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Dam Safety Quarterly Report

Executive summary

The purpose of this report is to update the Operations, Planning, Information & Technology Committee of the Board of Directors on key dam risk management activities during the period from October 1 to December 31, 2021 and to provide reasonable assurance that the safety of dams operated by BC Hydro continues to be managed to the established guidelines and criteria of the Dam Safety Program. To keep the Committee as fully abreast of the Dam Safety Program as possible, some notable developments that took place after December 31, 2021 but before the completion of this report have also been included.

The key highlights from F2022 Q3 documented in this report are:

- There were no changes to the Vulnerability Index in Q3.
- There were no new issues identified in Q3.
- Active monitoring of the newly identified St. Cyr Landslide on the east slope of Revelstoke Lake Reservoir has commenced, with some initial installation of displacement monitoring instruments and survey markers and the release of a capital project to install additional instrumentation. See pages 5 and 17.
- Surveillance, regulatory compliance and civil maintenance (preventative, corrective and condition-based) activities are fundamentally on track to complete their planned work programs for F2022. See pages 6-11.
- Program and Contracts Management is forecasting the completion of 67 spillway gate maintenance work orders through the fiscal year, which should approximately offset the number of new maintenance items added through the fiscal year.
- Dam Safety personnel were active during the November and December “atmospheric rivers” and supported BC Hydro’s corporate and regional emergency coordination centres. Dam Safety and Stations Field Operations performed over thirty additional inspections to verify the dam facilities were performing as expected. Dam Safety’s “Event Response Dashboard” was used in a real event for the first time and proved to be a very effective tool for monitoring the status of BC Hydro’s dams and observations and activities of Dam Safety personnel in responding to the event. See page 13.
- The John Hart Dam Seismic Upgrade project submitted the application for approval to the British Columbia Utilities Commission, the detailed design for the civil works was completed and the Request for Proposals for Early Contractor Involvement on that component of the project was issued. See page 16.
- Rock slope stability improvements on the “731 Block” that sits above Revelstoke Dam and Generating Station went into service. See page 17.
- Five new Dam Safety projects were released. See pages 15-18.

Presenter: Bob Schubak, Director, Dam Safety

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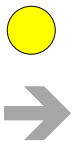
Dam Safety Program Dashboard

The following dashboard provides an overview of the status of the Dam Safety Program. "Traffic lights" provide a qualitative indication of the status of each of five elements of the Program and trend arrows identify whether the status is improving, deteriorating or unchanged. As referenced, these indicators are supported by more detailed metrics and narratives in the report.

Risk Profile and Issues Management		• **Vulnerability Index (pp. 3-4):** The aggregated Vulnerability Index was unchanged through F2022 Q3. • **Program Non-Conformances (p. 4):** The total number was unchanged. • **New and Current Issues (p. 5):** There were no new issues identified in F2022 Q3. Issues from last quarter's report are all under active management or closed.
Regulatory Compliance		• **Operation, Maintenance and Surveillance Manual Updates (pp. 6-7):** Five Manual updates were completed and issued in accordance with the revised work plan. Work is on track to issue the remaining two updates in Q4. • **Dam Safety Reviews (pp. 6-7):** Work is on track to issue the two planned Dam Safety Review reports in Q4.
Surveillance		• **Dam Inspections (p. 8):** 407 of 411 scheduled routine dam inspections were completed in Q3, with 4 inspections missed over the last two weeks of December. Formal dam inspections and reporting are fully on plan. • **Reservoir Slopes (p. 9):** All 17 reservoir slopes inspections scheduled for F2022 have been completed and preparation/completion of reports is on plan.
Maintenance and Testing		• **Civil Maintenance (pp. 10-11):** Condition-based maintenance progressed essentially on plan. Preventative maintenance caught up significantly over Q3 and 94% completion is forecast for year-end. • **Spillway Gates (pp. 11-12):** All 201 scheduled gate tests were completed, and no gates failed to operate on demand. The number of outstanding maintenance work orders decreased slightly over Q3. The year-end forecast of 67 work orders to be completed is expected to just offset the number of maintenance work orders added through the year.
Projects and Investigations		• **Capital Projects (pp. 15-19):** Five new projects were released in Q3. The application for approval of the John Hart Dam Seismic Upgrade Project was filed with the British Columbia Utilities Commission. Rock slope stabilization works on the 731 Block above Revelstoke Generating Station were put into service. • **Deficiency Investigations (pp. 19-20):** An update to the Probable Maximum Flood at Cheakamus Dam is expected to resolve concerns regarding overtopping of the dam in an extreme flood.

Legend:		All areas within the Program element are being implemented to a satisfactory level. Minor, isolated issues may exist but are not deemed to be indicative of deteriorating performance.
		One or more areas within the Program element exhibit or are at risk of underperformance and are being monitored.
		One or more areas within the Program element exhibit unsatisfactory performance and require correction.
		Status of the Program element has improved over the quarter.
		Status of the Program element was unchanged over the quarter.
		Status of the Program element deteriorated over the quarter.

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Risk Profile of BC Hydro's Dams

Dam Safety Contribution to Enterprise Risk

Dam Safety is assigned a high "risk priority" within BC Hydro's Enterprise Risk report. Please refer to that report for additional details.

Vulnerability Index Update

Identified physical deficiencies in BC Hydro's dams and the degree of concern that exists with respect to their impact on the integrity and performance of the dam are characterized by the Vulnerability Index. The higher the value of the Vulnerability Index (scale of 0-10), the higher the likelihood of that deficiency leading to poor performance. The Vulnerability Index for each identified issue at each dam site is shown in Figure 1. Vulnerability Indices for the individual deficiencies are aggregated into stacked bars for each dam, and dams are sequenced from left to right in order of increasing downstream consequences per the BC Dam Safety Regulation. Changes in Vulnerability Index for actual and potential deficiencies (including those related to spillway reliability), aggregated across the entire fleet of dams, are tracked on a quarterly basis and shown in Figure 2. No Vulnerability Index changes relating to identified physical deficiencies were made in F2022 Q3.

