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May 13, 2020

Mr. Patrick Wruck
Commission Secretary and Manager
Regulatory Support
British Columbia Utilities Commission
Sixth Floor – 900 Howe Street
Vancouver, BC V6Z 2N3

Dear Mr. Wruck:

RE: Project No. 3698623
British Columbia Utilities Commission (BCUC or Commission)
British Columbia Hydro and Power Authority (BC Hydro)
PUBLIC Ruskin Dam and Powerhouse Upgrade Project
Semi-Annual Progress Report No. 16 - October 2019 to March 2020 - Final Completion Report (Report (Report)

BC Hydro writes as directed by Commission Order No. C-5-12, to provide its public Report.

Commercially sensitive, contractor-specific information, and culturally sensitive information has been redacted in accordance with part IV of the Commission's Rules of Practice and Procedures pertaining to Confidential Documents and the *British Columbia Administrative Tribunals Act*. Public disclosure of this information could harm BC Hydro's commercial and cultural responsibilities which in turn could harm BC Hydro's ratepayers.

A confidential version of the Report is being filed with the Commission only under separate cover.

For further information, please contact Chris Sandve at 604-974-4641 or by email at bchydroregulatorygroup@bchydro.com.

Yours sincerely,

Fred James
Chief Regulatory Officer

st/tl

Enclosure (1)

Ruskin Dam and Powerhouse Upgrade Project

Final Completion Report

January 2020

PUBLIC

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1 Board of Directors Summary Report

This section (section 1) provides the content that was submitted to the BC Hydro Board of Directors (**the Board**). The rest of the document (section 2 onwards) provides more details consistent with BC Hydro's past progress and completion reporting with the British Columbia Utilities Commission (**BCUC, Commission**).

As outlined in section 2, BC Hydro filed an application for a Certificate of Public Convenience and Necessity (**CPCN**) for the Ruskin Dam and Powerhouse Upgrade Project (**Project**) with the BCUC in February 2011. In March 2012, the BCUC issued Order No. C-5-12 stating that the BCUC had concluded that BC Hydro's consultation with First Nations was adequate, and that the proposed scope of the Project and the Project expenditure schedule, excluding the part relating to the Capital Overhead, was in the public interest.

1.1 Executive Summary

The Ruskin Dam and Powerhouse Upgrade Project was initiated to improve the seismic performance of the facility and substantially improve the operating reliability of the three generating units. The Project scope included civil work to the upper dam, right and left abutments, powerhouse superstructure, and replacement of powerhouse and switchyard equipment.

The Ruskin facility remained in operation during the six years of construction. It was successfully returned to full service in February 2018, without a significant safety or environmental incident. The forecast completion cost is $658.6 million or 0.7 per cent less than the final approved Expected Amount of $663.5 million and 3.5 per cent above the First Full Funding (adjusted for IFRS) amount of $636.3 million. The Project met its objectives and is delivering the planned benefits.

Consultation undertaken as part of the Project resulted in the development of a strong relationship between BC Hydro and Kwantlen First Nation (**Kwantlen**). In

March 2019, BC Hydro and Kwantlen signed the *ya:ỷəstəl'* - Enduring Relationship Agreement that included an Impact Benefit Agreement (**IBA**)[redacted]

1.2 Background

The Ruskin facility was built in the 1930s. The three generating units and associated equipment are no longer reliable. The age of the three generating units is between 60 and 80 years. The powerhouse equipment had Equipment Health Ratings (**EHR**) indicating either "Unsatisfactory" or "Poor" condition throughout, and needed to be replaced.

Dam Safety investigations confirmed seismic deficiencies in the Ruskin Dam crest block upper dam, and right abutment, as well as a potential deficiency in the lower dam.

1.3 Project Objectives & Results

The Project was initiated in 2005. The overall objective of the Project was to upgrade the facility to meet modern seismic, safety and reliability requirements. The scope implemented improved the seismic and safety performance of the Ruskin dam and powerhouse superstructure, and substantially improved the operating reliability of the three generating units. The current operating reliability of the generating equipment has been good. There were nine forced outages on the newly installed equipment caused by various incidents including a roof leak, protection and control issues, human error and a transformer oil leak. All the issues were addressed and the Project has met its reliability objectives and is delivering the planned benefits.

The Ruskin facility remained in operation during the six years of construction and it was successfully returned to full service in February 2018, when the last major asset was placed into service one month ahead of schedule, without a significant safety or environmental incident. The forecast completion cost is estimated at $658.6 million, $4.9 million (0.7 per cent) below the final approved Expected Amount. This was achieved despite the highest cost and scope risks of the Project having materialized; that being the unknown conditions at site associated with a ‘brownfield’ project. The Project is one of the most comprehensive dam and generating station rehabilitation projects in BC Hydro’s history.

One of the most significant technical legacies of the project was the seismic investigative work completed on the Ruskin dam, BC Hydro developed new protocols for testing and characterizing the strengths of concrete and construction joints, and developed new methods for modelling the complex interactions between the dam body, its foundations and abutments, and the impounded reservoir, when subjected to seismic ground motions. As an example, it was determined that a potential Ruskin dam deficiency, discovered in 2012, would not require 34 new post tensioned anchors that were specified at the time to treat the deficiency. This avoided costs estimated to be tens of millions of dollars. This seismic investigative work was favourably reviewed by several industry Dam Safety experts, including members of the project Advisory Board, and through these reviews and presentations at dam safety conferences and owners’ meetings, has been recognized to be industry-leading and representing current state-of-the-art. The Ruskin dam work will serve as the prototype for future stability analysis of BC Hydro’s concrete dams. In addition, dam owners from across North America, who have faced similar challenging concerns regarding the seismic stability of their dams, are seeking to develop BC Hydro’s work into a set of guidelines and practices for use across the industry.

1.4 Scope and Scope Variance

Key elements of the scope were:

Dam Work

The dam work addressed seismic deficiencies in the upper dam, right abutment, and left abutment. This component of the Project included a new seepage cut-off wall, replacement of the spillway piers and spillway gates, installation of new unit intake gates, left bank slope re-grading, and replacement of the roadway crossing the top of the dam. The reliability of the Spillway Gate System was improved significantly by installing adequate redundancy in equipment and control systems.

Powerhouse Work

The powerhouse work addressed the poor seismic rating of the powerhouse superstructure, replaced major equipment and ancillaries to improve reliability, and provided asbestos abatement throughout the facility to improve safety. The three generating units and ancillaries were rehabilitated. The plant dependable capacity was uprated from 105 MW to 109 MW, reflecting efficiency gains from the new equipment.

Switchyard Work

The switchyard work consisted of upgrading and relocating the switchyard from the roof of the existing powerhouse (Worker Safety and Limits of Approach constraints) to a new location atop of the hill above the Left Abutment and Hayward Avenue.

All intended Project scope items were achieved. No major work changes outside of the general scope of the Project were required. However, a number of implemented work solutions (Design Change Notices) were not envisaged in the original project plan, and they include:

- Installation of six anchors on Right Abutment Blocks 1 and 2 to meet the 1 in 10,000 year seismic requirement, and sustain the loads imposed by the temporary spillway gate construction bulkhead system;
- Purchasing a building for the Lower Mainland Generation Operations group, rather than renting facilities as originally intended. The purchase decision was based on a number of factors including the lack of available suitable rental properties. It had the lower net present value recognizing the initial costs, lease costs over the term, and eventual disposal proceeds. The existing Ruskin office (previously occupied by Operations) was converted to a site office for the Project staff; and
- Providing a permanent (rather than temporary) back-up diesel generator for emergency power to ensure the spillway gates can be operated after a seismic event, or if station service is interrupted.

1.5 Procurement Strategy

The Project was delivered through a combination of Design-Build (**DB**) and Design-Bid-Build (**DBB**) contracts. All major electrical and mechanical equipment, civil and geotechnical work was secured through a competitive public procurement process, with the exception of the supply of new radial spillway gates which was procured using a pre-established Spillway Gate Program Partnering Agreement with HMI Construction Inc., and supply of new power transformers which was procured using a Blanket Contract Order (**BCO**). Other miscellaneous materials and minor equipment were procured under existing BCOs or were supplied by the contractors.

Construction work was split into four major contracts:

1. Right Abutment-Stage 2: DB contract to address the existing seismic deficiency by building a cut-off wall and implementing jet grouting technology;

2. Upper Dam and Powerhouse Structure: DBB contract to upgrade the spillway piers, install new spillway gates and seismically improve the powerhouse;
3. Turbine and Generator Supply and Install: DB contract to design, supply, install, test and commission the three new turbine-generator units; and
4. Powerhouse Completion Contract: DBB contract to rehabilitate the intake tunnels and Intake Gates 1, 2 and 3; anchor the powerhouse; install the power transformers and balance of plant mechanical and electrical components.

The overall procurement strategy worked well, and with early market engagement, BC Hydro secured multiple bids for all four major contract packages.

1.6 Schedule Variance

The overall project was placed into service in February 2018, taking 72 months to construct, approximately one month ahead of schedule. February 2018 is when the last major asset went into service; the third and final generating unit. For planned and actual schedule completion dates and schedule variance analysis by major asset element, refer to Table 3 – Project Milestones in section 6.

1.7 Cost Variance

The Project was originally approved by the Board in February 2011 for an Expected Amount of $718.1 million and an Authorized Amount of $856.9 million. Over the course of the project, a number of changes were made to the cost estimates. For example, the funding amounts were adjusted for conversion from Canadian Generally Accepted Accounting Principles (**CGAAP**) to International Financial Reporting Standards (**IFRS**) in September 2012. Over the course of the project, reserve delegated by the Board was allocated to anticipated scope and schedule risk, work and design integration requirements between contracts, higher contract prices received from market, as well as unanticipated events such as severe weather conditions causing work delays, and a $12 million Project Reserve funding request was made to complete the remaining contract and BC Hydro work.

