

Project Title: Main Unit 2 Blade Sleeve Upgrade and Rehabilitation

Dam and Reservoir Project: Lower Granite

Estimated Total Cost: \$1 - \$3 million

Estimated Schedule for Completion of the Project: Phase 1a: FY2018-2019

Phase 1: FY2019-2020

Phase 2: FY2021-2022

Expected Physical Completion: FY2022

Project Background

This new project includes a permanent upgrade to each of the 6 blade packing sleeves on main hydropower generating unit 2 (Unit 2) at Lower Granite dam and reservoir project (Lower Granite). A blade packing sleeve is a pipe that fits closely over the trunnion (shaft) of the turbine blade that allows the blade to be able to rotate and not damage the blade packing (a seal that is located on the outside of the blade) and the blade trunnion surface. The blade packing sleeve seals the oil in the turbine hub (a component that facilitates the simultaneous movement of the blades and requires oil lubrication). On December 12, 2016, one of Unit 2's blade packing sleeves failed, resulting in oil entering the lower Snake River. This oil spill was reported to the U.S. Coast Guard National Response Center that day per the Corps Walla Walla District's (NWW) Spill Prevention, Control and Countermeasure plan. Unit 2 was taken out of service to prevent additional oil entering the river. Unit 2 underwent an interim repair (see Project Justification below) to ensure that the unit was in operation to support high spring run-off and provide attraction flow for adult fish passage through Lower Granite's south shore fish ladder, including fish listed under the Endangered Species Act (ESA). It was critical for Unit 2 to be operational because Unit 1 was out of service for repairs during the 2017 fish passage season. The permanent upgrade of Unit 2 will include unstacking the unit to remove all 6 blades and upgrade of the blade packing sleeve material on all 6 blades. This upgrade will ensure that Unit 2 is a fully-adjustable Kaplan unit, which allows the unit to operate efficiently across differing flow levels and within the $\pm 1\%$ turbine efficiency operating range and will minimize the risk of future failure.

Project Justification:

Lower Granite Unit 2 blade sleeves were installed in 2006. A blade sleeve failed in 2016 and an interim repair was completed in April 2017 utilizing a combination of a custom designed rubber seal and filling in the wear ring groove on the blade trunnion with epoxy. This repair required that the unit no longer operate as a fully-adjustable Kaplan unit, but rather as a fixed-position blade unit due to the absence of the wear sleeve. A similar interim repair to that completed at Lower Granite Unit 2 was previously performed at John Day dam and reservoir project on Unit 6 and at Cordell Hull dam (a Corps dam in Tennessee) on Unit 1. The repair on John Day Unit 6 failed after about 12 months. The Cordell Hull repair improved upon the approach utilized at John Day and so far has lasted for about 24 months. These lessons learned were incorporated into the Lower Granite Unit 2 interim repair. Despite this improvement, an expedited permanent upgrade is prudent for Lower Granite Unit 2 to minimize the risk of a future failure and achieve fully-adjustable Kaplan capability to operate efficiently across differing flow levels.

Regional fishery managers, including Idaho, Oregon, Washington, and the Nez Perce Tribe, expressed a specific preference for returning Lower Granite Unit 2 to fully adjustable Kaplan capability at the January 2017 Fish Passage Operations and Maintenance meeting, due to the attraction flows it provides for adult fish in locating the adult fish ladder. A fixed blade unit cannot adjust to differing levels of river flow, which limits the range of flow conditions the turbine over which it can operate. In its current fixed state, Unit 2 is the last unit turned on in priority order. In the event that Unit 1 must be taken out of service and Unit 2 is not in operation, an eddy can form below the powerhouse. When an eddy below the powerhouse is present, a hydraulic blockage can occur that may delay adult fish travelling upstream.



Photo 1–Removal of Turbine Blade

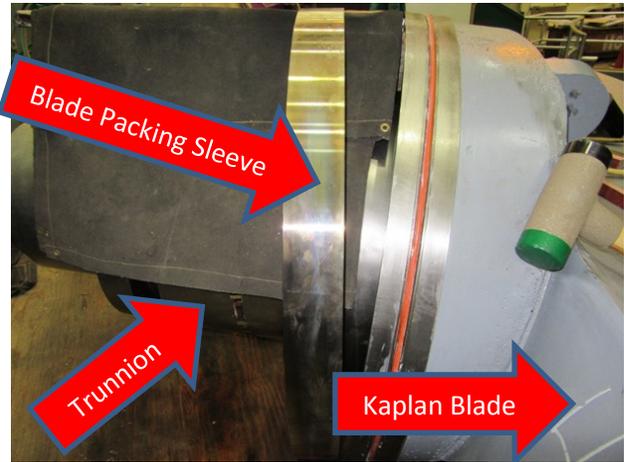


Photo 2–Turbine Blade Close Up
Blade Packing Sleeve Removed

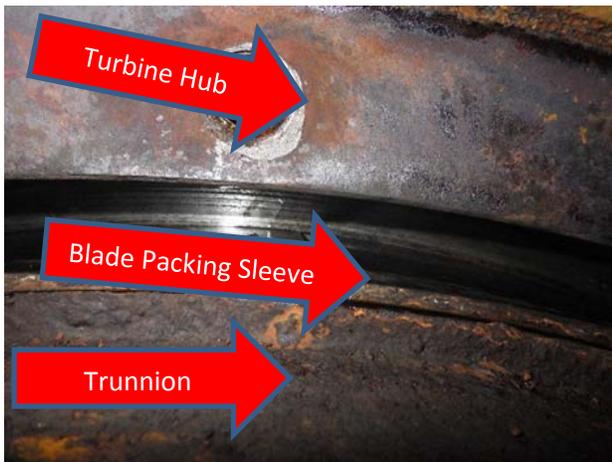


Photo 3– Unit #2 Failed Blade Packing Sleeve and
Other Turbine Components



Photo 4 – Extreme Close-up of Blade Packing
Sleeve after Removal from Unit Shows Fatigue on
Left Side

Strategic Context

This investment is not in the System Asset Plan as it has been recently re-classified from expense to capital and was originally scheduled in the non-routine extraordinary expense program for FY18.