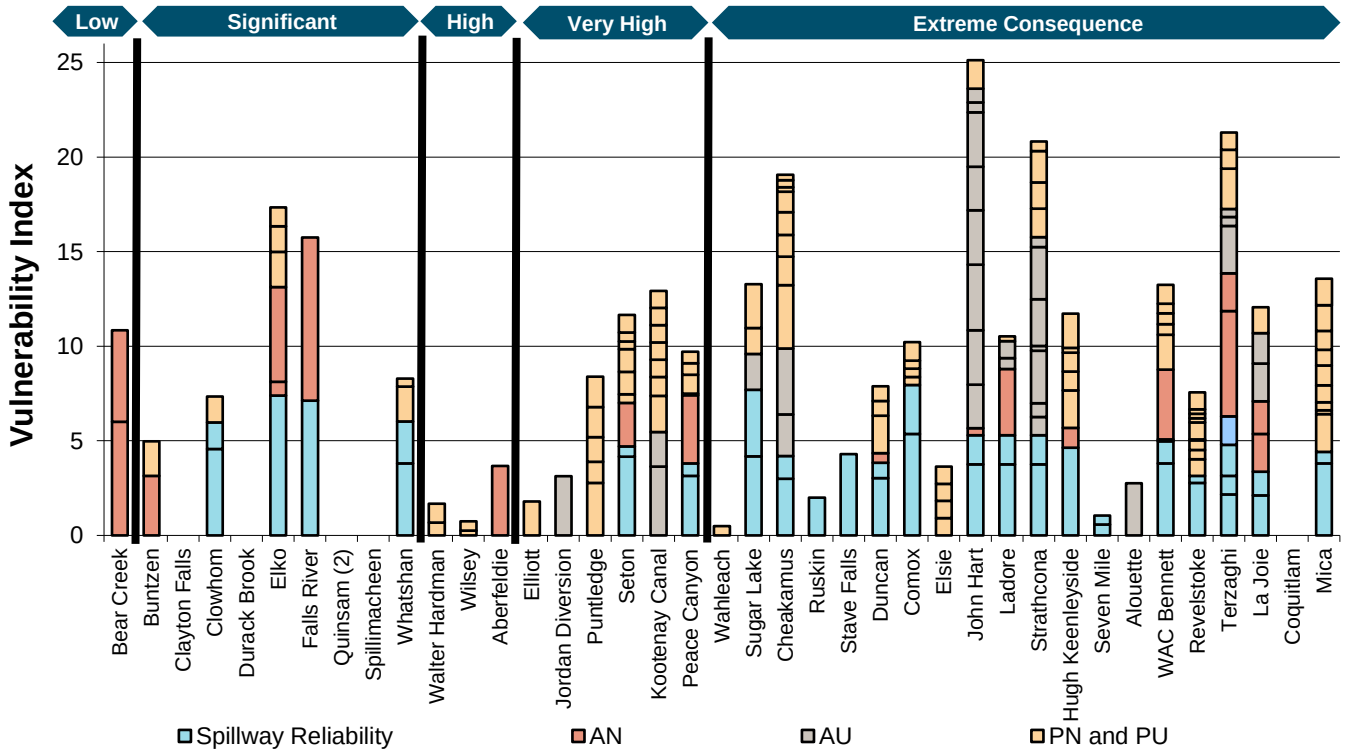


Figure 1 Dam Safety overall risk profile at the end of F2022 Q3, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

AN	***Actual*** deficiency (demonstrated to exist) under ***normal*** load conditions
AU	***Actual*** deficiency (demonstrated to exist) under ***unusual*** load conditions
PN and PU	***Potential*** deficiency (requiring further investigation to demonstrate existence) under either normal or unusual conditions
Spillway Reliability	Actual or potential deficiency related to operational reliability of the dam's spillway and/or other flood discharge systems

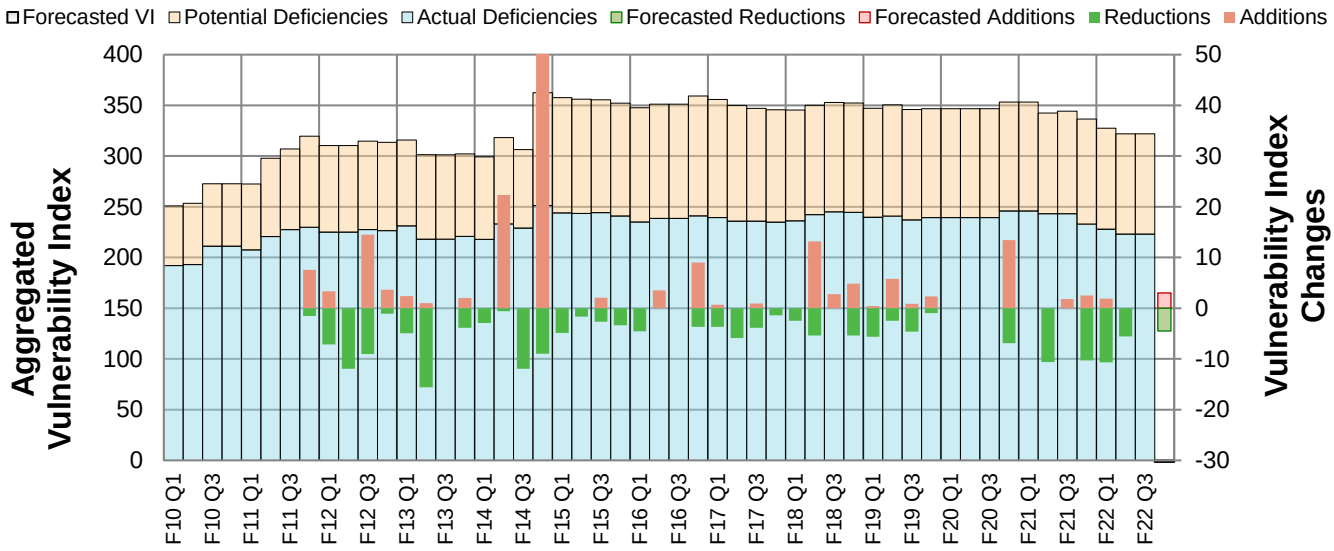


Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

Over the last several years, new issues have added to the aggregated Vulnerability Index at a rate of approximately 12 per annum. Therefore, to prevent deterioration of the overall risk position, reductions in Vulnerability Index through resolved issues should occur at the same pace or faster. Table 1 below confirms that this is presently the case.

