

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 July 1 to September 30, 2022 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 September 30, 2022 but before the completion of this report have also been included.

The key highlights from F2023 Q2 documented in this report are:

- The system's aggregated Vulnerability Index remained stable through F2023 Q2, with a small decrease of 1.98 through the quarter. See page 3.
- A rockfall occurred on the Marble Shear Block at Revelstoke Dam, blocking and closing the principal access road to the generating station. Design of a temporary protection berm to allow limited travel on the road is near completion and an emergent project to permanently stabilize the slope is being initiated. See page 5.
- The potential surcharge of Kinbasket Reservoir (Mica Dam) was not realized. The surcharge at Downton Reservoir (La Joie Dam) commenced in August and is being managed through an Interim Dam Safety Risk Management Plan until the reservoir is drawn back down to its normal elevation in mid-November. See pages 6 and 7.
- The failed hinge between two segments of the floating guidewall for the navigation lock at the Hugh Keenleyside Dam has been replaced. See page 7.
- Maintenance on the civil and spillway gate assets progressed well through Q2. Strengthened oversight by Programs and Contract Management and increased collaboration by Dam Safety, Stations Field Operations and Programs and Contract Management in planning of the work continues to yield improved results. See pages 10-13.
- A kinked wire rope on a low level outlet gate at Hugh Keenleyside Dam has been replaced and the gate has been returned to full service. Closure of the database issue and adjustments to the Vulnerability Index for this issue and the gates at Ruskin and Terzaghi Dams returned to service in Q1 are pending. See page 12.
- During the Battleship Mountain wildfire in the District of Hudson's Hope, which occurred while the spillway at WAC Bennett Dam was out of service for upgrades to the concrete structure, Operations and Dam Safety prepared contingency plans to ensure continued flow of water downstream into the Peace River under extreme scenarios of transmission and generation outages. See pages 14 and 15.
- Following the wildfire, additional shifts were added to complete the upgrades to the WAC Bennett Dam spillway before the onset of winter. See page 17.
- Upgrades to the Wahleach Dam access road, damaged in last year's environmental river events, were completed in October. See page 18.

Presenter: Bob Schubak (Director, Dam Safety)

10: Dam Safety Quarterly Report

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 reduced by 1.98 through Q2.
- **Program Non-Conformances (p. 5):** The total number of non-conformances was reduced by 1 through Q2.
- **New and Current Issues (pp. 5-7):** A rockfall at Revelstoke Dam does not threaten the dam or critical infrastructure. A new issue of white sturgeon entering the low level outlets at Hugh Keenleyside Dam and the continuing reservoir surcharge of Downton Reservoir are under active management. Other issues from last quarter have been resolved.

Regulatory Compliance



- **Operation, Maintenance and Surveillance Manual Updates (p. 7):** Work continued to plan on scheduled Manual updates.
- **Dam Safety Reviews (p. 7-8):** Dam Safety Reviews that were scheduled for completion in F2022 but were held in draft for improvements before issuing to the Comptroller of Water Rights remain in progress. F23 Reviews are progressing on schedule.

Surveillance



- **Dam Inspections (pp. 8-9):** All 411 scheduled routine dam inspections were completed in Q2. Formal dam inspections were slightly behind plan but are presently being caught up in Q3.
- **Reservoir Slopes (p. 9):** Reservoir slopes inspections progressed ahead of plan through Q2. No new issues were identified.

Maintenance and Testing



- **Civil Maintenance (pp. 10):** Condition-based and preventative civil maintenance progressed well in Q2.
- **Spillway Gates (pp. 11-13):** All 220 scheduled gate tests were completed. No gates failed to operate on demand. The number of outstanding maintenance tasks decreased by 1 over Q2.

Projects and Investigations



- **Capital Projects (pp. 16-18):** Upgrades to the access road to Wahleach Dam were completed. New reservoir booms at WAC Bennett and Mica Dams were completed. Construction on the WAC Bennett Dam and installation of piezometers on Cheakamus Dam progressed to plan.
- **Dam Safety Investigations (p. 19):** Investigation of the post-earthquake operability of the spillway sluice gate at Alouette Dam was completed.

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.

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. The next page shows a variety of template options for various ways to display your information including bullets, tables, and feature boxes.

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.

There was one notable change in Vulnerability Index in F2023 Q2, as described below and identified in Figure 1.

- 1** A **reduction** of 1.98 (Potential Normal deficiency closed) at **Duncan Dam**.

The F2021 Q4 Dam Safety Quarterly Report described that an area of active seepage and roiling sand had been observed at the western end of the seepage collection ditch at the toe of the earthfill dam. This small, localized area of seepage showed no signs of turbidity or other evidence of internal erosion and was considered to be a result of seepage flows converging around the toe of the ditch. It was treated with the application of a fine sand filter blanket to stabilize underlying sediments while allowing seepage to exit into the ditch. This “reverse filter” has been observed to be performing well and as intended through the full range of reservoir elevations. The area remains marked for quick identification and ongoing inspection, but this issue is now closed.

Over the last several years, new issues have added to the aggregated Vulnerability Index at a rate of approximately 12 per annum. 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; that Vulnerability Index reductions have far exceeded additions over the past four quarters and that forecast Vulnerability Index reductions through F2023 will exceed the target.

Table 1 Trends and forecasts for Vulnerability Index changes in F2023.