The forecast completion cost is $658.6 million or 0.7 per cent less than the final approved Expected Amount of $663.5 million and 3.5 per cent above the First Full Funding (adjusted for IFRS) amount of $636.3 million.

Further detail on project funding approvals and costs are summarized in Table 1 - Project Approvals & Costs. Project cost performance and cost variance analysis are discussed in section 5.

1.8 Deficiencies and Ongoing Commitments

The Project is now substantially complete, and has progressed from an initial peak deficiency count of over 900 to three outstanding items: final record drawings, Operations & Maintenance Manuals, and a performance certification of the Spillway Gate Operating System, which are expected to complete by end of Q1 F21.

One additional deficiency resulted from the relocation of the substation from the top of the Ruskin dam, which caused the orientation of transmission circuit 60L007 to change as it crossed over the Stave River. BC Hydro is waiting for Crown documentation to convert the Licence of Occupation to a Statutory Right of Way for the change in orientation.

In early 2020, two small sinkholes along with apparent movement of the upper bench developed at the left abutment area above the powerhouse. An investigation is underway and we have not yet determined whether these warranty issues are an error of the design consultant or the installation contractor. Based on an analysis of the information gathered by BC Hydro Engineering, our current assessment is that the noted issues do not pose an immediate safety risk to the dam, public or plant operations.

1.9 Regulatory Approvals

On February 22, 2011, BC Hydro filed a Project Application with the BCUC pursuant to section 46(1) of the Utilities Commission Act for a Certificate of Public Convenience and Necessity (**CPCN**) for the Project. On March 30, 2012, the Commission issued a CPCN certificate to BC Hydro and directed BC Hydro to file semi-annual project progress report; fifteen reports were filed. BC Hydro also responded to Commission information requests on Report No.1 and No.12.

The Project did not require any material federal, provincial or local government agency authorizations. A number of minor changes and temporary orders were secured including: modification to a Crown Statutory Right of Way for the transmission line, reservoir draw-downs, spill authorizations, a minor land exchange with reciprocal Statutory Rights of Way, and a new land licence with the District of Mission for BC Hydro constructed works.

1.10 Indigenous Relations

The Project is located within the asserted traditional territory or Statement of Intent areas of several First Nations or groups of Nations. The territory is mostly associated with the Kwantlen First Nation (**Kwantlen**), and the other affected Nations referred BC Hydro's consultation efforts to Kwantlen.

[redacted] Kwantlen intervened in the Ruskin CPCN application process arguing that BC Hydro had failed in its duty of consultation, and the project should not be granted a CPCN. The BCUC did not agree with Kwantlen's position and granted the CPCN to move ahead with the project.

In the intervening years between 2006 and 2015, BC Hydro took an intentional approach to the relationship with Kwantlen, with a sincere interest in understanding Kwantlen's perspectives and interests so that they could be appropriately integrated in the development of the project, as well as advance reconciliation. BC Hydro continued consultation, providing employment and economic opportunities where possible. [redacted]

The on-going communication between BC Hydro and Kwantlen, and BC Hydro's willingness to better understand and accommodate Kwantlen's interests, gradually improved the relationship to such a positive level that at a celebration in February 2019, Chief Marilyn Gabriel referred to BC Hydro employees on the Project as "now being part of her Kwantlen family."

In March 2019, BC Hydro and Kwantlen also signed the *ya:y̓əstəl'* - Enduring Relationship Agreement (**y-ERA**) [redacted] The impact this agreement has had on the Nation is evident by the advancement we have had in implementing project deliverables through our joint working group.

1.11 Environment and Archaeology

Environment

Key areas of environmental management for the Project included water quality and conveyance, sediment and erosion control, spill prevention, Total Gas Pressure (a measure of dissolved gases in the water), hazardous materials removal including asbestos, fish salvages during Hayward Reservoir drawdowns, and wildlife management including eagle nests.

Over the six year construction period, 108 environmental incidents occurred, none of which were considered serious. Corrective actions for the incidents were addressed quickly by the contractors to minimize environmental impacts. No environmental orders were received from Regulators during the Project.

Archaeology

An Archaeological Impact Assessment was completed as part of the Environmental Assessment process, identifying archaeological sensitivities associated with the Project. Kwantlen First Nation archaeology technicians provided monitoring whenever ground disturbance was anticipated, due to the high potential for chance archaeological finds at the project site. Two significant archaeological finds were encountered during the project, one on the Left Abutment above the powerhouse and one on the Right Abutment below the dam. The presence of artifacts such as tools, pottery and arrow heads at various depths is evidence of long term use of the area by First Nations. Artifacts discovered at the Right Abutment area were removed to a repository funded by BC Hydro and built by Kwantlen, while the second find on the Left Abutment above the powerhouse was capped and left in place. In both cases, BC Hydro worked closely with Kwantlen First Nation to mitigate project disruptions and satisfy their request for the respectful treatment of these sites.

1.12 Stakeholder Engagement

As part of the CPCN Application review process, the Commission concluded that BC Hydro's overall public consultation efforts was adequate, issues and concerns had been identified, and plans or commitments had been put in place to address these concerns as the Project proceeds. During the course of construction, regular updates were sent to stakeholders regarding the status of activities on site and anticipated "noisy" work. Multiple tours of the project site were conducted with representatives from the Provincial and Municipal Governments, and local residents, to promote awareness and communication.

Public use of Stave and Hayward recreation sites were temporarily disrupted for the six year construction period. Prior to project implementation, an access plan was executed to provide alternate public access and parking. As part of project completion, parking and access were reinstated and identified improvements made to public use facilities and information kiosks.

1.13 Safety

The construction work was carried out while the Ruskin facility remained in operation. The Project scope involved major construction work that included high risk construction hazards inside and surrounding the Ruskin generating station. To maintain a safe work environment, BC Hydro assumed the Prime Contractor role for the Project. The Prime Contractor assumes full safety administration responsibilities for all work activities on the site.

Over the six year construction period, there were no major injuries. There were two notable safety incidents: one near miss when the dam face swingstage failed, and one worker injury when the barge crane load shifted and impacted a worker. The swingstage safety incident resulted in a work stoppage on the dam face for five weeks in order for the contractor to comply with the WorkSafeBC orders. Another order[1] was received from WorkSafeBC regarding work on the intakes; the work was deemed to be within a confined space and BC Hydro did not have this area listed on the confined space inventory for the site.

Overall, the number of reported lost-time injuries and medical aid injuries were low for a project of this size, complexity and duration.

1.14 Key Lessons Learned

Over the course of the 13-year project there were many lessons learned. We identified some valuable activities that had favourable outcomes and some items where we experienced challenges, all of which we can apply to future projects. The following are a few examples:

The seismic upgrade work on the dam and powerhouse were more tightly coupled than anticipated. The Project plan was based on there being little interference between the dam and powerhouse work. This assumption was correct as long as two turbine-generators were available for water conveyance. When Unit 1 unexpectedly failed in May 2016, Unit 2 had already been taken out of service for rehabilitation work and with only Unit 3 operational, spilling was required. This unanticipated spill event lasted a year due to unusual weather and inflow conditions, and the spray significantly reduced productivity on the dam work. *Future projects should consider possible interference from "N-1" events or other conditions such as unusual weather.*

Design Change Notice process worked well. Engineering developed a Design Change Notice process to reduce churn and allow an efficient and timely review and approval/rejection of all proposed changes, while allowing the Engineering team to assure that the design intent would be met through construction. The process proved very useful for efficient management of changes through construction and it

[1] In total, twenty nine (29) safety violation orders were issued to contractors and one (1) to BC Hydro.

became an excellent communication tool between the designers, project engineers, construction managers, construction field personnel, Resident Engineering team, and the Project Management team. *This process was subsequently implemented by the John Hart Redevelopment project.*

General Contractor must be responsible for design integration. The general contractor was responsible for the detailed design for some powerhouse system, but they sub-contracted the work to mechanical and electrical contractors. The mechanical subcontractor did a mechanical design, but did not have the expertise to do electrical and protection & control (**P&C**) design. The general contractor did not integrate the mechanical design with the off-the-shelf electrical and P&C components, leaving BC Hydro field staff to direct the subcontractors. *If a contractor is responsible for design, future projects should consider making 'acceptance of detailed design' a milestone and pay item to encourage the contractor to address design integration.*

Deficiencies. Due to the size and complexity of the project, numerous deficiencies were anticipated after placing each asset into service. These deficiencies were successfully managed by prioritizing the deficiencies by operational importance, and segregating them into those that were the commercial responsibility of the contractor, and those that were the responsibility of the project. One of the key challenges in closing out the deficiencies was keeping key knowledgeable contractor resources after the project went into service, as they were reassigned to higher priority projects in their respective organization [redacted]. *Future projects should close out as many deficiencies as possible after the asset in-service date well before the project in-service date.*

Contradictory advice received from equipment manufacturer. BC Hydro engaged the manufacturer of a very specialized component (the Lead-Rubber Bearings for the spillway bridge), and based the contract specification on the information obtained from the supplier. The contractor ordered the bearings based on those specifications and was told that the supplier could not manufacture the bearings described in that specification. A post-mortem revealed that both BC Hydro and the contractor were dealing with different people from the supplier, and no one at the supplier had a full picture of our needs and constraints; while their responses individually were correct, they did not work when taken in aggregate. *Future projects should ensure that communication with suppliers during the design stage is through a single point of contact to avoid their internal miscommunication.*