Table 1 Trends and forecasts for Vulnerability Index changes in F2022.

		Actual / Forecast	Target	
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	26.5	12	✓
	Reductions – FY forecast	20.7	12	✓
	Additions - Last 4 quarters	4.4		

Non-Conformances in the Dam Safety Program

Activities to identity, review, resolve and close non-conformance issues continued in F2022 Q3, with Issues Database review meetings held for 17 dam sites. Due to high volumes of work, including the completion of the regulatory inspection reports (page 6), contributions to and reviews of five Operation, Maintenance, and Surveillance Manual updates (page 8), and responding to the series of atmospheric rivers in November and December (pages 13-14), the preparation of sealed memoranda by the responsible Dam Safety Engineers to document these reviews was deferred into Q4.

Since these sealed memoranda are required before any changes to the Issues Database are permitted, no changes to the Issues Database – whether relating to identified deficiencies or non-conformances – were made in Q3. The memoranda are being completed and the Issues Database will be updated in Q4.

Dam Safety Quarterly Report

New Issues

No new dam safety issues were identified in F2022 Q3.

Update on Existing Issues

Dam Safety Response to COVID-19

Dam Safety critical work continued through Q3 of F2023 without significant impact. As the Omicron variant took hold, Dam Safety Engineers and Technologists were instructed to resume working and dispatching to dam sites from their homes rather than from their offices to prevent transmission of the virus among Dam Safety personnel.

St. Cyr Landslide

The discovery and verification of the St. Cyr Landslide was described in the F2021 Q4 and F2022 Q2 quarterly reports. In Q3, the work completed at St. Cyr focused on the installation of instrumentation near the toe of the landslide. This included a continuous Global Positioning Station that is similar to those installed as a part of the “Revelstoke – Replace Downie Slide Instrumentation” project described in the F2022 Q2 report, and six survey monitoring points and “tell-tale” markers along the highway. Measurements obtained from these instruments have confirmed the displacement rates identified in the initial slide discovery using the satellite-based radar (InSAR) scanning.

Bimonthly ground inspections of the lower portions of the St. Cyr Landslide were initiated in Q3 to obtain additional landslide parameters and to access and read the displacement monitoring stations described above. During one of these inspections in late December 2021, the extremely cold weather afforded an opportunity to precisely locate a portion of the southernmost extent of the landslide that had previously been obscured by vegetation cover. Where the slide interface “daylights” at the ground surface, relatively warm subsurface air was escaping into the very cold air above, creating highly visible “steam vents”. See Figure 3 at right. These steam vents are not a cause for additional concern; similar phenomena are observed at several other landslides that we monitor around our reservoirs.

Figure 3 Steam vents observed along the southern boundary of the slide area, below the highway.

A new capital project was released in Q3 to further characterize and install instrumentation in the St. Cyr Landslide. Additional details of the released project are provided in the Capital Projects section of this report.

Dam Safety Quarterly Report

Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

During F2022 Q3, Dam Safety contributed to the completion and December submission of the filing for regulatory approval of the John Hart Dam Seismic Upgrade Project and submitted responses to Dam Safety-related Information Requests arising from the Fiscal 2023 to Fiscal 2035 Revenue Requirements Application, the Bridge River projects filing and the Inquiry into the Regulation of Safety.

Work is continuing into Q4 on second rounds of Information Requests for the Fiscal 2023 to Fiscal 2035 Revenue Requirements Application and the Bridge River projects filing, as well as preparations for a March 10 workshop (to be held virtually) on the John Hart Dam Seismic Upgrade Project with the Commission's Panel and registered intervenors.

Regulatory Communications – Comptroller of Water Rights

Regulatory Communications with the Provincial Dam Safety Office consisted of the transmission of hard copy Dam Safety Reviews and Operation, Maintenance, and Surveillance Manuals that had previously been submitted electronically and submittal of five Operation, Maintenance, and Surveillance Manuals, as discussed in the following section. A letter requesting guidance on the authorization process for the John Hart Seismic Upgrade Project under the Dam Safety Regulation and the Water Sustainability Act was sent to the Comptroller of Water Rights.

Operation, Maintenance and Surveillance Manuals

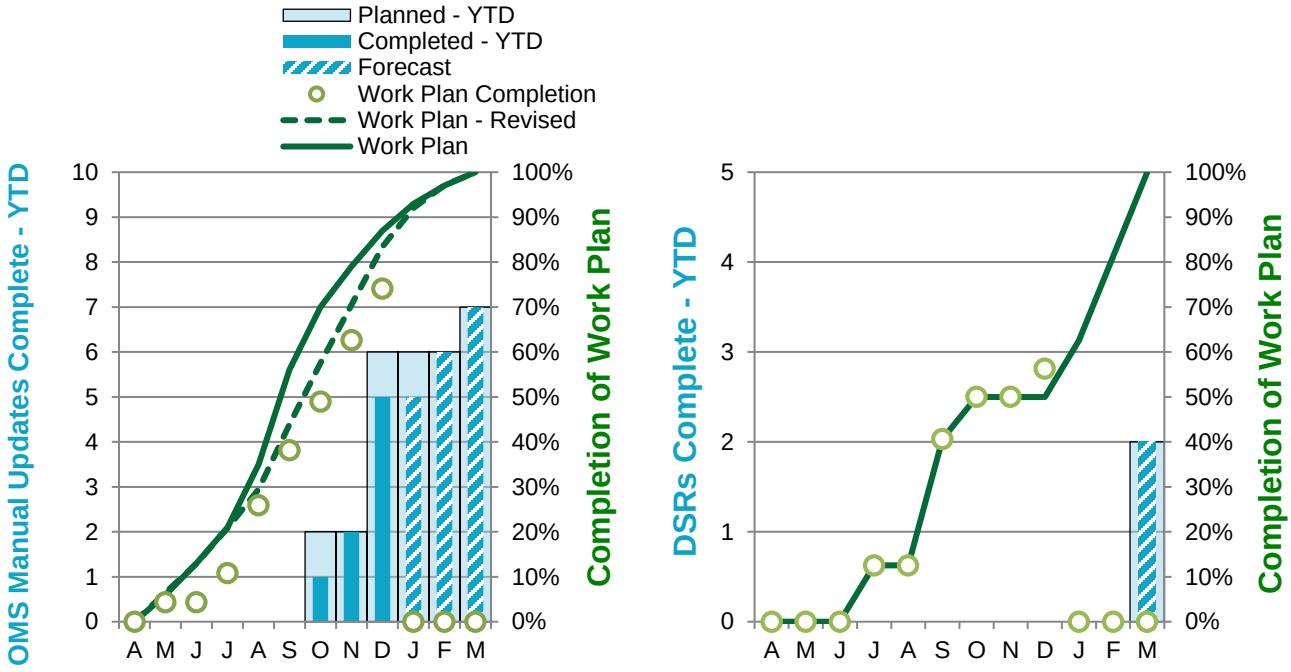
Each dam has an Operation, Maintenance and Surveillance Manual ("Manual") for Dam Safety that identifies responsibilities and expectations within BC Hydro for maintaining the safety of the dam. These Manuals are a requirement under the Dam Safety Regulation and must be updated every seven to ten years, depending upon the dam's failure consequences classification.