		Actual / Forecast	Target	
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	66.2	12	✓
	Forecast Reductions – Fiscal Year	20.6	12	✓
	Additions - Last 4 quarters	16.1		

10: Dam Safety Quarterly Report

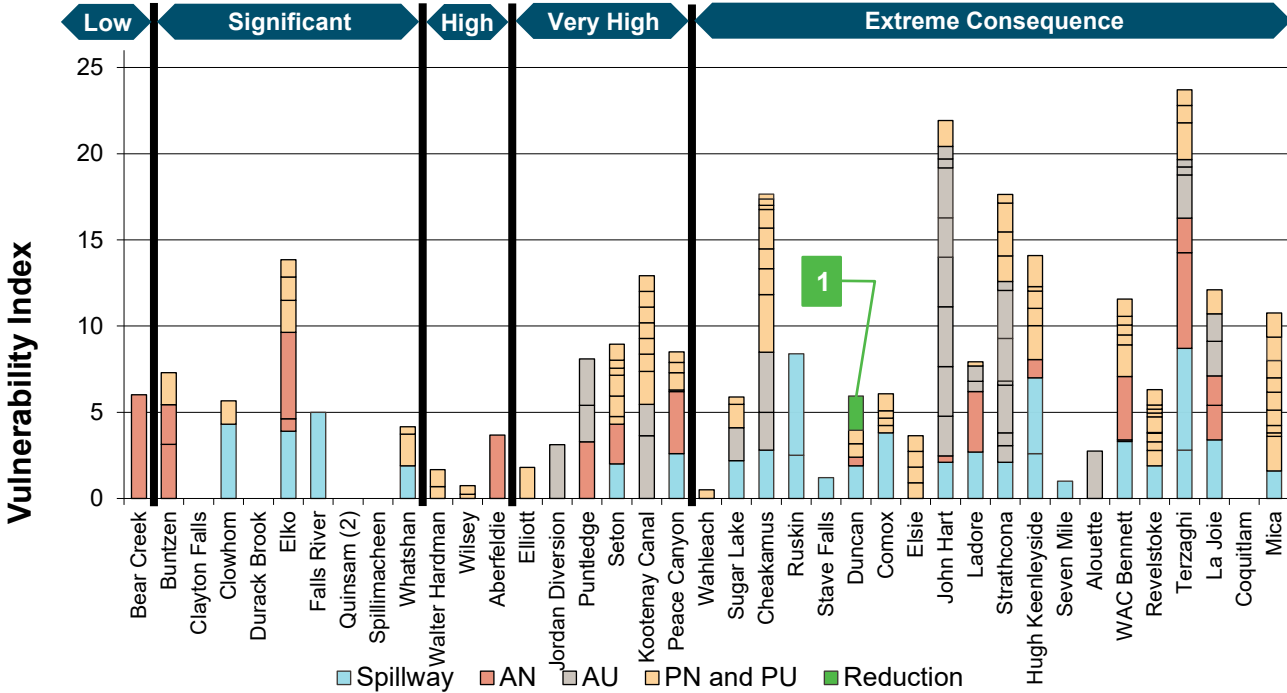


Figure 1 Dam Safety overall risk profile at the end of F2023 Q2, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

- 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

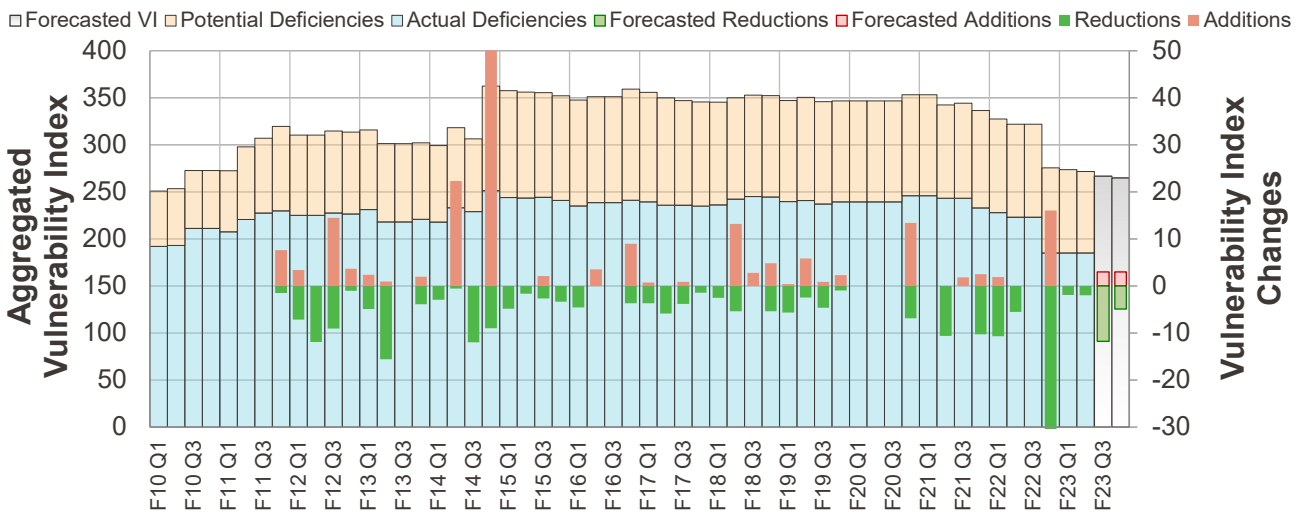


Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

10: Dam Safety Quarterly Report

Non-Conformances in the Dam Safety Program

Activities to identify, review, resolve and close non-conformance issues continued through F2023 Q2. Scheduled reviews of the existing issues in the Dam Safety Issues Database were completed for 16 dams. Due to prioritization of other work, as described under “Surveillance” on page 8, documentation of the reviews is ongoing and changes to the Database remain pending with only one non-conformance issue being closed in Q2. There are currently 376 outstanding non-conformance issues in the database.

New Issues

Revelstoke Dam – Rockfall on Marble Shear Block

A rockfall occurred into the main parking lot at Revelstoke Generating Station at approximately 2:00 am on the morning of October 5, 2022. Comprising approximately 350 cubic metres of rock, the rockfall occurred on a feature known as the Marble Shear Block, over which the dam’s spillway is routed and below which is the principal access road to the generating station. Nobody was in the vicinity at the time and there were no injuries. The rockfall and potential instability of adjacent surfaces poses no threat to the dam, spillway or other critical infrastructure at the site, as instrumentation within the Marble Shear Block conclusively shows that there has been no global movement or instability of the Block. The access road to the generating station is partially blocked, however, and the road is closed. Access via the Visitor’s Centre and parking on the powerhouse roof remains open. See Figure 3, below, for photos showing the location and extent of the rockfall.