Objective(s):

The primary objective of this project is to upgrade the blade sleeve material utilized on Unit 2 to prevent potential future oil spills into the river and maintain unit reliability for power generation, support high spring flows, and adult fish attraction to the fish ladder, including fish listed under the ESA. The project includes all materials and labor necessary to return the equipment to acceptable functional level and place it into service.

Project Summary:

This project will upgrade the blade sleeves on Unit 2 for Lower Granite utilizing a similar approach to that used to address Lower Granite Unit 1's blade sleeves. For Unit 1, the blade sleeves were fabricated out of 17-4 PH SS, instead of 410 SS. The 17-4 PH SS is not prone to stress corrosion cracking (SCC) and has very good wear resistance.

Proposed Alternatives:

Status Quo – Do Nothing, Repair in the event of failure

Summary: This alternative would leave the Unit 2 blade sleeves as is.

Rationale for not selecting this alternative: The interim repair to restore capability to support high spring flows, power generation, and fish attraction water and to prevent unintended oil spills, but was not intended as a permanent repair because the absence of a wear sleeve requires the unit to be hydraulically fixed in place reducing the capability of maintaining $\pm 1\%$ turbine efficiency operating range over a broad range of flow and head conditions compared to a permanent repair involving the upgraded metal wear sleeve that would permit the unit to be returned to a fully adjustable Kaplan unit as requested by the agencies and tribe listed above.

Alternative 1 – Upgrade the Packing Sleeve Material (Recommended)

Summary: The recommended alternative is to unstack the unit and upgrade the blade packing sleeve material from 410 SS to 17-4 PH SS on all 6 blades. Additional work identified during the Phase 1a effort described below, would also be performed, including additional work that may be necessary to return the equipment to acceptable functional level and place it into service.

Rationale for selecting this alternative: In order to provide consistent attraction flows for adult fish to locate the south shore fish ladder (the preferred ladder), Unit 2 must ultimately be repaired to fully adjustable Kaplan status so that the blades may be adjusted to operate at different levels of discharge flows, as was documented in the “Kaplan Turbine Repair Strategy” study completed in 2009 by the Corps’ Hydroelectric Design Center (HDC). HDC conducted this comprehensive study due to Baldwin-Lima-Hamilton (BLH) turbine failures at Lower Monumental, Lower Granite and John Day projects and sought to preemptively decide which BLH turbines from that family of turbines could have the blades hydraulically fixed into one position and which units must remain fully adjustable Kaplan units. The HDC study considered the economic costs and benefits, along with the operational and environmental requirements, and concluded that both units 1 and 2 at Lower Granite must remain Kaplan as both units are critical to provide attraction flows to direct adult fish, including fish listed under the ESA, to the south shore fish ladder. While the specific type of turbine failure addressed in the HDC study is different (e.g., BLH turbine failures as opposed to the failure of the blade packing sleeve at Lower Granite), the overall analysis is applicable to the issue this project addresses and supports selecting this alternative.

Alternative 2 – Hydraulically Fix Unit 2 Blades

Summary: Hydraulically fix Unit 2's blades and remove oil from the hub and associated modifications and convert the unit permanently to a fixed blade operation.

Rationale for not selecting this alternative: This alternative goes against the recommendation of the 2009 Kaplan Turbine Repair Strategy, which recommends the unit be returned to fully adjustable Kaplan capability as soon as possible for fish passage considerations. Moreover, this option will likely preclude any possibility of returning the unit to fully adjustable Kaplan functionality in the future without extensive repairs to the blade linkage due to corrosion. Corrosion would occur when water enters the turbine hub internal components due to the absence of oil inside the hub as the oil is drained from the hub when the blades are hydraulically fixed.

Process:

Phase 1a: FY2018-2019 activities involve Lower Granite, NWW, and HDC personnel including operations, engineering and project management offices, as well as BPA's Generating Assets personnel.

- Investigate all of the identified subsystems of the unit and develop a list of recommended alternatives for replacement, rehabilitation, or repair.
- Develop initial design resource needs, project schedule and budgetary cost.

Phase 1: FY2019-2020 activities involve Lower Granite, NWW, and HDC personnel including operations, engineering and project management offices, as well as BPA's Generating Assets personnel.

- Prepare Plans & Specification for 60% & 90% Design Reviews.
- Prepare contract documents to Biddability, Constructability, Operability, Environment and Sustainability (BCOES) level (*See Corps' Engineering Regulation 415-1-11*).
- Revise/Update total project cost estimate based on the BCOES level contract documents.
- Advertise contract and pre-award acquisition activities.

Phase 2: FY2020-2021 activities involve Lower Granite and NWW personnel including operations, engineering, project management, contracting and construction offices, BPA's Generating Assets personnel, and contracted personnel and equipment for construction.

- Award and execute the contract.
- Contract administration, submittal reviews, and development of as-built drawings.
- Contract and subagreement closeout.

Performance Metrics

Upgrade of the blade packing sleeves on Unit 2 will return the unit to fully adjustable Kaplan capability, improve reliability, reduce environmental risks, including oil entering the river reduce fish passage delays, and extend the useful life of this critical asset.