There are seven Manual updates planned to be completed in F2022. Five of these Manuals – those for Hugh Keenleyside, Peace Canyon, Puntledge, Strathcona and Sugar Lake Dams – were completed and issued as scheduled in Q3. As reported last quarter, the work plan for delivery of these Manuals was adjusted to smooth out the progression of work through the course of the fiscal year, as shown in Figure 4(a). The remaining Manuals are on forecast for delivery in February (Ladore Dam) and in March (Elsie Dam) in alignment with the revised schedule.

Dam Safety Reviews

Dam Safety Reviews are carried out at minimum intervals of every five to ten years for dams that are classified in accordance with the Dam Safety Regulation as High, Very High and Extreme consequence dams.

The work and delivery plans for the Dam Safety Reviews are shown in Figure 4(b). The Dam Safety Reviews for La Joie and Seton Dams are progressing on plan and are forecast to be completed in March of 2022.



(a) Operation, Maintenance and Surveillance Manual updates

(b) Dam Safety Reviews

Figure 4 F2022 work and delivery plans for (a) Operation, Maintenance and Surveillance (OMS) Manual updates and (b) Dam Safety Reviews (DSRs).

Surveillance

Key activities comprising dam safety surveillance include inspections, monitoring of instrumentation and quality control of data, and characterization of dam performance. Table 2 below provides key metrics regarding these activities, which are described in the following sub-sections of the report.

Table 2 Dam safety inspections and surveillance activities.

		Quarter Q3		Year-To-Date	
		Actual	Plan	Actual	Target
Routine dam inspections	Completed	407/411 = 99%	100%	1226/1233 = 99.4%	99.5% ✘
	Missed	**4**		**7**	
Formal (annual and semi-annual) dam inspections	Field work completed	23	17	72	72 ✓
	Reports issued	10	21	35	31 ✓
Instrumentation data checks		200/195 = 103%	95%	585/585 = 100%	95% ✓
Reservoir Slopes inspections	Field work completed	9	5	17	17 ✓
	Reports issued	4	4	4	4 ✓

Dam Inspections

Routine Inspections

Routine weekly and monthly inspections are a regulatory requirement. These visual inspections are carried out by trained inspectors within Dam Safety or Stations Field Operations using checklists prepared by the Dam Safety Engineer. The purpose of these inspections is to identify changing conditions at a dam, reservoir or appurtenant structure that could threaten the safety of the dam.

In Q3, 407 of the 411 scheduled site inspections were completed. All four missed inspections occurred during the last two weeks of December, as noted below:

- Wahleach Dam, week of December 20: A high avalanche hazard along the access road created concerns for worker safety, and Stations Field Operations prudently decided to cancel this inspection with Dam Safety's agreement.
- Kootenay Canal, week of December 20: The assigned inspector had conflicting work requirements and prioritised other assignments.
- La Joie and Terzaghi Dams, week of December 27: The assigned inspector called in sick and the inspections were not re-assigned to another crew member.

As in all instances of missed inspections, the Dam Safety Engineers have discussed these misses with the Stations Field Operations managers and reiterated their importance. Dam Safety is reviewing all missed inspections over the last three fiscal years (albeit only 14 misses out of

approximately 4500 inspections overall) to identify if there are any common or systemic causes that can be corrected.

Formal Inspections

Formal inspections of the dams are regulatory inspections completed by Dam Safety Engineers on a semi-annual or annual frequency, as dictated by each dam's Consequence Classification. These inspections include a comprehensive visual inspection, a review of the monitoring data and an assessment of the condition of the water containment and conveyance structures.

At the end of Q3, work on the formal inspections was slightly ahead of plan. The field work components of all the required inspections were completed and 35 of the 71 inspection reports had been issued with the remaining reports to be issued in Q4.

Instrumentation and Monitoring

Dam Safety Surveillance collects, checks and assesses about two million data points a month. A vast majority of the data is collected and checked against threshold values automatically by the Automated Data Acquisition System. Even though most of the data is checked automatically it is essential that qualified staff review the data regularly to ensure the systems are functioning as expected. The Dam Safety Technologists in each region regularly check instrumentation data plots for all dams to ensure the Automated Data Acquisition System is functioning as expected, identify any unusual trends, and ensure continued accuracy of the data being for ongoing engineering assessment. They are tasked to perform three such checks per week. During Q3, 200 checks were completed on a plan of 195.

Reservoir Slopes

Reservoir Slopes inspections are completed on a frequency ranging from semi-annually to once every 10 years depending on the assessed hazard of the slope. They are typically carried out by the Reservoir Slopes Geologist and the Specialist Dam Safety Engineer for the Upper Columbia Region. The inspections generally consist of a review of all monitoring data and a visual inspection completed from helicopter with boots-on-ground assessment of identified areas of concern.

All 17 reservoir slopes inspections scheduled for F2022 were completed by the end of Q3 despite the challenges of extremely dry conditions on the slopes, active forest fires in the areas to be inspected, and a general lack of helicopter resources throughout the summer. Four reservoir slopes inspection reports have been issued in accordance with the plan. The remaining 13 reports will be issued in Q4.

Unusual Events or Observations

The Dam Safety On Call Person responded to 114 calls in Q3, which included instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications.