Figure 3 Rockfall on the Marble Shear Block at Revelstoke Dam and Generating Station. At left: the location of the rockfall as viewed from above the spillway. At right: view of the rockfall onto the access road and main parking lot of the generating station.

Dam Safety has established monitoring of the slope above the road through daily point cloud laser surveys, drone surveys, and inspections of the slopes above for signs of potential progressive failure. Engineering is presently completing designs for a temporary protective berm, composed of lock blocks and rock, to be constructed along the road centerline, that would contain a similar rockfall and allow one lane of the access road to be opened up for safe delivery of essential equipment and materials to the station. Construction will be sequenced such that construction crews will always be working behind the constructed protective works and not be directly exposed to the rockfall hazard. This work is being

10: Dam Safety Quarterly Report

funded under the Dam Safety Investigations budget while an emergent project is being initiated to design and implement permanent stabilization of the rock slope.

Hugh Keenleyside Dam – White Sturgeon in Low Level Outlets

White sturgeon, an Endangered Species under the Federal Species at Risk Act, are known to occupy the tailrace of Hugh Keenleyside Dam to feed on kokanee salmon during the period when kokanee are aggregating in the tailrace prior to spawning. Since the middle of August of 2022, white sturgeon have been observed to be entering the dam's low level outlet ports, downstream of closed operating gates not conveying water. Sturgeon swim into the low-level outlets and when they reach the closed gate, swim up the operating gate slot to access the top of the gate, where they have been observed. If the low level outlet port's gate were opened, either for operational water conveyance or monthly gate testing, the fish would be subjected to considerable water turbulence and vulnerable to injury or mortality.

In immediate response:

- Gate testing scope was modified to exclude gate movements, i.e., only testing control and power supply components of the system up to the point of gate actuation; and
- During normal operational flow releases, only low level outlets without sturgeon visibly present were used to pass water required for Columbia River Treaty obligations until spills could be transferred to the spillways in mid-September.

A plan for interim operations was also developed and communicated to the Department of Fisheries and Oceans whereby weekly visual monitoring of sturgeon presence within the low level outlets was performed to understand how it changes over time as water temperatures cool, and a gate operation protocol was developed and tested on gates where sturgeon were not present to determine the feasibility of flushing the fish from the low level outlets prior to gate operation for operations and testing. BC Hydro is coordinating with the Department of Fisheries and Oceans for a demonstration and acceptance by that agency prior to putting this approach into operation. Updates will be provided in future reports.

Update on Existing Issues

Mica Dam – Potential Kinbasket Reservoir Surcharge

The F2023 Q1 Dam Safety Quarterly Report noted that the June 1, 2022 residual water supply forecast for Kinbasket Reservoir was 130% of normal, with a 30-50% probability of exceeding the Normal Maximum Reservoir Level (i.e., "surcharging") and/or spilling. Kinbasket Reservoir peaked in elevation in early September and has since maintained elevations between 1.2 metres and 1.7 metres below the Normal Maximum Reservoir Level. Surcharge and/or spilling was not required and is not expected to be through the remainder of this year. This issue is now closed.

La Joie Dam – Downton Reservoir Surcharge

As was forecast in the F2023 Q1 Dam Safety Quarterly Report, Downton Reservoir rose to an elevation above the current Normal Maximum Reservoir Level of 734.0 metres on August 12, 2022 and continued to rise to a peak elevation of 738.7 metres on September 5, 2022. The reservoir has receded since then but remains in surcharge and is expected to remain so until approximately mid-November. Generation System Operations is managing the elevation of Downton Reservoir along with Carpenter Reservoir under the requirements of an Interim Dam Safety Risk Management Plan to protect against the risk of a cascading failure of Terzaghi Dam in the unlikely event of a failure of La Joie Dam following a major earthquake.

10: Dam Safety Quarterly Report

Hugh Keenleyside Dam – Floating Guidewall Hinge Failure

Last quarter it was reported that, on April 7, 2022, one of the hinges connecting pontoons 3 and 4 of the navigation lock floating guidewall at Hugh Keenleyside Dam had failed and a frame had been installed to temporarily brace the failed hinge until a replacement hinge could be fabricated and installed. The replacement hinge was installed on August 15, 2022, ahead of schedule. This issue is now closed.

Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

The application to the British Columbia Utilities Commission for the John Hart Dam Seismic Upgrade Project continued into F2023 Q2. Just prior to the Commission issuing its schedule for the remainder of the application proceedings, BC Hydro received responses to its Request for Proposals on the civil works portion of the project. On the basis of these proposals, BC Hydro determined that an updated project cost estimate would be required and informed the Commission. BC Hydro submitted the updated cost estimate to the Commission on October 25, 2022 and is anticipating a third round of Information Requests pertaining to the updated costs.

Regulatory Communications – Comptroller of Water Rights

Regulatory Communications with the Provincial Dam Safety Office in F2023 Q2 consisted of the submission of a request for approval to install new instrumentation at Cheakamus Dam and receipt of a letter from the Comptroller of Water Rights providing guidance on the authorization process to be used for the John Hart Dam Seismic Upgrade Project.

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 required by the Dam Safety Regulation and must be updated every seven to ten years, depending upon the dam’s failure consequences classification.

Updates to seven Manuals are scheduled to begin in F2023 and five are scheduled to be issued this fiscal year, with the first of these in Q3. Work on six Manuals – for Revelstoke Dam, Cheakamus Dam, Comox Dam, Stave Falls Dam, Ruskin Dam, and Kootenay Canal – progressed on plan in Q2.