Contractor Site Performance. The first of three generating units built by Voith Hydro Inc. (**Voith**) for the project experienced numerous construction issues, safety incidents and schedule delays. Upon reviewing the aggregate of these issues, it was decided to replace Voith's construction manager. This resulted in improved performance on the remaining two generating units. *For subsequent projects currently being executed with Voith, more scrutiny was applied to key leadership roles, and wherever possible, those key resources recognized for good performance were encouraged to work on future BC Hydro generating unit projects.*

Engineering Non-Conformance Reports were a good tracking tool. The Engineering Non-Conformance Reports were a good means for tracking design issues, deficiencies and associated costs, and also allowed Engineering to determine how to resolve the issue. *Non-Conformance reporting is a standard practice that should be continued.*

Plant Ancillary Systems – transition design. Some of the plant ancillary systems were not operable until all three generating units had been rehabilitated; there was no transition configuration between the old and the newly rehabilitated units. This required temporary design and engineering in the powerhouse. *Future projects, especially in a brownfield situation, should ensure the staging and design work allows for the transition from old to new equipment.*

Non-Standard Designs or Specifications Increased Costs. Given the complexity of the project including dam safety redundancy, some of the design criteria or specifications were non-standard or not commonly available in the market. This reduced market interest in the supply and therefore the competitive tension on suppliers. Supply of non-standard items can extend procurement schedules and have adverse cost and schedule impacts due to testing and commissioning required in certifying performance. *Future projects should consider the relative cost and effectiveness of using existing or commonly-available designs and equipment compared to custom or semi-custom designs.*

Two archaeological sites were impacted during construction. Impacts occurred despite extensive investigation in the Definition phase (Archaeological overview assessment and Archaeological Impact Assessment as part of the Socio-Economic Impact and Mitigation Assessment) and specific work instructions included in the Environmental Management Plan. The archaeological assessments treated identified discrete sites to be avoided or requiring mitigation when working in or near them. However, these assessments did not identify the entire site as one large archaeological site, despite defining it as a high-likelihood of containing artefacts. As a result, when the project was required to excavate previously undisturbed-soils, artefacts were encountered. This led to trust issues with Kwantlen First Nation that required significant work and relationship building to repair. The Project later implemented procedures to include archaeological monitoring whenever site excavation was required regardless of location. This likely prevented later encounters with archaeological resources. *Better understanding of the potential and more extensive archaeological monitoring from the start of construction would likely have prevented the earlier impacts.*

First Nations relationship approach. The relationship began from a difficult place, and over the course of the project, the project team took a significant role in building a positive and meaningful relationship with Kwantlen. *This experience serves a* *model for how a project team should engage in the relationship (rather than it be solely Indigenous Relation's responsibility).*

2 BCUC Application, Decision and Progress Reporting

On February 22, 2011, BC Hydro filed an application for a CPCN for the Project with the BCUC.

The proceeding extended to three rounds of Intervenor Requests (**IRs**) for a total of 1,067 IRs issued to BC Hydro. Eight intervenors participated, and one intervenor – the Kwantlen First Nation – provided evidence. There was no oral hearing, and the evidentiary phase of the proceeding concluded on January 9, 2012.

On March 30, 2012, the BCUC issued Order No. C-5-12 stating that the BCUC concluded that BC Hydro's consultation with First Nations was adequate, and also finding that the proposed Project scope and expenditure schedule, excluding the part relating to the Capital Overhead, was in the public interest. The Order also directed BC Hydro to file project progress reports on a semi-annual basis to the Commission. Since September 2012, BC Hydro has filed the required semi-annual project progress reports to the Commission, with the last semi-annual project progress report (Number 15) filed in November 2019. BC Hydro also responded to Commission IRs on Report No. 1 and No. 12.

2.1 BCUC Cost Reporting Differences

In Order No. C-5-12 (CPCN Order), the Commission approved a "Basic Expected Amount" of $640.5 million, which was the Expected Amount for the Project of $718.0 million, less the Implementation Phase Capital Overhead of $77.5 million, and directed BC Hydro to report project expenditures against that amount. The Basic Expected Amount did not include funding for an IBA with Kwantlen First Nation, but the Commission directed BC Hydro to include any IBA amount in its reporting on the

Project[2]. Internally BC Hydro made adjustments to capital overhead arising from the conversion from CGAAP to IFRS (and these calculations differ from those used by the Commission in establishing the Basic Expected Amount), and funded the Kwantlen IBA cost under a separate project to maintain confidentiality of the IBA. Table 1 is a summary of funding approvals and costs for the project. The table illustrates the reporting costs for BC Hydro's purposes and the Commission as directed by the BCUC decision.

Table 1 Project Approvals & Costs in ($000s)

Approvals	**Notes**	**BC Hydro**		**CPCN Order**	
Project Expected Amount	1	718,035		718,035	
Less: Adjustment for IFRS (BCH)		(81,688)			
Less: Implementation Overhead (BCUC)				(77,547)	
Initial Approval Expected Amount (FFF)	2	636,347		640,488	
Add: Reserve Draw	[redacted]	[redacted]			
Revised Expected Amount	[redacted]	[redacted]		640,488	
[redacted]	[redacted]	[redacted]			
Final Approved Expected Amount	[redacted]	[redacted]		640,488	
Project Actual Costs	[redacted]	[redacted]			
[redacted]	[redacted]	[redacted]		[redacted]	
Total Project Actual Costs		658,596		658,596	
Less: Implementation Overhead				(13,536)	
Adjusted Total Project Actual Costs	5	658,596		645,060	
Adjusted Total Project Actual Costs vs Initially Approved EA		22,249	*3.4%*	4,572	*0.7%*
Adjusted Total Project Actual Costs vs Final Approved EA		(4,901)	*-0.7%*	4,572	*0.7%*

2 BCUC IR 1.3 to BC Hydro Semi-Annual Report No. 1, as amended by BCUC IR 2.2.1

Notes

1. This was the basis of initial approval by the BC Hydro Board and the Application to the BCUC for a CPCN.
2. The Initial Approval amounts represent BC Hydro Board approval after adjustment for IFRS, and the "Basic Expected Amount" as set out in Directive 3 of BCUC Order No. C-5-12.
3. The Reserve Draw did not affect the Project Approved Authorized Amount of $758,036k, net of IFRS adjustment.

[redacted]

5. Adjusted total cost matches the cost reporting method directed by the BCUC.
6. All amounts exclude Asset Net Book Value write-offs of $10.5 million.

3 Project Approach and Outcomes

The Project was a highly challenging project due to the refurbishment nature of the work, the requirement to maintain river flow continuity while minimizing spills, and performing all the work while keeping portions of the plant in operation. The Project was delivered through a combination of DB and DBB contracts. Construction work was split into four major packages, segregated by physical location of work and primary trades required.

Right Abutment – Stage 2: DB contract to correct the existing seismic deficiency through building a cut-off wall and implementation of the jet grouting technology. The contract was awarded as a result of a two-stage procurement process, which consisted of a public Request for Proposal (**RFP**) and a competitive Early Contractor Involvement (**ECI**) process. BC Hydro received three proposals and selected two suppliers for the ECI process. Throughout the ECI process, which included a collaborative three-stage process with the selected suppliers (both with demonstrated foundation and geotechnical expertise), BC Hydro jointly developed design solutions that each supplier could implement with the equipment and technology available to them. Through this process BC Hydro had an opportunity to assess the merits of each design, as well as the ability of the supplier to implement their selected design and manage risks on the project. Based on this collaboration and BC Hydro assessment of the work execution methodologies and pricing information supplied by the vendors, BC Hydro awarded the work to Golder Associates Innovative Applications (**GAIA**).

Upper Dam and Powerhouse Structural: DBB contract to address the heavy civil requirements of the dam piers and gates and powerhouse seismic improvements. Five bids were received in response to BC Hydro’s RFP#943. After the evaluation and clarification/negotiation process, BC Hydro awarded this contract to FDJV.

Turbine and Generator Supply and Install: DB contract to design, supply and install three new turbine-generator units. BC Hydro received three proposals in response to RFP#731. The contract was awarded to Voith as a result of BC Hydro evaluation and subsequent negotiation with the supplier.

Powerhouse Completion Contract: DBB contract to cover the remaining mechanical and electrical installation work in the powerhouse. BC Hydro issued RFP#1338 for this scope of work and received three bids. The contract was awarded to FDJV upon completion of the evaluation and clarification/negotiation process.

The Upper Dam and Powerhouse Structural contract, Turbine and Generator Supply and Install contract and Powerhouse Completion package were enhanced to include a Cooperation Agreement, which FDJV and Voith were required to sign prior to commencement of the work at the dam and the powerhouse to ensure cooperation among the contractors in resolution of any conflicting contractual situation, which could arise because of the overlapping work areas, adjacent laydown/staging areas and schedule dependencies.

In addition to the four major contacts, BC Hydro utilized a number of existing agreements:

- Spillway Gates Program with HMI Construction Inc. for the supply of the new Spillway Gates;
- Blanket Contract Order (**BCO**) with Fortune Electric for the supply of new power transformers;
- BCO with ABB for the supply of excitation systems; and
- BCO with L&S for the supply of governors.

Contracts for the design and supply of the Powerhouse Crane and design and supply of the Spillway Gantry Crane were procured through public RFPs.

Miscellaneous electric and P&C equipment was procured under the pre-established BCOs.

Refer to section 7 for individual contracts exceeding $3 million.

4 Engineering and Construction Management

Engineering Management

BC Hydro assigned a lead engineer (referred to as the Project Engineer at BC Hydro) who has been accountable for all Engineering activities on the project, along with assistant and deputy project engineers for major sub-components of the work.