The extreme rainfall in the Lower Mainland and on Vancouver Island during the atmospheric rivers in November and December (pages 13-14) caused a number of instruments to exceed their "normal" levels, triggering automated notifications to the Dam Safety On Call Person for further evaluation. In all cases the follow-up assessment indicated that the dam was performing as would be expected and remained in a safe state.

Maintenance and Testing

Civil Maintenance

Table 3 Dam Safety and Generation civil maintenance for F2022.

		Quarter Q3		Year-To-Date	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Work Orders Completed	4	10 ✗	17/22 = 86%	90% ✗
	Spend ($k)	238	29	2,953	2,924
Preventative Maintenance	Tasks Completed	206/177 = 116%	90% ✓	612/722 = 85%	90% ✗

Corrective and Condition-Based Maintenance

Table 3 above indicates that completion of corrective and condition-based civil maintenance projects is lagging the plan with 17 of 22 work orders completed as of the end of F2022 Q3. Of the five outstanding work orders, however, four were substantially complete but with the Work Orders remaining open for contract administration purposes, and the fifth was in a well-progressed state. These high-level metrics notwithstanding, the program remains essentially on track to complete all 30 planned projects on a total budget of $3.6 million.

The Seton Canal forebay detailed inspection was completed in Q3. This project engaged Construction Services to access and clean the concrete and joints of the forebay liner (see Figure 5 at right) and Stations Maintenance Civil Engineering and Dam Safety to perform the inspection. The forebay was dewatered at a specified rate to allow Dam Safety to monitor the effect of water elevation on the measured leakage rates from the forebay, understanding of which may assist in targeting planned future repairs or upgrades to the forebay.

Other condition-based civil maintenance projects completed in Q3 were: the Seton Canal horizontal joint leakage inspection and repair specification; GM Shrum (WAC Bennett Dam) spillway concrete repairs (maintenance portions within capital project work); and the Bear Creek Dam spillway gravel removal investigation and report.

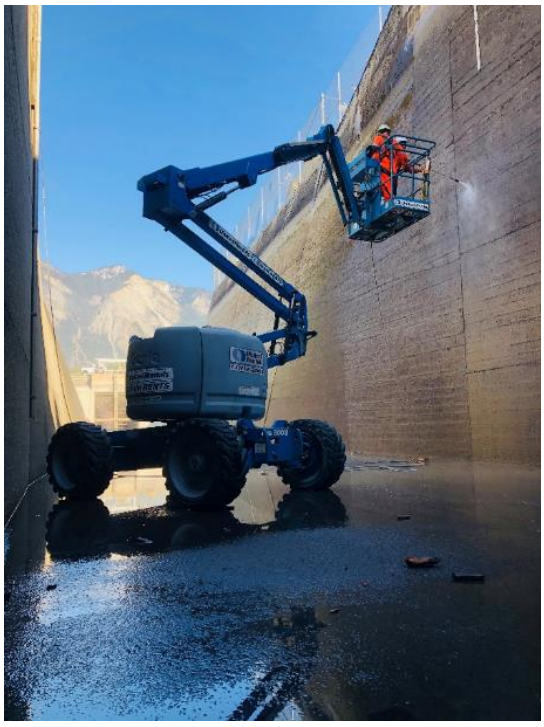


Figure 5 Cleaning the Seton Canal forebay concrete liner prior to inspection.

Preventative Maintenance

In F2022 Q2, Stations Field Operations and Engineering Services completed 206 civil preventative maintenance work orders against a plan of 177. This brings the total through three quarters to 612 against a plan of 722, which is a significant improvement over the results presented in last quarter's report.

Completion of work orders and program spend are on track with the revised plan for civil preventative maintenance that was developed by Program and Contract Management, Stations Field Operations and Engineering Services and presented in last quarter's report. The forecast for the end of the fiscal year is to have completed 761 of the funded inventory of 806 civil preventative maintenance work orders through the course of F2022, which will consitute a very strong completion rate of 94 percent. Through the efforts of Program and Contract Management, Stations Field Operations and Engineering Services, the F2022 targets and objectives for preventative maintenance of dam, reservoir, water passage and generation-related civil assets are now expected to essentially be met.

Spillway Gate Testing and Maintenance

Spillway Gate Testing

Table 4 below provides key metrics related to spillway gate testing. During Q3 of F2022, all 201 scheduled gate test operations at 23 sites were completed, and no gates failed to operate on demand during testing.

Table 4 Spillway gate testing results for F2022.

		Quarter Q3		Year-To-Date	
		Actual	Target	Actual	Target
Monthly Tests	Completed	201/201 = 100%	100% ✓	620/622 = 99.7%	98% ✓
	Missed	0		2	
Gates Failing to Operate on Demand during Testing	No. of failures	0		4	
	Failure rate	0/201 = 0%		4/620 = 0.64%	

Spillway Gate Maintenance

The number of outstanding gate maintenance work orders is shown in the chart in Figure 6. The total number of outstanding work orders decreased from 173 to 164 in F2022 Q3, while the number of "high priority" maintenance work orders has increased from 9 to 15. "High priority" gate maintenance work orders are those where the asset shows moderate to severe signs of deterioration and/or its ability to perform its intended function may be compromised and failure of the asset could lead to loss of reservoir control, albeit with a long intervention time available. The increase of "high priority" maintenance work orders is attributable to one deficiency that was newly identified in Q3 and five that were previously identified but were reassessed as being high priority. (This reclassification is the reason for the negative values for "Other WOs Added" in October and November, which offset positive values of "High Priority WOs Added" from that activity.)