Dam Safety Reviews

Dam Safety Reviews are independent, systematic reviews and evaluations of all aspects of a dam’s physical condition, design, construction, operation, maintenance, processes, and other systems affecting the safety of the dam. Performed by external consultants, they 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.

As of the end of Q2, the Dam Safety Review of Wahleach Dam had been completed ahead of schedule. Two other Dam Safety Reviews (La Joie Dam, Seton Dam) that were scheduled for completion in F2022 remained in progress, their reports requiring an additional round of revisions prior to being issued. The Dam Safety Review of Terzaghi Dam remains on track for completion and issuing of the report in Q3. The Dam Safety Review of Elsie Dam commenced in Q2, with the site visit held at the end of August and review of the hazards and failure modes performed in September. The report is scheduled for completion in Q4. The Dam Safety Review of Ruskin Dam will be started in Q3 and will be completed in F2024.

10: Dam Safety Quarterly Report

Surveillance

Dam Safety Surveillance has been working to fill several vacancies in the Peace River and Lower Columbia regions. The combination of new employees and yet-to-be-filled vacancies has temporarily diminished the department's capacity and, through Q2, required reprioritization of some work to account for that. With highest priority given to ensuring the safe operation of dam facilities including responding to emerging issues and supporting time-critical regulatory updates of Manuals, Dam Safety Reviews and Emergency Action Plans, several activities with less acute regulatory deadlines (e.g., completion of formal inspections and reports) and non-regulatory work (e.g., re characterization of issues in the Dam Safety Issues Database) have been deferred to later in the year.

Table 2 Dam safety inspections and surveillance activities.

		Quarter Q2		Year-To-Date	
		Actual	Target	Actual	Target
Routine dam inspections	Completed	411/411 = 100%	100%	822/822 = 100%	99.5% ✓
	Missed	0		0	
Formal (annual and semi-annual) dam inspections	Field work completed	8	35	43	55 ✗
	Reports issued	6	10	7	10 ✗
Instrumentation data checks		197/195 = 101%	95%	396/390 = 102%	95% ✓
Reservoir slopes inspections	Field work completed	9	12	17	16 ✓
	Reports issued	7	4	7	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 Q2, all of the 411 scheduled site inspections were completed.

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. The Dam Safety Engineers are required to complete 71 of these inspections and reports annually. As of the end of Q2, due to the capacity limitations described above, the field work for 43 inspections had been completed and seven inspection reports had been issued, lagging the planned completion of field work at 55 sites and 10 inspection

10: Dam Safety Quarterly Report

reports issued. Since then, the field work for an additional 20 inspections was completed through October, and the remaining eight field inspections are expected to be completed through November.

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. 197 of these checks were completed in Q2, which is slightly above the target 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.

The field work for nine reservoir slope inspections was completed and seven engineering reports documenting the performance of the slopes were issued in F2023 Q2. The slopes program is ahead of plan for both the field and reporting components. No new landslide issues were identified.

Unusual Events or Observations

The Dam Safety On Call Person responded to 40 calls in Q2, which typically includes instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications. This number of calls and responses is lower than typical, likely due to the dry conditions and low reservoir levels. None were sufficiently noteworthy for inclusion in this report.

Maintenance and Testing

Civil Maintenance

Civil maintenance on Dam Safety and Generation assets progressed well in F2023 Q1, per Table 3 and the following narrative.

Table 3 Dam Safety and Generation civil maintenance for F2023.

		Quarter Q2		Year-To-Date	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Spend (\$k)	1,332	1,428	2,248	2,792
	Work Orders Completed	13	12	13/12	
Preventative Maintenance	Tasks Completed	238	349	355/479 = 74%	

10: Dam Safety Quarterly Report

Corrective and Condition-Based Maintenance

The corrective and condition-based civil maintenance program is on track for completion in F23. As of the end of Q2, thirteen projects had been completed compared to a plan of twelve. Of a total of 32 projects to be delivered through the year, field work was substantially complete on 19 projects and underway on eight others.

One maintenance project of interest took place at Cheakamus Dam. Various areas of the concrete dam are deteriorating due to alkali aggregate reactivity, as shown in Figure 4 at right. Repairs were made at two of the locations – areas 2 and 6 – and included trial applications of two products that are intended to mitigate the ongoing chemical reaction that is leading to the deterioration. These areas will be monitored for effectiveness of the treatment.



Figure 4 Drone photo showing areas of Cheakamus Dam where concrete is deteriorating due to alkali aggregate reactivity.

Preventative Maintenance

As of the end of Q2, Stations Field Operations and Engineering Services had completed 355 preventative maintenance tasks against a plan of 479, for a 74% completion rate year-to-date. Progress was better than is indicated by the absolute number of completed tasks, however, with approximately 130 additional tasks that were in flight. Of these in-flight tasks, a significant portion had completed the field work (inspections) and reports were in preparation.

Spillway Gate Testing and Maintenance

Spillway Gate Testing

During Q2 of F2023, all 220 scheduled gate tests at 23 sites were completed, including annual gate tests at three of those facilities. No gates failed to operate on demand during testing. Table 4 below provides key metrics related to spillway gate testing.

Table 4 Spillway gate testing results for F2023.

		Quarter Q2		Fiscal Year F2023	
		Actual	Target	Actual	Target
Monthly Tests	Completed	220/220 =100%	100% ✓	415/415 =100%	98% ✓
	Missed	0		0	
Gates Failing to Operate on Demand during Testing	No. of failures	0		2	
	Failure rate	0/220 =0%		2/415 =0.5%	

10: Dam Safety Quarterly Report

Exceptions to Gate Testing Program

Gate testing scopes were reduced to exclude gate movements on four gate systems for reasons described below:

- At W.A.C. Bennett Dam, testing excluded gate movements to accommodate concrete structure upgrade work in the spillway chute.
- At Duncan Dam, testing excluded gate movements as one of the two low level outlet gates is used for fish counting/transferring in the summer.
- At Hugh Keenleyside Dam, testing of all 11 gates in operating condition excluded gate movements due to the presence of white sturgeon in the low level outlets. The number of gate tests affected varied by month. Refer to the New Issue identified earlier in this report for more information.
- At Peace Canyon Dam, testing of one of the six spillway gates excluded gate movements to accommodate other planned maintenance activities on the gate. Normal testing resumed in September.