While BC Hydro retained overall engineering accountability for the project, the resourcing strategy included:

- Retaining MWH (now Stantec) as the Engineer of Record for all powerhouse, intake, power tunnels and left abutment components, with BC Hydro's oversight provided using internal Owner's Engineers;

- Including detailed design of turbines and generators in the Voith supply and install contract, with BC Hydro carrying out the preliminary design of these components internally;
- Implementing an innovative Early Contractor Involvement process in the design and construction of the highly complex and challenging Right Abutment cut-off wall system; and,
- Retaining engineering accountability for all Dam Safety related components of the work (with the exception of the power intake and left abutment slope that was with MWH's scope per above) while using various smaller contracts to augment internal engineering resources, as required.

BC Hydro retained MWH to perform preliminary Identification phase work in early 2008 with the submittal of the Ruskin Powerhouse Improvement Project Alternatives Assessment Report, and the Feasibility Design Report (**FDR**). These reports identified alternatives for improvement of over 30 project features associated with the powerhouse.

The FDR report recommended preferred alternatives for several of the project features and narrowed down alternatives for the remaining features to be studied during the remaining phases of the project.

Based on terms of the initial RFP and contract, as well as successful experience with the work described above, BC Hydro issued 12 change orders extending the original contract with MWH through final design, construction and project closure engineering activities.

While MWH was retained as Professionals of Record (**POR**) for a majority of the intake, power tunnels, powerhouse and left abutment work, BC Hydro retained in-house engineering teams to complete Fire Protection System and Protection and

Control designs to maintain consistency with BC Hydro' system-wide safety requirements and design approaches.

The above engineering resourcing strategy allowed BC Hydro to complete all engineering activities for a successful conclusion of the project, especially considering that BC Hydro and the utility industry in general was experiencing significant engineering resource shortages when this project started.

Construction Management

The BC Hydro Construction Management Group was responsible for managing and administrating all work activities at site. Key responsibilities included: providing support to procurement; administering contracts; implementing safety and environmental programs; conducting design and constructability reviews; performing audits and inspections; monitoring and reporting on construction progress; coordinating site activities; and completing asset commissioning.

5 Cost Variance Explanations – Actuals Versus the BCUC Basic Expected Amount

5.1 Project Expenditures Summary

The forecast project cost at completion of $645.1 million[3], including the remaining deficiency work, is slightly above (0.7 per cent) the Basic Expected Amount of $640.5 million approved by the Commission. This forecasted cost is higher than that reported in Semi-Annual Progress Report No. 15 by $0.1 million. The overall variance was attributed to a number of causes including design and work complexity, adverse weather conditions, worse than expected equipment condition, challenging site conditions, and the reintroduction of the PST. This is a good cost performance for a project of this size and complexity.

3 Include IBA cost less Implementation Phase overhead.

Table 2 below shows the BCUC approved Basic Estimate Amounts and BC Hydro Expected Amount at completion for each major cost element. The table is consistent with prior semi-annual progress reports filed with the Commission.

Table 2 Project Expenditure Summary ($000s)

[redacted]

[redacted]

Variances

[redacted]

[redacted]

[redacted]

[redacted]

6 Project Schedule Milestones

Major asset interim in-service date milestones were based on a construction work sequence to maintain powerhouse and dam operation. These milestones were all established as their "Early Finish Date" in the schedule[4] – dates which represented conservative use of schedule contingency. The remaining portion of the overall schedule contingency was allotted to the last project completion milestone.

The spillway gate piers and system replacement work was divided into three sequential parts to meet gate operation requirements[5]. The generating unit replacement/refurbishment work was also sequential; each generating unit had to be completed before the next generating unit was taken out of service, starting with the least reliable unit (Generator Unit No. 3) because of tight workspace inside the powerhouse. In addition, to meet plant Operating Order requirements, two units must be running[6] to maintain minimum water level at the toe of the dam.

Work on the first major asset interim milestone, Right Abutment, was completed on time on July 2013. The interim in-service milestones for Spillway Gate 1 & 2 and Generator Unit 1 were not achieved.

Spillway Gate 1 & 2 in-service date was delayed by nine months. The delay was caused by a number of factors including: (1) need to complete anchoring work on

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4 The schedule is in Primavera P6, enterprise project portfolio management software adopted by BC Hydro in 2011 for project scheduling.

5 Sufficient spillway gate capacity is required to discharge water behind the reservoir when high inflows exceed the ability of the generating units to pass the volume of water required. Loss of spillway discharge capacity could result in a dam being overtopped, leading to loss of life, financial loss, damage to the environment and loss of reputation.

6 By passing water from intake gate upstream through the turbine and discharging out from the draft tube to the tailrace.

Right Abutment Block 1 and 2, drainage and other works prior to spillway gate/pier work; (2) challenges in installing temporary upstream bulkhead system in high- inflow period; (3) longer design progression[7] duration due to Project complexity; (4) contractor's performance deficiencies; and (5) unexpected spill requirements[8]. The cumulative impact of these delays consumed the entire schedule contingency for the remaining spillway gates.

Generator Unit 3 in-service date was delayed by 11 months due primarily to additional work to assess and rectify: (1) worse than expected conditions at the concrete foundation around the stator soleplate; (2) greater than anticipated damage in the draft tube requiring significant draft tube repair work; (3) information discrepancies from original construction drawings; and (4) contractor's performance deficiencies. With limited opportunities to pursue Generator Unit 2 and Unit 1 work in parallel, and a cumulative impact from a Generator Unit 3 delay, a large portion of the schedule contingency for Generator Units 2 and 1 was consumed.

Because the work had to be "sequenced", the initial delay caused a ripple effect to all subsequent interim in-service milestone dates. The delays to generating units' in-service dates also resulted in ongoing unplanned spilling which impacted the repair work at the lower sections of the dam spillway shotcrete, dam spillway steps, and powerhouse access bridge piers. Unusual weather and high inflow condition also contributed to the requirement to spill. In effect, the delays experienced from the three generating units also contributed negatively to the overall spillway gate schedule performance.

[7] A progression process where engineering design improve from a preliminary level prepared based on a set of assumptions to final detailed design (solution for implementation) reflecting actual site conditions, technical constructability issues, integration requirements, and construction methods and techniques.

[8] Inflows in the 2014 construction season were well below normal. Inflows in 2015 were well above normal. The spillway facility was utilized for a prolonged period. Spilling creates worker hazards and limits work activities in some dam areas, reducing worker productivity in general.

With these challenges, and setting interim milestones based on "Early Finish Date", many interim in-service dates were missed. The original planned in-service dates for Spillway Gates 3 & 4 and Spillway Gate 5 were missed by seven and eight months, respectively. The second and third generating unit in-service dates were missed by nine and eight months, respectively. The actual switchyard in-service date was missed by approximately one month.

Overall, the Project was completed in February 2018, one month ahead of the original planned Project in-service date, as a result of having a large portion of the project schedule contingency at the end of the project.

With learnings from the Project, the BC Hydro Project and Portfolio Management (**PPM**) practice has been improved. Subsequent projects have established interim milestones based on the "Late Finish Date" in the P6 schedule to reflect a distribution of the project schedule contingency to each asset in-service date and a more accurate measure of progress performance in alignment with identified risks.

Table 3 below shows the plan and actual dates for key Milestones on the Project.

Table 3 Project Milestones

No.	Description/ Status	Original Plan Date	Actual (A) or Forecast Date	Variance (Months)	Status and Comments
1.	BC Hydro Board of Directors Approval	February 2011	February 2011	0	
2.	BCUC CPCN Decision	January 2012	March 2012	2	Major contract award delayed by two months.
3.	Right Abutment In-Service	July 2013	July 2013	0	
4.	Spillway Gates 1 & 2 In-Service	February 2015	November 2015	9	Dam work preceding gate work was delayed. Anchoring on Crest Block 1 & 2, Horizontal Drain Installation, and Buttress improvement affected Pier 1 work. Challenges in temporary bulkhead installation work. Contractor work deficiencies and safety issue on platform caused additional delays.

No.	Description/ Status	Original Plan Date	Actual (A) or Forecast Date	Variance (Months)	Status and Comments
					Wet 2014/2015 winter & spring season; dry 2015 summer season - spilling created worker hazards and limited work activity at some of the Dam areas, the long spill duration reduced overall productivity.
5.	Spillway Gates 3 & 4 In-Service	June 2016	January 2017	7	Work had to be done sequentially. Ripple effect from Spillway 1 & 2 late completion date. Demolition and reconstruction work for Spillway 3 & 4 and Spillway 5 could not proceed in parallel without Spillway 1 &2 returning back to service. This was a requirement for safe reservoir operation. The initial delay shifted the remaining in-service dates for Spillway Gates 3, 4 and 5. Spillway Gate 4 installation work delayed due to concrete placement and quality problems. Spillway Gate 5 experienced challenges in pier anchoring work; the anchoring area was over crack rocks and unplanned spilling because of an unexpected Generating Unit 1 failure.
6.	Spillway Gates 5 In-Service	May 2017	January 2018	8	
7.	1st Unit In-Service (Generator Unit 3)	November 2015	October 2016	11	Draft tube condition was worse than expected. Extensive repairs and form work modifications were required. During commissioning, contractor construction deficiencies were noted on rotor poles. Remediation and re-testing work on rotor poles along with draft tube repair work consumed the entire schedule float for Generating Unit 3.
8.	2nd Unit In-Service (Generator Unit 2)	September 2016	June 2017	9	Unit replacement/refurbishment activities were dependent on timely completion of the previous unit. Delays experienced from the previous unit caused a ripple effect for subsequent units. This schedule impact was not recoverable because parallel work for Unit 2 and 1 was not possible[1]. The third unit was delayed because of the need to redesign power line tie-in to the new switchyard to avoid disturbing the Left Abutment archaeological site discovery.
9.	3rd Unit In-Service (Generator Unit 1)	June 2017	February 2018	8	
10.	Switchyard In-Service	June 2017	July 2017	1	Delayed due to artifacts discovered near the site during civil excavation work. Duct work was rerouted from the original plan.

