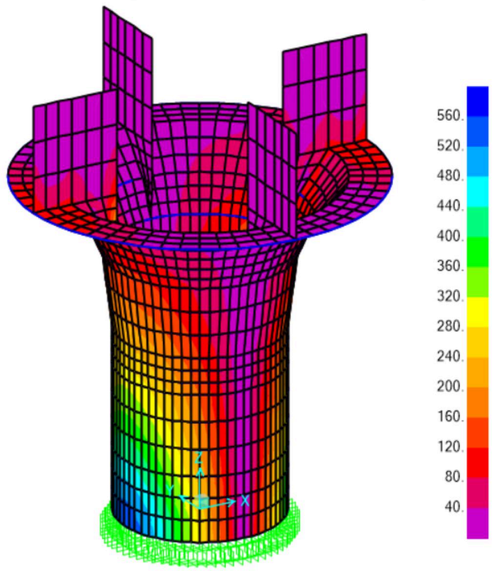
Water Seal

Buoyant forces apply pressure on the rubber seal, stopping water flowing from the bottom.



Structural Analysis

- Stiffener Rings: hydrostatic forces on the gate are resisted by these members. Making sure no additional stress is imparted on the spillway.
- Vertical Plates: serve to reduce buckling of stiffener rings, one of the failure modes analyzed.



Earthquakes?

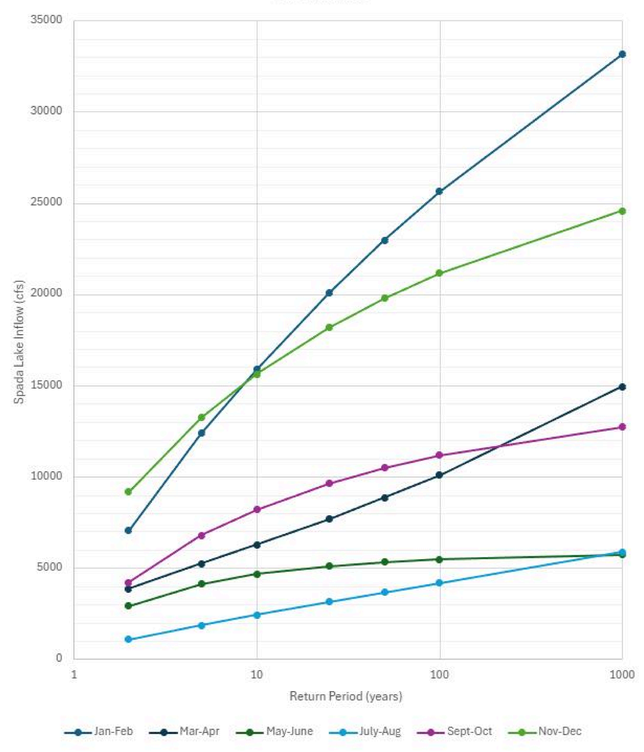
Adding mass at the top will have noticeable effects on the structure's response to earthquakes. Using spectral response curves, the stress in the spillway was analyzed to determine localized failure and demands in the structure as a whole. Above is the longitudinal tension from an earthquake load.

Hydrology Analysis

Inundation Mapping

Using LiDAR and bathymetry data provided by SNOPUD, we modeled reservoir water volume gains and shoreline inundation extents at various heights.

Orange area indicates inundation from a 5' elevation



Flood Frequency Analysis

From the historical inflow records, we completed a flood frequency analysis in line with the procedures outlined by the U.S. Geological Survey to understand risk of summer floods and inform design decisions.