Gates Out of Service or Under Restricted Service

The availability of flood passage devices is a key measure of our ability to pass high inflows and manage reservoir levels. Updates on spillway gates or flood passage devices that are out of service or under restricted service are provided below.

- Hugh Keenleyside Dam – Low Level Outlet Gate 7 returned to service
In F2022 Q4 it was reported that Low Level Outlet Gate 7 was put into restricted service due to a kinked hoist rope. The gate remained on restricted service through F2023 Q2. The damaged wire rope was replaced, and the gate was returned to service in November. The Gate Serviceability deficiency (with associated Vulnerability Index of 4.4) in the Dam Safety Issues Database will be reviewed and reassessed in Q3.

Last quarter's report noted gates at Ruskin Dam and Terzaghi Dam that had been returned to service. The memoranda documenting those gates' satisfactory return to service and closure of the associated Gate Serviceability deficiencies were issued in October and November, respectively, and the Vulnerability Index reductions will be reported next quarter.

Spillway Gate Maintenance

Spillway gate maintenance results are shown in Table 5, below. Twenty-three planned and emergent spillway gate maintenance tasks were completed in Q2. Largely offset by 22 new tasks that were entered into the system, the net result was a decrease of one task in the outstanding work inventory in Q2. Although a significant inventory of work still exists, year to date results are close to the plan. As reported last quarter, Programs and Contract Management has assigned a program manager to oversee this program of work and to work closely with Operations to ensure that any issues are identified early and that the program remains on track. The continuing indications, based on these year-to-date results, are that this approach is yielding improvements in work completion.

Table 5 Spillway Gate Maintenance Results for F2023.

Corrective and Condition-Based Maintenance Tasks	Quarter Q2		Year-To-Date
	Completed	Planned	
Planned Tasks	20	23	37/39 = 95%
Emergent Tasks	3		12

10: Dam Safety Quarterly Report

The number of outstanding gate maintenance tasks is shown in the chart in Figure 5, below. As explained above, the total number of outstanding maintenance tasks has remained nearly steady in F2023 Q2, dropping from 144 to 143. Through the first two quarters of F2023, there has been a net decrease in outstanding maintenance tasks from 160 to 143.

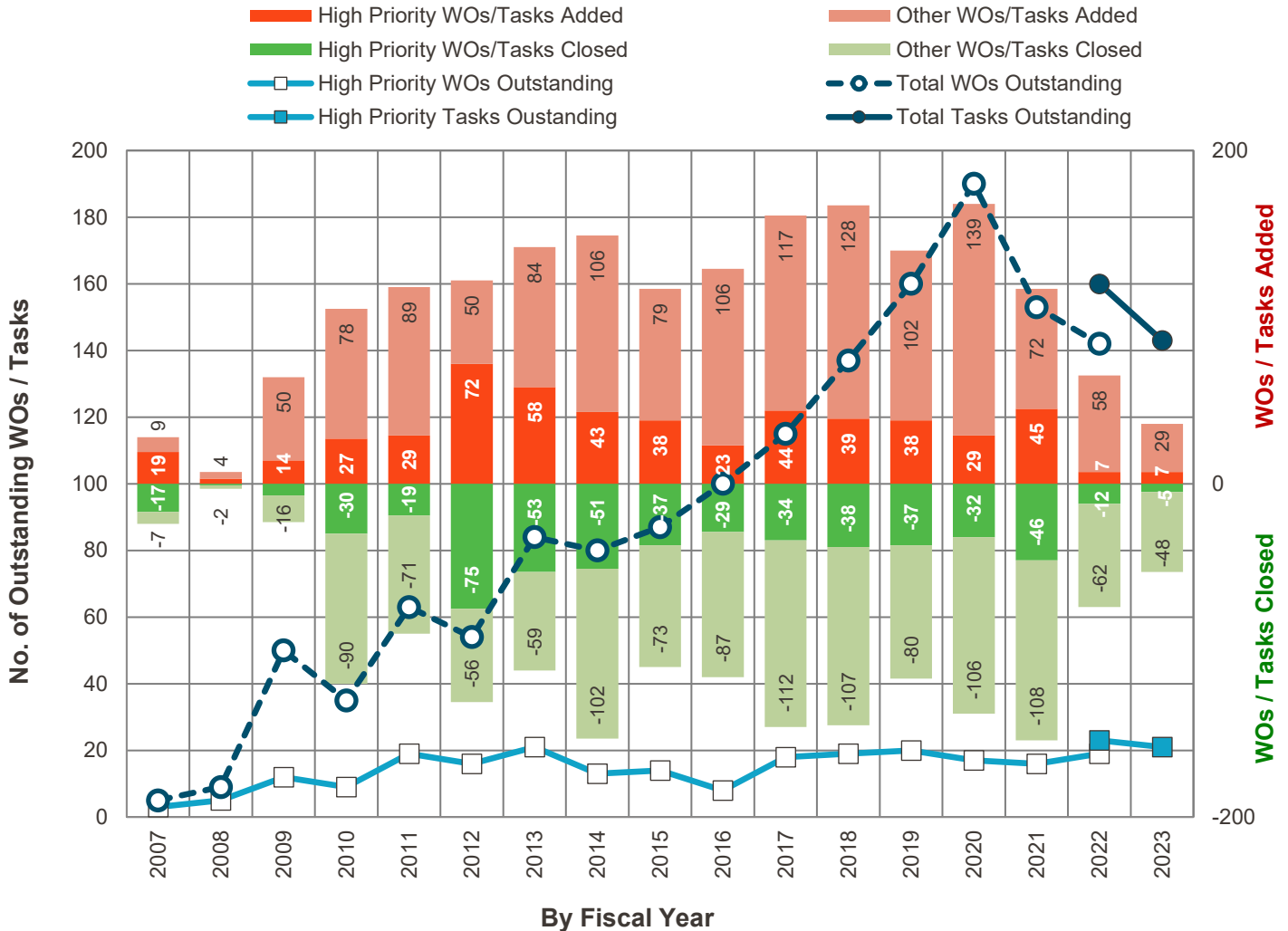


Figure 5 Number of outstanding corrective and condition-based spillway gate maintenance work orders and tasks, new work orders and tasks added, and work orders and tasks closed as at the end of each previous fiscal year.