No.	Description/ Status	Original Plan Date	Actual (A) or Forecast Date	Variance (Months)	Status and Comments
11.	Project Completion	March 2018	February 2018	(1)	Project was placed into service when the last major asset was placed into service, that being Generating Unit No. 1 on February 20, 2018.
12.	Project Close Out[2] (Financial Close Out)	March 2019	Forecast March 2020	12	Additional time required to address and resolve remaining deficiencies and minor scope items.
Notes: 1	Other units must be operational to maintain reservoir elevation and river flow downstream.				
2	Project Close Out represents the date when all chargeable accounts to the project are closed. It will follow approval of the Project Completion and Evaluation Report, close out of all contracts, accounts and completion of archiving of project documentation.				

7 Individual Contracts Exceeding $3 million

[redacted]

[redacted]

8 Indigenous Relations Engagement Activities

The Project is located within the asserted traditional territory or Statement of Intent areas of several First Nations or groups of Nations. The territory is most associated with the Kwantlen First Nation (**Kwantlen**), and the other affected Nations referred BC Hydro's consultation efforts to Kwantlen. Kwantlen First Nation has 280 members and is part of STO:LO Tribal Council. Kwantlen Traditional Territory extends from Richmond and New Westminster in the west, to Surrey and Langley in the south, east to Mission, and to the northernmost reaches of Stave Lake. Kwantlen Nation's priorities include: environmental sustainability, cultural heritage protection and economic development. Through recent engagement on projects in their territory, Kwantlen's leadership has shared with BC Hydro that it has and continues to feel deeply impacted by BC Hydro's infrastructure and that reconciliation with BC Hydro is the community's number one priority.

[redacted] Kwantlen intervened in the Ruskin CPCN application process arguing that BC Hydro had failed in its duty of consultation, and the project should not be granted a CPCN. The BCUC did not agree with Kwantlen's position and granted the CPCN to move ahead with the project.

In the intervening years between 2006 and 2015, BC Hydro took an intentional approach to the relationship with Kwantlen, with a sincere interest in understanding Kwantlen's perspectives and interests so that they could be appropriately integrated in the development of the project, as well as advance reconciliation. BC Hydro continued consultation, providing employment and economic opportunities where possible. [redacted]

The on-going communication between BC Hydro and Kwantlen, and BC Hydro's willingness to better understand and accommodate Kwantlen's interests, gradually improved the relationship to such a positive level that at a celebration in February 2019, BC Hydro and Kwantlen Chief and Council, and members of the Nation celebrated together at the dedication of six decorative panels, designed by a young Kwantlen artist (Figure 8 Upper Dam with New Spillway Piers and Gates). The art acknowledges the depth of Kwantlen First Nation's spiritual, cultural and physical presence in the area, and BC Hydro's commitment to a lasting relationship that is

[redacted]

built on reconciliation. At that dedication ceremony Chief Marilyn Gabriel referred to BC Hydro employees on the Project as “now being part of her Kwantlen family.”

In March 2019, BC Hydro and Kwantlen also signed the *ya:y̓əstəl’* - Enduring Relationship Agreement (**y-ERA**) [redacted] The impact of this agreement has had on the Nation is evident by the advancement we have had in implementing project deliverables through our joint working group.

9 Key Areas of Environmental, Archaeological and Public Use Management

9.1 Environmental Management and Monitoring

The environmental management process was based on the development of a comprehensive environmental management plan (**EMP**) which addressed all of the environmental sensitivities and potential Project impacts. The EMP was presented as a high-level document that identified all of the environmental requirements by legislation and applicable permits. The EMP formed part of the Project contracts.

The EMP detailed the requirement for the Contractor to develop an environmental protection plan (**EPP**) that described the site-specific mitigation measures that were put into place by the Contractor to meet the requirements of the EMP. The Contractor provided an EPP that described the site sensitivities, potential environmental impacts and general mitigation measures.

Site monitoring was undertaken during implementation phase using risk-based determinants. BC Hydro had an on-site Qualified Environmental Professional (**QEP**) who was responsible to identify what activities required an environmental work procedure (**EWP**), perform monitoring function as well as reviewing and accepting all EWPs. EWPs were prepared by the Contractor's independent environmental monitor and were signed off by the QEP. In total there were 38 EWPs issued.

Over the six-year construction period, there were 108 environmental incidents reported. There were 17 externally reportable incidents. 16 incidents were reportable to Emergency Management BC as per the Provincial *Emergency Management Act*. 15 of the incidents were associated with either small oil spills to water (largest spill was 5 litres) or elevated turbidity in water. The remaining reportable incident, a PCB leak from out of service equipment stored at the Stave yard, resulted in an internal investigation and root cause analysis resulting in recommendations for identifying and tracking temporarily stored equipment. All incidents were not considered serious. Incidents were addressed quickly by the contractor to minimize impact and corrective actions implemented. No environmental orders were received from Regulators for the duration of the Project.

9.2 Archaeological and Heritage

An Archaeological Impact Assessment was completed as part of the Environmental Assessment process, identifying archaeological sensitivities associated with the Project. Kwantlen First Nation Archaeology Technicians provided monitoring whenever ground disturbance was anticipated, due to the high potential for chance finds at the project site. Two significant archaeological finds were encountered during the project, one on the Left Abutment above the powerhouse and one on the Right Abutment below the dam. The presence of artifacts such as tools, pottery and arrow heads at various depths is evidence of long term use of the area by First Nations. Artifacts discovered at the Right Abutment area were removed to a repository funded by BC Hydro and built by Kwantlen, while the second find on the Left Abutment above the powerhouse was capped and left in place. In both cases, BC Hydro worked closely with Kwantlen First Nation to mitigate project disruptions and satisfy their request for the respectful treatment of these sites.

9.3 Public Use

The Stave River hydroelectric system provides many recreational opportunities. Stave Lake is a popular fishing and camping destination while Hayward Lake is a day use area for swimming, canoeing and kayaking as well as hiking. Downstream of the Ruskin dam, the lower Stave River is also a well-known destination known for its salmon fishing.

While access to Stave Lake and the main beach at Hayward lake were not affected, the Project required use of the recreational amenities in the area, including:

- Lower Railway Trail parking area;
- Stave River parking and picnic area; and
- Access to the Hairsine Bay and reservoir hiking trails.

The Project’s use of these areas limited parking and access to Hayward Lake as well as access to the lower Stave River for fishing. Prior to the project, BC Hydro completed upgrades to the Hayward Lake Recreational area including a new parking area near the main beach site to mitigate for the lost parking area near the dam, construction of a new dog beach and recreation area on the west shore of Hayward Lake and a replacement parking area to provide public access to the Railway Trail.

As the Project was completed, the public use management areas were rehabilitated including the following:

- The Lower Railway Trail parking area was restored to provide additional parking spots and re-paved. This parking area now provides access north along the Railway Trail and south where pedestrians have access to view and walk across the Ruskin dam. There were also significant public safety upgrades completed for pedestrians and cyclists crossing the Ruskin dam;

- The Stave River parking and picnic area on the east side of the river was returned to its original condition with improvements. The parking area was re-paved, the picnic areas were revegetated and new picnic tables were provided. The pit toilets were replaced and a new overflow parking area increased the capacity of the area for users; and
- Additional parking was also provided on the east side of the dam where public users can access hiking trails towards Hairsine Bay or across the dam to the Railway Trail. With completion of the Hairsine Bay floating bridge, hikers will once again be able to circumnavigate Hayward Lake on the recently upgraded, 17 km Reservoir Trail.

While the Project limited access to some recreational areas on both Hayward Lake and the Stave River, the areas have been restored and with the additional areas developed prior to the project and improvements made to existing areas, the result is improved access and recreational opportunities.

10 Safety Activities

10.1 Safety Risk Management

The construction work was carried out while the Ruskin facility remained in full operation. The scope of work involved major construction work that included high risk construction hazards inside and the surrounding Ruskin generating station. The construction footprint plus the area with critical safety factors included the powerhouse, dam, tailrace and downstream Stave River and public roadways. Key components within the Safety portfolio include: Safety Management, Public Safety, Security and Traffic Management leading toward and exiting the construction worksite. A full time safety management team was deployed from the early planning stages up through to project completion.

BC Hydro assumed the Prime Contractor role for the Project. The Prime Contractor assumes full safety administration responsibilities for all work activities on site.

Over the six-year construction period, there were no major injuries. There were two notable safety incidents: one near miss when the dam face swingstage failed, and one worker injury when the barge crane load shifted and impacted a worker. The swingstage safety incident resulted in a work stoppage on the dam face for five weeks in order for the contractor to comply with the WorkSafeBC orders. Another order was received from WorkSafeBC regarding work on the intakes; the work was deemed to be within a confined space and BC Hydro did not have this area listed on the confined space inventory for the site.

Overall, the number of reported lost-time injuries and medical aid injuries were low for a project of this size, and complexity and duration.

There were two notable safety incidents:

1. Dam Face Swingstage[10] Failure Near Miss – Although there were not any significant injuries sustained during this incident there were four orders issued by WorkSafeBC. Some of these orders included training, and modifying an engineered design[11].
2. Upper Dam Barge Crane Load Shift impacting worker – A worker did sustain an injury as a result of this incident a total of nine orders issued by WorkSafeBC. Some of these orders were written on supervision, worker, and ignoring alarms.

[10] An elevated work platform constructed for downstream access to spillway piers, crest and chute areas.
[11] Platform design completed by contractor, and the contractor accepted full responsibility for this incident.

BC Hydro Orders Received from WorkSafeBC:

Prime Contractor – During initial work on the intakes this work was deemed to be within a confined space and BC Hydro did not have this area listed on the confined space inventory for the site.