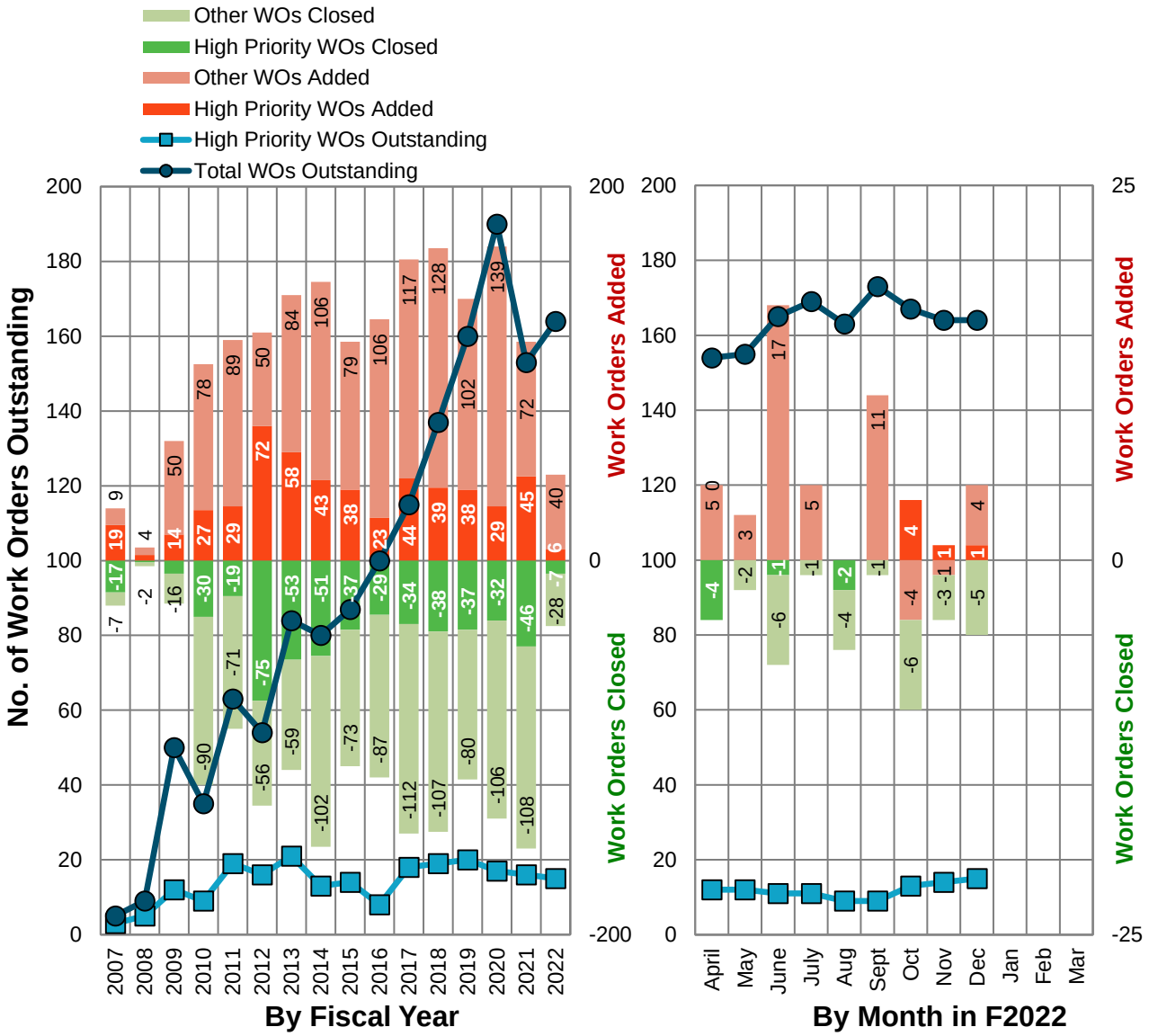


Figure 6 Number of outstanding corrective and condition-based spillway gate maintenance work orders, new work orders added, and work orders closed as at the end of each previous fiscal year and the end of each month in the current fiscal year.

Completion of spillway gate maintenance work orders in Q3 did not improve to the level foreseen in the revised plan that was developed by Program and Contract Management and Stations Field Operations and presented in last quarter's report. The revised work plan had 30 work orders being completed in Q3 for a planned year-to-date total of 52 completions. In comparison, actual completions were 16 over Q3 and, as of the end of Q3, completed spillway gate maintenance work orders stood at 38. There are 29 work orders currently in the plan for completion through Q4 and, at the time of this report's preparation, 19 of those work orders were actively under way. Successful completion of these 29 work orders will result in a total of 67 work orders closed through F2022, which should approximately offset the number of new maintenance items added through the year.

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Emergency Preparedness and Public Safety

Emergency Preparedness is managed by Security & Emergency Management. Dam Safety reports on the updating of emergency plans for compliance with the Dam Safety Regulation as part of annual reporting to the Comptroller of Water Rights. Public safety near dams and reservoirs is managed by the Public Safety team in Safety Engineering & Work Methods. Dam Safety reports on Public Safety activities related to dams during the Dam Safety Reviews. Please refer to the Safety & Emergency Management Quarterly Report, submitted to the Operations, Planning, and Information & Technology Committee, for updates on emergency preparedness and public safety.

November and December 2021 Atmospheric Rivers

Between November 14, 2021 and December 2, 2021, a series of atmospheric rivers brought severe rainfall and snowmelt from high freezing levels to the Lower Mainland, Vancouver Island and the Okanagan, causing widespread flooding and damage to infrastructure. At several BC Hydro dam sites, these storms resulted in inflow volumes and reservoir levels that approached or exceeded historical highs but were nevertheless significantly smaller than the dams' Inflow Design Floods. For example, the peak hourly inflows at Alouette and Stave were approximately one-half of the design flood peak hourly values and the daily inflows were approximately one-third of the design flood daily values; spillway releases at Alouette and Wahleach were less than 20 percent of the design capacity and at Ruskin and Stave were approximately 40 percent of the design capacity. Figure 7 shows photographs of spills during the event at four Lower Mainland BC Hydro dams.

In view of this disparity between inflows and the dams' design bases, there were never any concerns for the dams' safety during these atmospheric rivers. Nevertheless, when a structure such as a dam or spillway is subjected to loads above what it has previously experienced, it is prudent to conduct enhanced surveillance of the structure to confirm its expected performance and safe operation. Dam Safety and Stations Field Operations performed over thirty additional inspections to verify the dam facilities were performing as expected.

During the event, BC Hydro opened regional and corporate emergency centres, which Dam Safety supported by providing input into proposed reservoir operations, identifying and evaluating potential dam safety concerns as conditions changed or new information became available, performing and coordinating visual assessments of dams and spillways, and performing inspections of areas downstream of our dams, such as the Highway 1 crossing at Jones Creek.