Notes:

1. At the conclusion of F2022 moving forward into F2023, figures were restated as outstanding tasks instead of outstanding work orders to align with Operations reporting.
2. Work Orders / Tasks Added includes new work orders / tasks created in the year and identified with the gate reliability work group. It does not include work orders / tasks from previous years that were recategorized with the gate reliability work group.
3. Work Orders / Tasks Closed includes work completed through the annual maintenance program. It does not include cancelled work orders / tasks or work orders / tasks that were recategorized out of the gate reliability work group.
4. Due to notes 2 and 3, above, the net change in the number of Outstanding Work Orders / Tasks will not always equal Work Orders / Tasks Added less Work Orders / Tasks Closed

10: Dam Safety Quarterly Report

“High priority” maintenance tasks 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. Through the first two quarters of F2023 – including the addition of seven new “high priority” tasks entered into the system – the number of outstanding “high priority” maintenance tasks decreased from 23 to 21.

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.

Battleship Mountain Wildfire

The Battleship Mountain wildfire occurred near WAC Bennett Dam and Peace Canyon Dam. The size and rate of spread of that wildfire led to an Evacuation Alert for the District of Hudson’s Hope, including those two BC Hydro facilities, being issued by BC Wildfire Service on September 3, 2022 and an Emergency Coordination Centre being stood up on that same day. An Evacuation Order for the District was later issued on September 10, 2022, though critical staff remained on station at GM Shrum Generating Station with safe means of egress throughout the event. The Evacuation Order was rescinded on September 17, 2022 and the Emergency Coordination Centre was stood down on September 20, 2022.

The wildfire did not pose a material hazard to the safety of either dam, but dam safety activities and considerations did impact BC Hydro’s response and contingency planning. Principally, WAC Bennett Dam’s spillway had been taken out of service for much-needed upgrades to the concrete surfaces within the WAC Bennett Dam – Spillway Concrete Upgrades Project. (See “Capital Projects” later in this report.) With large sections of the spillway’s concrete surface removed for this work, returning the spillway to service would have required eight days per the Interim Dam Safety Risk Management Plan. Williston Reservoir, however, was well below the Storage Reservation Curve elevation in place for management of flood risks at Site C and even further below the Maximum Normal Reservoir Elevation, so there were no tangible risks relating to overtopping of the dam and no dam safety priorities for returning the spillway to service. With the spillway out of

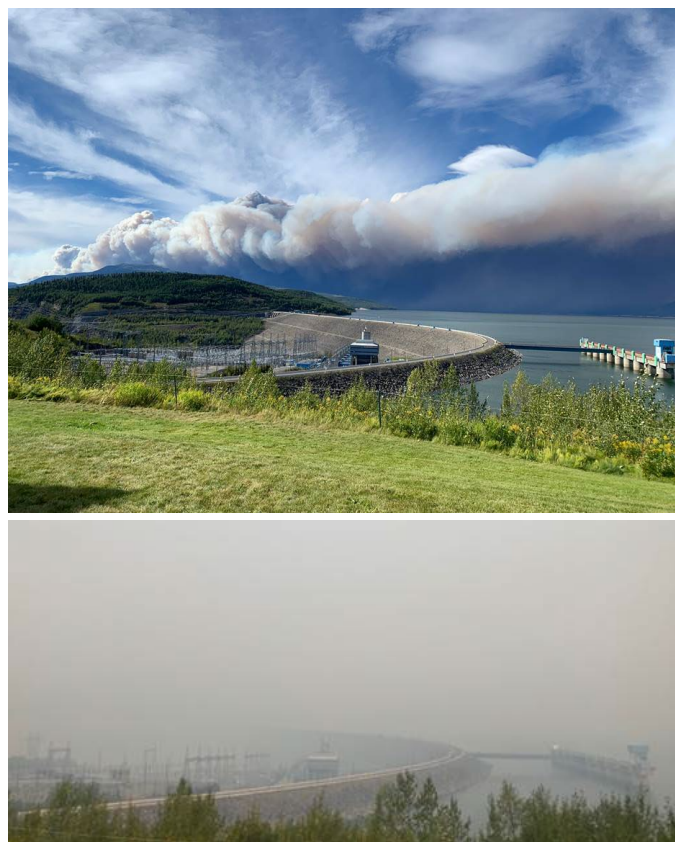


Figure 6 Smoke from the Battleship Mountain fire, as seen from WAC Bennett Dam: on September 8, 2022 (top) and September 9, 2022 (bottom).

10: Dam Safety Quarterly Report

service, however, the only available means of conveying water downstream into the Peace River – and avoid drying it up – was through the generating units. Were the generating station to be isolated from the system due to fire-severed transmission lines, generating units would have to be reconfigured to pass water without generating electricity (called “speed no load”) and that would require personnel to attend the site. If safe access to site were to also become unavailable, then no such reconfiguration could occur and there would be no means of restoring flows into the Peace River. To prevent such an outcome, Dam Safety collaborated with senior personnel from Generation System Operations, Transmission & Distribution System Operations and Stations Field Operations to develop contingency planning within an Operations Response Plan that established how generating, transmission and telecommunications assets would be configured under various scenarios and upon various triggering events. The plan was followed through the course of the event, though the most stringent contingencies associated with complete loss of access to the station were not realized.