The Project experienced 12 lost-time injuries, and 28 medical aid injuries over 1.6 million person-hours worked, for an all-incident frequency rate of 4.8 and a lost-time frequency rate of 1.44. The frequency rate of 4.8 indicates just less than five incidents for a full year work, based on 200,000 working hours in a year.

Safety statistics to March 31, 2018 by contractor were as shown in Table 5.

Table 5 Safety Statistics

CONTRACTOR	**LOST TIME INJURY (LT)**	**MEDICAL AID (MA)**	**P-HOURS Worked**	**Frequency** All Incident	**Frequency** Lost Time
[redacted]	0	0	**77,861**	0.00	0.00
	8	17	**844,301**	5.92	1.90
	1	4	**444,571**	2.25	0.45
	3	7	**287,516**	6.96	2.09
	0	0	**6,975**	0.00	0.00
TOTAL	**12**	**28**	**1,661,224**	4.82	1.44

Note: The below formula is an industry standard formula based on BC Hydro and OSHA Standards
AIF = (MA+LT) X 200,000 / Hours Worked
LTF = LT X 200,000 / Hours Worked
Both frequency figures indicate the rate of incidents per year of full-time work, assuming 200,000 working hours in a year.

10.2 Safety Orders

10.2.1 WorkSafeBC Orders

During the construction period, a number of inspections were conducted by WorkSafeBC. A total of 30 orders were issued: [redacted] and one to BC Hydro. Orders noting safety violations were assessed and communicated with the three contractors. All recommendations and corrective actions were implemented by the contractors and BC Hydro on a timely basis.

11 Risk Management

The Project's approach to risk management followed the generally accepted practice of risk identification, analysis, evaluation and treatment. The project created and employed a rigorous risk identification process that focused on anticipating risk events before they happened, with the objective of applying earlier risk treatments so that risk event occurrences could be eliminated, or reduced if the risk events occurred. When risks were identified, the Consequence, Severity, Frequency, of Occurrence, Mitigation Plan, and Residual Risk were recorded in the Project Risk Register and Project contingency was set aside in the Project forecast to recognise the associated impact to the project budget should the risk event be triggered. The net result was a reduction in cost and schedule impacts, as well as providing a continuously updated risk based forecast that more accurately reported the Estimate at Completion.

The Project identified a number of broad risk categories that could have potentially impacted the cost and schedule. They included:

- Unknown site conditions, geotechnical or characteristics of subsurface or structures;
- Unknown equipment conditions;

- Excavation and construction work challenges on Upper Dam piers, the Right Abutment cut-off wall and the Power Intake System[12];
- Construction work to be completed with the Ruskin Facility remaining in operation;
- Adverse weather; and
- Inflow conditions.

These identified key risks and their treatments are shown below.

Table 6 Risk Table

No.	Risk Event	Control and Mitigation Strategy	Description of Residual Probability and Impact	Status
Public Safety				
1	There is a risk the public may access the reservoir or other areas of concern (including Stave River immediately downstream of the Dam) which may result in public injury.	Restrict public access during construction, formalizing a public restricted zone and implement a public awareness program once the Project is operational.	Low probability of significant injury or fatality; High impact.	Passed
2	There is a risk an extreme precipitation event during construction may result in flood inflows that exceed the Dam's capacity to route. This could result in public injury or fatality.	Implement Flood Management Plans and Safety Management Plans.	Low probability; Impact dependent upon magnitude of event. Events to date have only impacted schedule float, primarily due to drawdown related work.	Passed

[12] Power Intake System consists of the following components: Intake Gate and Structure, Intake tunnel or conduit leading up to the turbine and generator.

No.	Risk Event	Control and Mitigation Strategy	Description of Residual Probability and Impact	Status
3	There is a risk during construction phase that an earthquake could cause any or all of the following: Bulkhead failure Right Abutment failure Upper Dam failure which may result in public injury or fatality.	Implement Emergency Response Plan. Implement proper design criteria for temporary works, and address the responsibility of contractors as well as appropriate review.	Low probability; High impact.	Passed
4	There is a risk of a vehicular accident on Hayward Road which may result in public injury or fatality.	Develop a comprehensive Traffic Management Plan. Review plan with contractors for improvements.	Low probability; High impact.	Passed
Worker Safety				
5	There is a risk of a safety event involving construction activities which may result in worker injury or fatality.	Provide Contractors with a Safety Management Plan and BC Hydro to provide experienced construction management and safety oversight.	Low probability of significant injury or fatality; High impact.	Passed
Procurement & Commercial Risk				
6	There is a risk of delay of vendors' supply chain for major equipment items (turbines, generators, crane, transformers and spillway gates) which may result in a delay to construction and ultimately the ISD.	Begin contract process early for long-lead time equipment purchases with appropriate exit clauses. Monitor progress and Quality Assurance results during fabrication.	Moderate probability; Low impact.	Passed
7	There is a risk that proponents bid higher than estimated contract values and/or BC Hydro does not receive enough bids to support a competitive process; either event may result in Project cost increases exceeding the Expected Amount.	All major contracts have been awarded. Aggregate budget remains on track. BC Hydro will continue to monitor the final major award.	Low probability; High impact.	Passed

No.	Risk Event	Control and Mitigation Strategy	Description of Residual Probability and Impact	Status
8	There is a risk a contractor may default which may result in unexpected costs and schedule delays to BC Hydro.	Include appropriate exit clauses in all contracts and a requirement for supplier performance bonds.	Low probability; Low impact.	Passed
9	There is a risk that construction coordination issues occur which may result in unexpected costs and schedule delays.	Include contract language to outline dependencies between contractors and 1) transfer risk to party causing the delay; 2) provide incentives for all parties to identify lowest overall cost to resolve issues. Monitor progress and pre-identify potential interactions between contractors.	Medium probability; Medium Impact	Passed
Design & Construction Risks				
10	There is a risk that issues may arise during late stages of First Nations consultation or relationship building which may result in a delay to construction and ultimately the ISD.	Proactive focus on continuing to build a strong relationship with First Nations, including the ongoing provision of Project updates.	Risks and impact will vary depending upon the nature of issue.	Passed
11	There is a risk of design changes (including changes from course of construction events and overall design integration requirements) and technical constructability issues (also including as-found conditions) which may result in increased Project costs and schedule delays. Similarly, operational issues may affect costs and schedule.	Engineers will work to minimise the impact of any required design changes. Ensure contractor has clear understanding of site constraints. Transfer as-found risk to contractors to extent possible; contingencies for as-found work not transferred; manage contract milestones. BC Hydro retains risks related to failure of existing equipment.	Medium probability; High impact.	Passed

No.	Risk Event	Control and Mitigation Strategy	Description of Residual Probability and Impact	Status
12	There is a risk construction related activities will disrupt the local community beyond acceptable limits, which may result in ill-will toward the Project, unexpected costs and Project delays.	Ongoing community information and engagement. Implementation of traffic management plan. Develop construction plan during design phase.	Medium probability; Medium Impact.	Passed
13	There is a risk of unforeseen geotechnical findings and / or weather events which may result in schedule delays and additional Project costs.	Transfer risk to contractor, as reasonable; Construction schedule reflects conservative schedule.	High probability; Impact will vary depending upon condition. Sub-surface issues have delayed the ISD for the first two spillway gates	Passed
14	There is a risk that equipment may fail during commissioning which may result in delays and additional Project costs as well as ongoing operational inefficiencies.	Supplier contract requirements, Project Quality Assurance Plan, Project Commissioning Plan, BC Hydro recent project experiences with similar equipment.	Low probability; Medium to High impact.	Passed
Resource Risk				
15	There is a risk of resourcing conflicts (both human and equipment) with other projects which may result in delays and additional Project costs.	Transfer external resource supply to contractors. Access to local resources managed at site.	Low probability; Low impact.	Passed
Environmental				
16	There is a risk one or more units may fail during construction which may result in inadequate water levels.	EMP to ensure monitoring and control of downstream water levels. Reservoir level restored to allow spill after Right Abutment Stage 2 completed.	High probability; High impact, but declines after first unit in service.	Passed

No.	Risk Event	Control and Mitigation Strategy	Description of Residual Probability and Impact	Status
17	There is a risk of an environmental incident during construction which may result in negative impacts to the environment, regulatory penalties, schedule delays, increased costs, and negative effects on BC Hydro's reputation.	Develop a comprehensive EMP to provide for sufficient monitoring, conduct regular reviews, and implement preventative and containment measures.	Low probability; Medium impact.	Passed
Operation Phase				
18	There is a risk of a safety event involving operation staff, due to inadequate training, which may result in worker injury or fatality.	Provide training and require appropriate manuals and information in supply contracts.	Low probability; High impact.	Passed
19	There is a risk of an environmental event, due to improperly functioning equipment, which may result in negative impacts to the environment, regulatory penalties, schedule delays, increased costs, and negative effects on BC Hydro's reputation.	Implement testing and monitoring procedures. Vendor warranties apply to equipment function	Low probability; Medium impact.	Passed
20	There is a risk of inefficient operations, due to inadequate performance requirements, which may result in worker injury or fatality.	Vendor warranties apply to equipment function. Warranties and functionality assessed as adequate during design and procurement processes.	Low probability; Impact varies with degree of performance gap.	Passed

No.	Risk Event	Control and Mitigation Strategy	Description of Residual Probability and Impact	Status
Costs Previously Un-assigned to Project				
21	There is a risk that unplanned items are incurred by the Project and that the aggregate of these events may result in Project cost increases exceeding the Expected Amount. One such event to date is the re-introduction of the British Columbia Provincial Sales Tax (**PST**).	Review and proper identification of PST-applicable scope. BC Hydro is determining the impact of the return to PST, and these costs are not reflected in current forecasts.	High probability; Moderate impact.	Passed
22	Impact Benefit Agreement (**IBA**) costs were not included in the Expected Amount at the time of the CPCN Application.	Negotiations resulting in a fair and equitable IBA for both parties.	High probability; Moderate Impact	Passed
Risks Encountered during Construction				
23	Construction interdependencies. Construction activities will depend on timely completion of prior tasks. Delays will have ripple effects, and the schedule impact may not be recoverable	Parallel work sequences if possible, allow adequate schedule float, on-going progression monitoring with contractors	Powerhouse: Moderate probability; impact varies by event Spillway: Moderate probability; high impact due to sequential nature of spillway construction	Passed

Risk Status:

Identified: Risk has been identified and assessed, and no specific response has been prepared; risk will be monitored until specific response is required or risk can be closed.