The storm event provided the opportunity to use, in a "real-life" situation, Dam Safety's newly developed Event Response Dashboard that was described in the F2022 Q2 report. The dashboard proved to be a valuable tool to record and disseminate information within the group, including the identification of key roles, tracking the status of flood notifications, inspection assignments and helicopter bookings, as well as providing an up to date list of observations. The dashboard was quickly re-configured from its default configuration for earthquake response to provide links to important information used to respond to the storm event, such as real time reservoir levels in the areas of concern.

(a) November 16, 2021 spill of approximately 1500 cubic metres per second (near the event's maximum spill) at Stave Falls (Blind Slough Dam).

(b) November 15, 2021 spill of approximately 1300 cubic metres per second (near the event's maximum spill) at Ruskin Dam.

(c) December 2, 2021 spill of approximately 70 cubic metres per second (about 80% of the event's maximum spill) at Alouette Dam.

(d) November 16, 2021 spill of approximately 50 cubic metres per second (about 50% of the event's maximum spill) at Wahleach Dam.

Figure 7 Spills at BC Hydro dams during the November and December atmospheric rivers.

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Capital Projects

Summaries of Dam Safety Capital projects are available for reference in the Dam Safety "book" in Diligent. This section of the report describes newly launched projects and provides updates for projects where significant developments occurred or milestones were achieved. Five new projects – at Hugh Keenleyside, Lake Buntzen 1, Revelstoke, Seton Canal and Terzaghi – were released in Q3.

Alouette – Improve Headworks Tower and Surge Tower Seismic

The objective of this project is to ensure that the tunnel that conveys water from Alouette Lake to Stave Lake, and the facilities and equipment required to regulate flows through the tunnel and provide active control to the Alouette Lake reservoir, will remain functional following a very severe earthquake with annual exceedance frequency of 1/10,000. The components of the tunnel requiring upgrade include the headworks tower and shaft, the surge tower and shaft, the headworks operating gate, the slopes adjacent to these structures, the power tunnel concrete lining, and mechanical, electrical, protection and control, power supply and communications equipment to support remote operation. The Preferred Alternative to implement these upgrades was endorsed by the Project Gate Review Board in Q3 and, at the time of developing this report, the project was seeking approval from the Board through the Audit, Finance and Capital Committee.

Bridge River 1 – Penstock Concrete Foundation Refurbishment

During the early stages of the project to recoat the four penstocks at Bridge River 1 it was identified that the visible portions of the penstocks' concrete foundations were damaged by cracking, spalling and other defects, and that the bottoms of the penstocks were covered by small rockfall over significant portions of their length. This project was initiated to refurbish the penstocks' concrete foundations and retaining walls and to improve rockfall protection measures in advance of the recoating project.

The project completed Feasibility Design in Q3. The vegetation removal contract was awarded to an environmental services company in partnership with Tsal'alh First Nation, and vegetation removal along the penstocks is planned to be completed in Q4 ahead of the bird nesting season.

Clowhom – Upgrade Spillway Gates and Diesel Generator Control

The objective of this project is to increase the reliability of the spillway gate system at Clowhom Dam for local manual, remote, and autospill operations by replacing the existing gate control equipment with modern equipment, upgrading the power supplies, and other selected gate system components. In Q3 the project was approved to proceed to Definition and Partial Implementation Phase. Partial Implementation will include procurement of long-lead-time electrical panels and telecommunications equipment through existing "blanket" contracts and awarding the first phase of a supply and install contract for other long-lead-time items and planning for full implementation. The intent is to expedite full implementation and award the second phase of the contract when full implementation funding is approved at a later date.

Hugh Keenleyside – Navigation Lock Tower Exterior Coating Restoration

The navigation lock downstream operating gate tower was installed in 1966. The tower is a 114 foot tall structure that straddles the lock and supports the hoisting equipment for operating the

downstream lock gate. A coating inspection completed by Powertech Labs in September 2016 recommended a full strip and recoat of the tower coating to prevent further corrosion from developing on the main steel. This project was released in Q3 to perform that work.

John Hart Dam – Seismic Upgrade

The John Hart Dam Seismic Upgrade project will address seismic deficiencies in each of the dam's component structures and spillway gates and will construct an overflow spillway in the concrete dam section to mitigate flow imbalance risks. The Board approved the project's Preferred Alternative in Q1 of F2020 and authorized the filing of an application for approval of the project to the British Columbia Utilities Commission in Q1 of F2022.

The project submitted the application to the British Columbia Utilities Commission in December. The detailed design for the civil works was also completed in December and the Request for Proposals for Early Contractor Involvement on that component of the project was issued. A workshop with the Commission and Intervenors is Scheduled for March 10, 2022.

Also in Q3, We Wai Kai and Wei Wai Kum signed a Project Agreement that will provide the two Nations with benefits in return for support and consent for this and the other two Campbell River projects currently underway. BC Hydro is currently reviewing a proposal from K'ómoks First Nation for a Nation-led study on cumulative effects.

La Joie – Dam Improvements

The key dam safety issues at La Joie Dam relating to the dam's failing shotcrete facing and seismic deficiencies, currently being managed by a drawdown of the reservoir, and the objectives of this project were described in the F2022 Q2 quarterly report. Also described in that report was the milestone of having received St'at'imc Authority's letter of support for the Alternative to improve La Joie Dam in a manner that can restore the full reservoir operating level. In Q3 the project secured senior management endorsement of this leading alternative and is proceeding into capital-funded work to complete the Conceptual Design Stage.

Lake Buntzen 1 – Penstock Interior Restoration

This project was released in Q3 to strip the old, failed coatings on the interior surface of the Lake Buntzen 1 penstock and recoat it to prevent further corrosion and to extend the penstock's life. The exterior recoating of the Lake Buntzen 1 penstock is already underway and has completed much of the supporting scope, such as access roads and vegetation removal, that will also be required for the internal recoating project.

Mica – Little Chief Inclinometers Installation

Little Chief Slide is located on the right bank of the Kinbasket Lake reservoir approximately 3 km upstream of Mica Dam. This active slide was identified and investigated during the development of the Mica project. Instruments such as inclinometers installed in 2004-2005 have been damaged and are progressively failing due to ongoing slide activity (as expected of instrumentation in such circumstances.) The objective of this project is to install new instrumentation at Little Chief slide to ensure that there is adequate and ongoing monitoring of the slide. The project is expected to follow along similar lines as the Revelstoke – Replace Downie Slide Instrumentation project that is nearing completion, as described in the F2022 Q2 report. Specifically, the project is expected to replace failing piezometers and some portion of the failing inclinometers, and to augment these instruments

with a new deformation monitoring system that uses continuous Global Positioning System (GPS) technology that is not prone to such failure. In Q3 the project was approved to proceed to Feasibility Design stage.