There may be a medium-term impact from the wildfire to safe operation of the dam. The fire may have created conditions that could lead to an increased debris load in the reservoir during next year’s freshet. Surveillance of the reservoir next spring will target that potential.

Additionally, a lesson learned from this event is that the hazard from wildfires, in addition to more conventionally considered inflow forecasts, must be accounted for when planning and scheduling spillway outages and in developing the associated Interim Dam Safety Risk Management Plans.

Site C Clean Energy Project

Dam Safety, Generation System Operations and the Site C Clean Energy Project team are engaged in ongoing collaborations to integrate the Project’s design and construction activities and the eventually constructed facilities into BC Hydro’s Dam Safety Program.

The Site C Project Team, Generation System Operations and Dam Safety are preparing several plans and documents that will take effect on closure and conversion of one of the diversion tunnels and will remain in effect through reservoir filling and through commissioning and bringing the generating units on-line. They are to be submitted in November – in an advanced draft form and well before tunnel conversion and reservoir filling – to the Comptroller of Water Rights for that office’s review. These documents include a new Operation, Maintenance and Surveillance Manual for Site C Dam and a revised Interim Dam Safety Risk Management Plan for water management at the upstream Peace River dams (WAC Bennett, Peace Canyon). The documents are presently undergoing checking and review by Dam Safety and other groups.

Dam Safety Regulatory and Asset Planning had initiated work in Engineering to perform inundation modelling and mapping for dam breach scenarios involving the Peace River dams, including the WAC Bennett Dam, the Peace Canyon Dam and the to-be-completed Site C Dam. That modelling and mapping is now complete for the British Columbia reaches of the river. With approval of Alberta Environment & Parks (who regulate dam safety and emergency management in that province), Dam Safety has engaged a consultant who has previously performed inundation modelling for Alberta and has an existing model of the Alberta reaches of the Peace River available. Outputs from the BC Hydro work (hydrographs of updated breach flows at the British Columbia - Alberta border) are being used as inputs for the Alberta modelling. The resulting maps will be used for communications with downstream communities and emergency management authorities in British Columbia and Alberta to inform their emergency response plans.

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.

Bridge River 1 Generating Station – Penstock Foundation Refurbishment

There are four penstocks at Bridge River 1 Generating Station that supply power to four 50 MW generating units. Inspections have observed cracking and other defects in the visible (above grade) portions of the concrete foundations of each penstock. It is assumed that the cracking and defects would be of a similar magnitude in the buried sections. Without remediation, the penstock supports could eventually fail or be undermined and lead to a penstock failure that would impact the switchyard, powerhouse, staff on site, CN Rail, and the local community. Further, there is a large accumulation of rock debris and failed or damaged retaining walls along the penstock alignments that inhibit access, inspection and maintenance of the penstocks.

This project’s objective is to refurbish the concrete foundations and retaining walls to ensure the continued safe operation of the four steel penstocks. The desired outcome is to ensure the Bridge River 1 penstocks continue to operate safely for another 40 years at the lowest life cycle costs by mitigating the risks.

The debris removal work along the Bridge River 1 penstocks is underway. The contractor has encountered delays due to large tree roots growing under the debris along penstock 3 which required additional effort to remove, and additional temporary measures being required for slope stabilization. The contractor has also had three safety incidents over the past month (one major incident and two minor incidents) which has resulted in BC Hydro calling Safety Shutdowns. The Contract Construction Management team has been working closely with the contractor to review safety plans before continuing work.

Cheakamus Dam – Concrete Dam Instrumentation Upgrade

In 1985, 21 piezometers were installed in the foundation of the Main Concrete Dam to monitor uplift pressures and confirm that current pressures still remain within design values. Only eleven of these piezometers remain functional, and new piezometers are needed to monitor the uplift pressures under the concrete dam. In all, the project’s scope is to install new piezometers in drilled holes along the crest of the dam and to refurbish and upgrade the standpipe piezometer collars at the toe of the dam.

In Q2, the project secured endorsement to proceed to Implementation and drilling for the new piezometers commenced. Construction is expected to continue into November when the installation is scheduled to be complete.

Ruskin Dam – Spillway Gate Cylinder Refurbishment

As was described in the Dam Safety Quarterly Report from F2022 Q2, a significant oil leak was discovered and was traced back to one of the two hydraulic cylinders on Spillway Gate 3. The sealing arrangement for a cable leading to a device used to measure gate position had failed, allowing water ingress, subsequent freezing damage, and hydraulic oil leakage, forcing the gate to be taken out of service. The cylinders on all five spillway gates are identical in design and construction, and all are susceptible to the same failure mechanism. This emergent project was initiated to correct the deficiency.

The project has installed a spare hydraulic cylinder and returned Spillway Gate 3 to service, and completed investigations of the failed cylinder to confirm the root cause. Also, in the interim, the gate position measuring devices have been

10: Dam Safety Quarterly Report

removed and the cable entries capped off on all other cylinders to prevent additional failures. With these devices removed, the spillway gates system now lacks adequate redundancy in gate position measurement, and an Interim Dam Safety Risk Management Plan that requires additional personnel to complete independent visual confirmation of gate position is in place to account for the removed devices. Work is now progressing to identifying and implementing a long-term solution to restore full performance – including reliable gate position monitoring – to the spillway gates system.

Seton Dam – Canal Flow Control Structure Upgrade

The five canal headworks gates at Seton Dam are required to isolate the power canal from Seton Lake Reservoir for periodic canal liner maintenance, during significant floods, or if there is uncontrolled flow from the canal due to a failure of the liner or aqueduct. These headwork gates have the following condition and design deficiencies that impact their ability to meet these functional requirements:

- Equipment defects that impact their ability to operate safely and effectively under normal conditions, including leaking gate seals that impede dewatering of the canal; and
- Inability of the canal headworks gates to close under flow.