Treated: Specific plans have been developed or actions taken to manage the risk; risk will be monitored to ensure that treatment plan is effective.

Retained: Risk has been deliberately retained.

Active: Risk event has occurred, and risk management response is in process.

Passed: Exposure to risk event has ended (as at December 31, 2019).

Risk No. 21 and No. 22 in the table above were cost risk items not identified during the planning phase of the Project.

12 Photographs

Figure 1 Spillway Concrete Steps (Before)

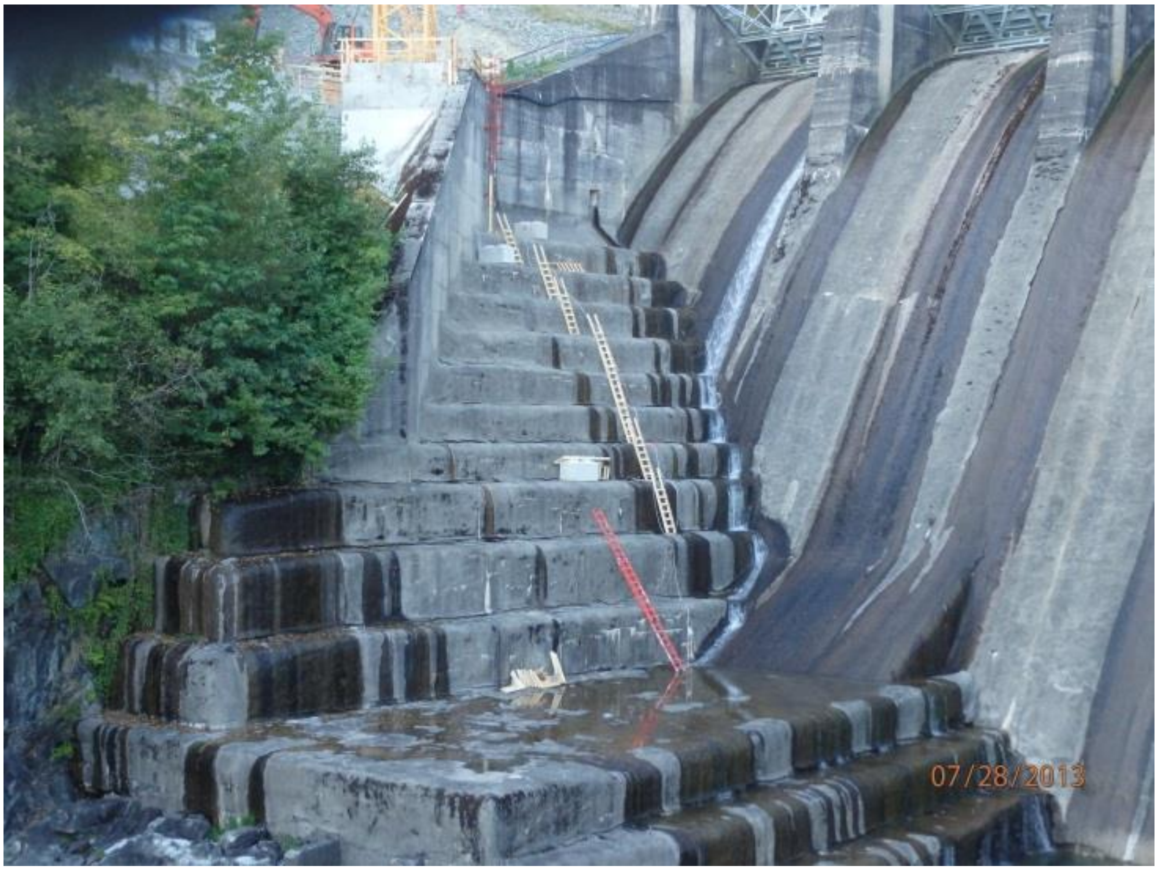


Figure 2 Spillway Concrete Steps (After)

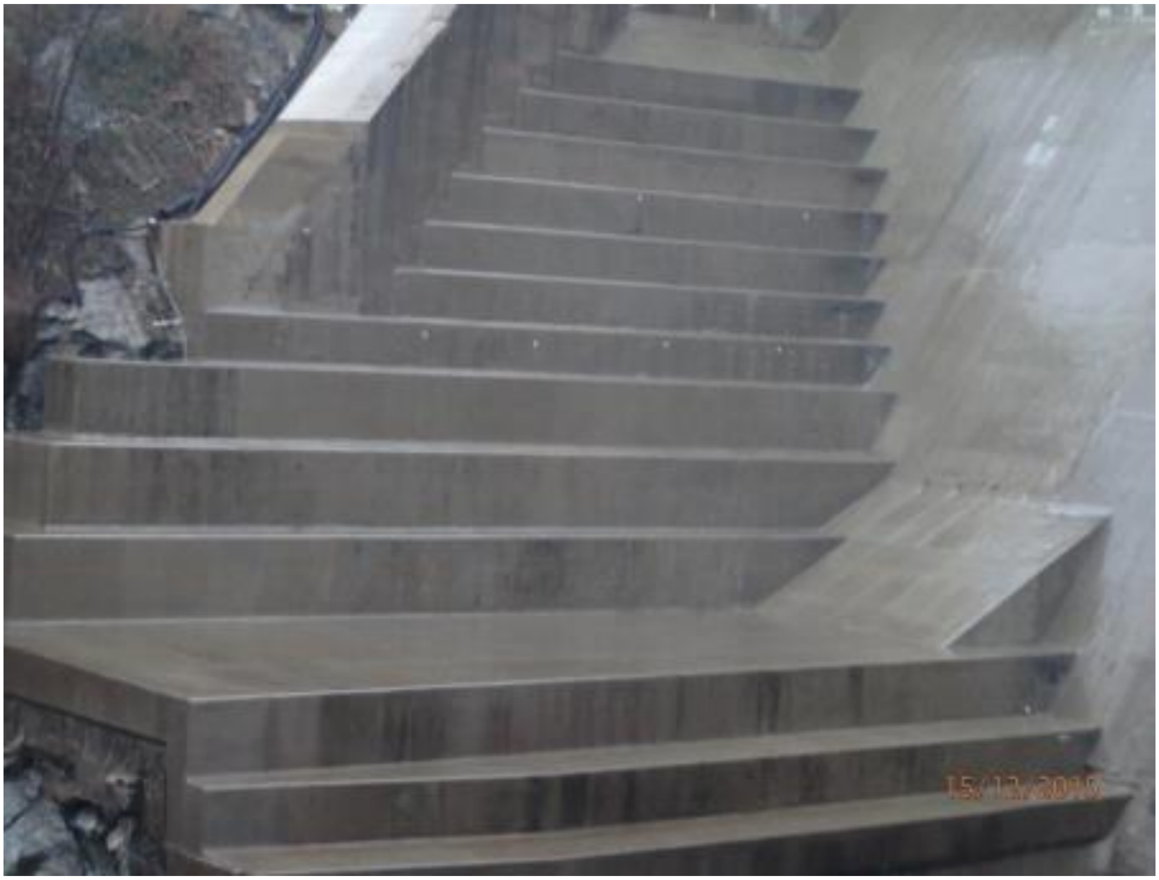
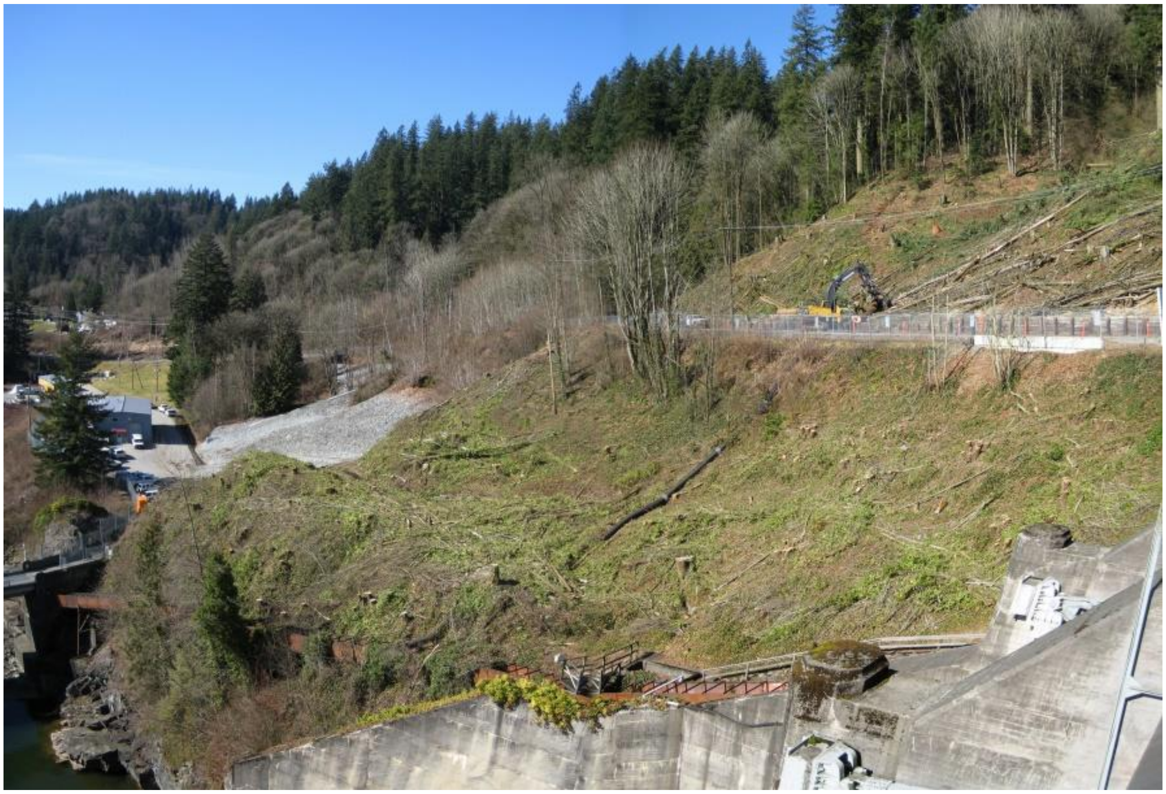