Revelstoke – 731 Block Stability Improvement

This project addresses the rockfall and rockslide risk posed by the 731 Block and the Monument 731A Nose features on the rock slope above Revelstoke Dam and Generating Station. Specifically, improvements are being implemented to stabilize the slopes on these features to reduce the rockfall hazard to the powerhouse (including penstocks 5 and 6), to BC Hydro personnel and to the public using Highway 23, and to improve protection of the anchors that stabilize the 731 Block from any residual rockfall risk or deterioration.

Slope stabilization works including scaling, anchored shotcrete, rock bolting and slope mesh, and excavation of soil overburden above the 731 Block, as well as the installation of shields to protect the 731 Block's anchor heads were put into service in Q3. See Figure 8. Replacement of the anchor head covers with an improved design and replacement of the walkways used for maintenance of the anchors is planned to proceed in Q1 and Q2 of F2023.

Figure 8 Slope stabilization work completed on the 731 Block on the rock slope above Revelstoke Generating Station, as seen from Highway 23 (left) and from above (right).

Revelstoke – St Cyr Landslide

As described in the "Update on Existing Issues" section of this report, an assessment of recent satellite remote sensing, aerial imagery and ground inspections around Revelstoke Dam has identified a large active landslide between St. Cyr and Coursier Creeks. With limited geologic information on the lithology, structure and hydrogeology of the slide area, this project was released in Q3 to carry out a drilling program to install instrumentation to help characterize the behaviour of the slide and collect additional information on the landslide geology. This project was released in Q3 and will leverage learnings from the Replace Downie Slide Instrumentation project and make use of design and contracted drilling resources from the Little Chief Inclinometers Installation project. The findings from this project will help inform future investigations and projects at the St. Cyr Landslide.

Seton – Canal 6-Year Concrete Refurbishment

The Seton Canal is a 3.9 km long concrete lined canal built in the early 1950s that conveys water from Seton Lake to Seton Generating Station. Failed joints and cracks that can lead to leakage from the canal have been observed, and the canal is dewatered every six years to complete a detailed inspection and to refurbish deficiencies of the concrete and joints. The last refurbishment project was carried out in 2017. This project was released in Q3 to plan for and preform the next refurbishment in 2023.

Terzaghi – Low Level Discharge Reliability Improvement

The low level discharge system at Terzaghi was constructed in 1955 and consists of two low level tunnels, each with an upstream maintenance gate and a downstream operating gate. The low level discharge system provides environmental flows to the Lower Bridge River. It is also required for flood passage and for potential reservoir drawdown following a large earthquake. The current low level discharge system at Terzaghi is dated and becoming increasingly unreliable, and the gates can no longer be safely accessed for inspection or maintenance. This project was released in Q3 to improve the long-term reliability and maintainability of the low level discharge system for normal target flow releases, flood passage, and post-seismic drawdown.

WAC Bennett Dam – Sluiceway Plug Installation and Stoplog Replacement

The spillway at WAC Bennett Dam has nine gated sluiceways located directly beneath the three spillway gates, as shown in Figure 9. The sluiceways have not been used since 1987, when operation of the gates was noted to be slow and there were indications of incomplete travel. Since then, inspections have identified progressing deterioration of the sluice gate system. An assessment of the sluiceways and gates identified only minimal potential benefit from their retention and, in light of the continuing deterioration of the gates and increasing hazard of their failure, the alternative to seal the low level outlet passages with reinforced concrete plugs was selected as being preferred.

Figure 9 Sluiceways (outlined) on the spillway of WAC Bennett Dam, as viewed from upstream during construction (at left) and from downstream on the spillway chute (at right).

During Feasibility Design, it was determined that to complete this scope of work the sluice gates must be accessed from upstream, which is currently not possible due to excessive leakage through the existing spillway stoplogs. See Figure 10. As a result, replacement of the stoplogs with an improved design was added to the project's scope.

In Q3 the project received endorsement to proceed to Definition Phase and Partial Implementation. Partial Implementation will include the fabrication in 2022 of a small number of stoplogs using the new design for a trial lifting and handling test with the existing stoplog crane.

Figure 10 At left: a spillway stoplog (blue semi-circular object) being installed at WAC Bennett Dam. At right: excessive leakage through the existing stoplogs as viewed from above.

Dam Safety Investigations

Dam Safety Investigation Projects ("Investigations") are generally performed to either refine knowledge regarding potential issues or non-conformances of information recorded in the Dam Safety Issue Database or to perform precursor work for planned capital upgrade projects. This section provides descriptions of newly launched Investigations and updates for those Investigations where significant developments have occurred or where milestones were achieved.

Cheakamus Dam – Flood Parameters Update and Performance Assessment of the Dam and Discharge Structures

The most recent calculation of the Probable Maximum Flood for Cheakamus Dam dates back to 1983 and is based on outdated information. Under those calculated inflows there would be a potential for overtopping of the earthfill and concrete dams. Further, the performance of the chute slab and side walls of the Emergency Overflow Channel under those conditions is unknown. The objective of this Investigation is to update the flood parameters and assess the discharge and flood-passing performance of Cheakamus Dam and its appurtenant structures. The scope of the investigation includes updating the Probable Maximum Flood for the dam, developing a computational fluid dynamics model to analyze the discharge capacities of the spillways and low level outlet, and assessing the geotechnical and structural performance of the facility during passage of the Probable Maximum Flood.

Dam Safety Quarterly Report

The Probable Maximum Flood simulation and routing has been completed and the report is being drafted. Results show that the Probable Maximum Flood has decreased from its previously calculated value from 1983 and that no overtopping of the dam is expected.

Preliminary computational fluid dynamics modelling indicates that the discharge capacities of the spillway gates and low level outlet are greater than what is currently characterized in those facilities' existing discharge curves and that the low level outlet is not required for safe routing of the Probable Maximum Flood.

On the basis of these preliminary results, completion of this Investigation is expected to lead to the resolution and closure of three information non-conformances and a Potential Unusual deficiency.