The Seton Dam – Canal Flow Control Structure Upgrade project was released in Q2 to address those deficiencies.

WAC Bennett Dam – Spillway Concrete Upgrades

The objective of this project is to upgrade the condition of the concrete spillway chute of WAC Bennett Dam to ensure its continued safe operation.

This project follows the Spillway Chute Upgrade Project, completed in 2016, which identified damage throughout the entire length of the spillway chute and remediated the highest priority areas located immediately upstream of the flip bucket. The specific sections of the spillway chute to be upgraded as part of this project are the next highest priority sections in the inclined chute, both above and below the previously resurfaced area, which have deteriorated more quickly than had been forecast.

The project was forced to halt work and evacuate from site on September 3, 2022 as a result of the Battleship Mountain wildfire and the Evacuation Order for the District of Hudson's Hope. (See page 14 of this report.) The contractor was able to return to site and resume work on September 20, 2022. To take advantage of the continued mild weather at the site, and in recognition of the need to complete the work this season, the project added night shift work to recover from the schedule delays caused by the evacuation.

The concrete placement was completed at the end of October. Hoarding and curing of the concrete is expected to extend into mid-November.

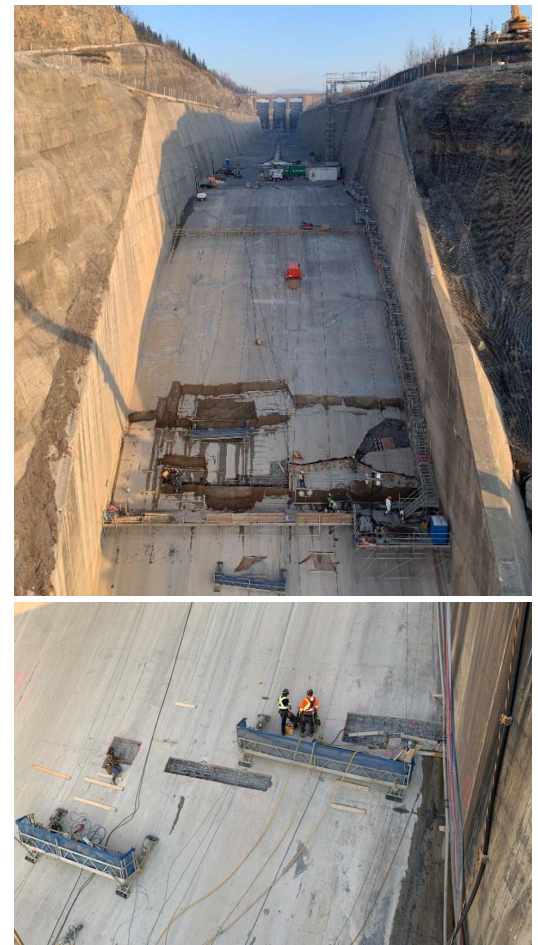


Figure 7 Concrete removal and replacement work in the WAC Bennett spillway.

10: Dam Safety Quarterly Report

Wahleach Dam – Access Road and Channel Refurbishment

Access to Wahleach Dam and to the generating station's power intake on Jones Lake is by way of a steep and narrow, 8-kilometre-long logging road. That road is vulnerable to washouts during heavy rains, preventing access to the dam. The atmospheric river events in November 2021 washed out a section of the road and caused flows in the spillway discharge channel to jump the bank and form a confluence with Wahleach Creek upstream of where the spillway discharge channel merges with Wahleach Creek. Temporary road access was restored promptly following the atmospheric rivers.

Subsequently, an emergency project was initiated to install a culvert across the road and to restore the bank of the spillway discharge channel to prevent recurrence. That work was completed on October 25, 2022.



Figure 8 Installation of a new culvert under the Wahleach Dam access road to prevent future washout.

Various Sites – Reservoir Booms Replacement

This project will replace the existing debris booms at WAC Bennett, Mica, Terzaghi, Sugar Lake, Cheakamus, Stave Falls, and Clowhom Dams. The new booms will be of the “next-generation reservoir booms” design that meet debris interception and public safety requirements. The new booms at Mica and WAC Bennett Dams were replaced during Q2.

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.

Dam Safety currently has 15 active Investigations underway to assess dam performance, investigate known issues, and collect additional information that is necessary to characterize the condition and performance of various dams in BC Hydro's fleet. Additionally, there are eight ongoing programs of work to update flood models, investigate seismic hazards, and improve capabilities in monitoring dams and reservoir slopes across the system.

One Investigation was completed, and another was initiated in Q2.

Alouette Dam – Spillway Sluice Gate Post-Earthquake Operability

Dam Safety initiated an Investigation in 2020 to identify alternatives for stopping the flow of water over the Alouette spillway in the event that an earthquake occurs while the sluice gate is in the open position to allow for seasonal smolt outmigration. Additionally, in the fall of 2021, the sluice gate was opened for 30 days to mitigate inflows prior to and during the large storm event. This event further emphasized the need for mitigation alternatives. The Investigation confirmed that the sluice gate is expected to be inoperable following a moderately sized earthquake due to differential movement of the piers and damage to the hoist system. It further presented alternatives to stop the flow of water assuming the sluice gate was stuck open. The leading alternative was the installation of a flap gate that could withstand the differential movement

10: Dam Safety Quarterly Report

of the piers and be dropped in place following an earthquake. Dam Safety is considering this option, alongside others, with consideration of possible interrelationships to the Alouette – Low Level Outlet Upgrade Project.

Revelstoke Dam – Marble Shear Block Rockslide

Dam Safety initiated a new Investigation in Q2 to assess the recent rockslide at the Marble Shear Block at Revelstoke, discussed above in New Issues. The Investigation will cover the costs of early assessments and monitoring, as well as identifying conceptual alternatives for long-term mitigation approaches until an emergent project has been initiated.