Figure 3 Right Abutment Lower Slope (Before)



1 **Figure 4 Right Abutment Lower Slope (After)**

Figure 5 Powerhouse Roof Switchyard (Before)

Figure 6 Powerhouse Roof (After) - Switchyard relocated

Figure 7 New Switchyard

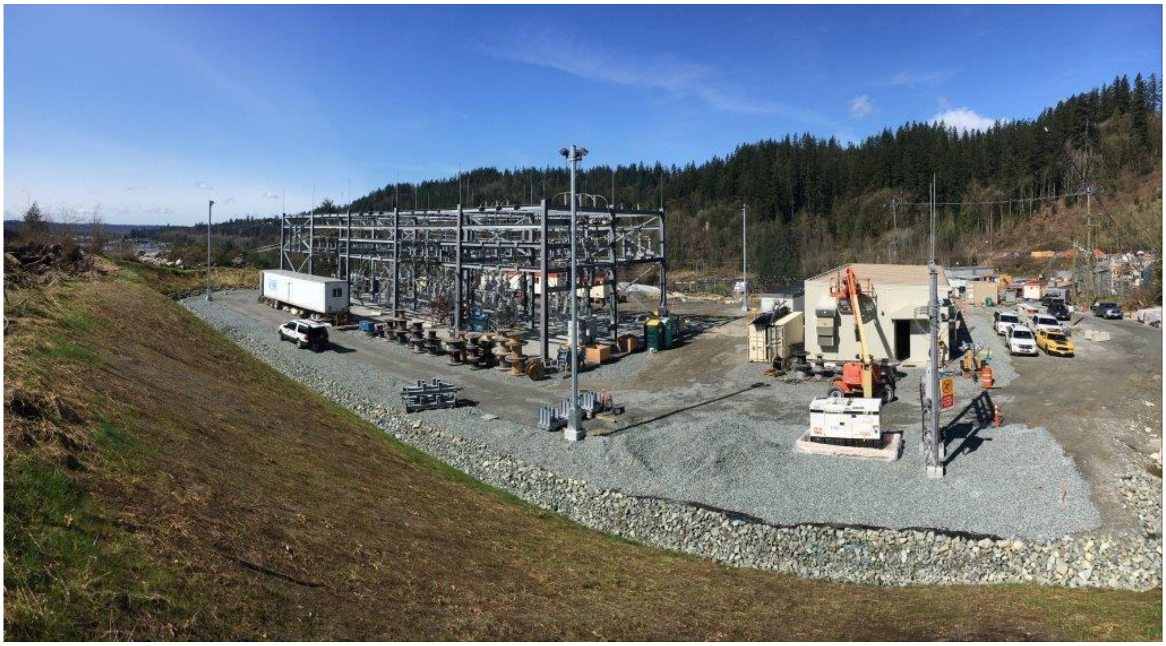
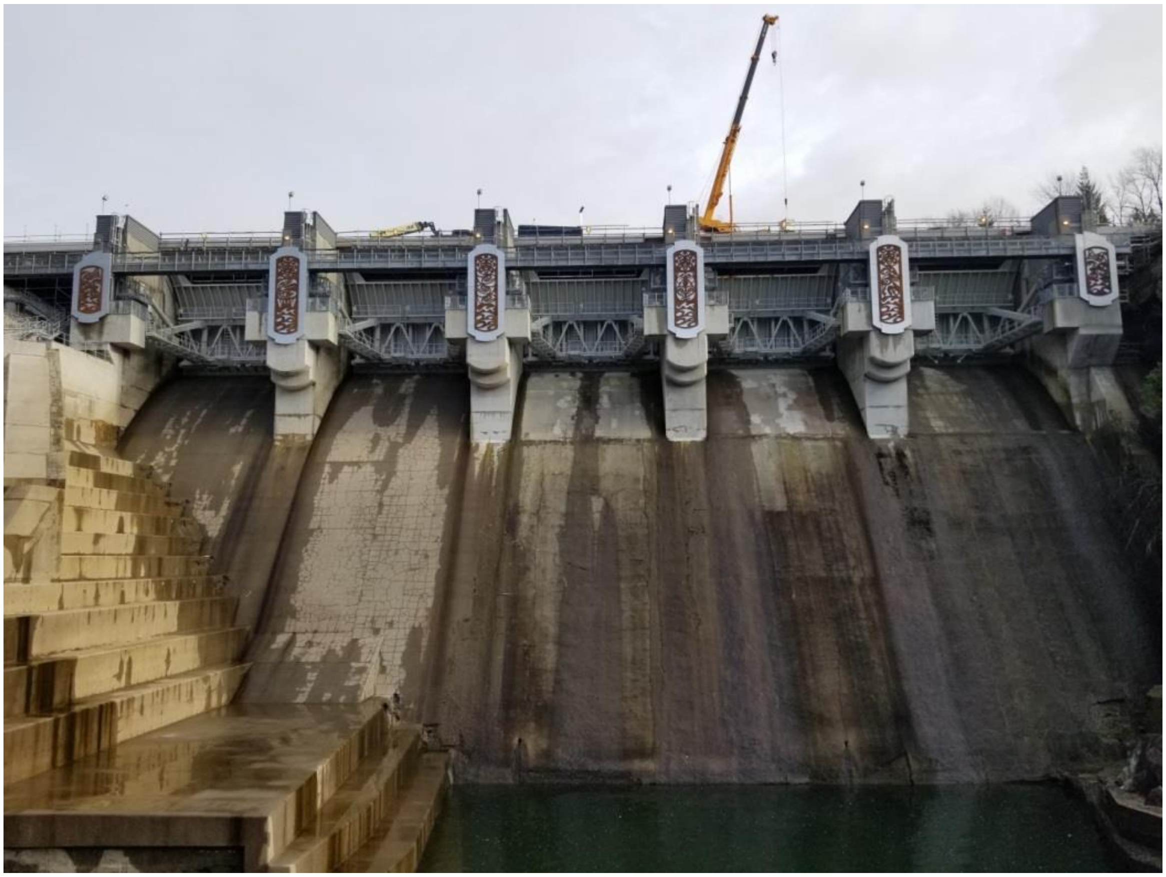


Figure 8 Upper Dam with New Spillway Piers and Gates



Ruskin Dam and Powerhouse Upgrade Project

Final Completion Report

Appendix A

Project Impacts and Benefits Tabulation

The facility is delivering the target benefits of the Project which is tabulated below.

Table A-1 Project Benefits Tabulation

Impact/Benefit Name	Project Objective	Asset Component	Baseline Value	Forecast or Estimated Value	Actual Value Measured
Meet modern seismic, safety and reliability Requirements	Reduce Dam Safety Risk	Dam – Right Abutment	1 in 475	1 in 10,000	1 in 10,000
		Dam – Left Abutment	Less than 1 in 2,475	1 in 10,000	1 in 10,000
		Spillway Piers	1 in 100	1 in 10,000	1 in 10,000
		Intake Gates	Less than 1 in 2,475	1 in 10,000	1 in 10,000
	Meet Flood Discharge Reliability Principles	Spillway Gate System	No	Yes	Yes (draft)[1]
Improve Seismic Performance	Improve Plant Safety	Powerhouse Superstructure	Less than 1 in 2,475	1 in 2,475	1 in 2,475
Improve Units Efficiency	Dependable Capacity[2]	Turbine and Generator (Unit 1,2 and 3)	105 MW	114 MW	109 MW
Improve Units Reliability	Restore Equipment Health (Unit 1, Unit 2 and Unit 3)	Turbine	Unsatisfactory	Good	Good (draft)[3]
		Generator	Unsatisfactory	Good	Good (draft)[3]
		Exciter	Unsatisfactory	Good	Good
		Transformer	Poor / Unsatisfactory	Good	Good
		Circuit Breaker	Fair	Good	Good
		Water Passage / Intake Gate	Unsatisfactory	Good	Good (draft)[3]

1 Performance certification of the Spillway Gate Operating System planned in or prior to June 2020 to confirm final assessment at which time 'draft' will be removed.

2 Dependable Capacity: The amount of megawatts a plant can reliably produce when required, assuming all units are in service. Factors external to the plant affect its dependable capacity. For example, streamflow conditions can restrict the dependable capacity of hydro plants. Planned and forced outage rates are not included. The nameplate capacity of the facility meets the 114MW objective (the turbines and generators can produce 114MW in overall output), but the conditions specified in the dependable capacity analysis limit the dependable capacity to 109MW.

3 Retesting work on the generators and other components planned in March 2020 by Engineering and Asset Management to confirm final assessment at which time 'draft' will be removed.