12.0: Quarterly Dam Safety 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 July 1 to September 30, 2023 (F2024 Q2) 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, 2023, but before the completion of this report have also been included.

The key highlights from F2024 Q2 and the beginning of F2024 Q3 documented in this report are:

- Wildfires on the Bridge River System have damaged BC Hydro infrastructure, including distribution power and communications lines to Terzaghi Dam. Temporary backup power and communications lines have been established until repairs are completed. See pages 6 and 7.
- New categories of issues to distinguish Non-conformances from opportunities for potential improvements or unavoidable uncertainties in information have been added to the Dam Safety Issues Database. This has contributed to a reduction of 54 Non-conformance issues in Q2. See pages 3-5.
- BC Hydro provided over 650 responses to Information Requests from the British Columbia Utilities Commission and Intervenors in the Application for the Ladore Spillway Seismic Upgrade Project and the Strathcona Discharge Upgrade Project. See page 8.
- A general revision of the Dam Safety Program Management System has been developed. The new Dam Safety Governance Manual was issued in September and preparation of the new, restructured Implementation Manual is well underway. See page 9.
- Surveillance of the dams, reservoirs and reservoir slopes was completed to largely to plan in Q2, but one routine inspection was missed (the first of F2024) and some formal dam and reservoir slope inspections were delayed, largely due to wildfire conditions. Delayed inspections are being made up in Q3. See pages 10 and 11.
- The number of outstanding spillway gate maintenance tasks increased from 94 to 114 over F2024 Q2, due primarily to the reclassification of existing work orders and planned tasks that were not completed because of wildfire or outage constraints. See pages 13-15.
- Construction on the John Hart Dam Seismic Upgrade Project commenced. The new intake operating gates and power and communications buildings for the Lake Buntzen – Coquitlam tunnel were installed, and good progress was made in seismic upgrades to the Alouette Tunnel surge shaft and tower. New subsurface instruments to monitor groundwater pressures and displacements of the Little Chief Slide upstream of Mica Dam were installed. See pages 16-19.
- New procedures and laboratory facilities at Powertech Labs to investigate the properties and performance of embankment dam fills were commissioned. A panel of experts have judged these facilities to be ready for production-level testing for performance assessment of BC Hydro's large embankment dams, like WAC Bennett, Mica, Strathcona, and others. They further commented that the adopted innovations and refinements to analysis of the test data have advanced the state-of-practice. See pages 20 and 21.

Presenter: Bob Schubak (Director, Dam Safety)

12.0: Quarterly Dam Safety 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	G →	• **Vulnerability Index (pp. 3-5):** The aggregated Vulnerability Index was slightly reduced by 0.75 through Q2. • **Program Non-Conformances (pp. 5-6):** The total number of non-conformances was reduced by 54 (approximately sixteen percent) through Q2. • **New and Current Issues (pp. 6-8):** New issues related to wildfires and a maintenance error are under active management or resolved. An active project is addressing the issue of white sturgeon entering the low level outlets at Hugh Keenleyside Dam.
Regulatory Compliance	G →	• **British Columbia Utilities Commission (p. 8):** Responses to Round 1 Information Requests for the Ladore Spillway Seismic Upgrade and Strathcona Discharge Upgrade Projects Application were submitted. • **Operation, Maintenance and Surveillance Manual Updates (p. 9):** The Manual update for Revelstoke Dam was issued in Q2. Five other Manual updates are proceeding to plan. • **Dam Safety Reviews (p. 9):** Dam Safety Reviews are proceeding to plan. • **Management System (p. 9):** The new Governance Manual was issued.
Surveillance	G →	• **Dam Inspections (pp. 10):** 410 of 411 scheduled routine dam inspections were completed in Q2. The one missed inspection was due to the wildfires at Bridge River. Formal inspections were slightly behind plan and are being caught up in Q3. • **Reservoir Slopes (p. 11):** Wildfires delayed several slopes inspections, but were largely caught up in early October.
Maintenance and Testing	Y ↓	• **Civil Maintenance (p. 12):** Civil maintenance projects progressed ahead of plan. Preventive maintenance lagged plan slightly in completions but continued to perform well. • **Spillway Gates (pp. 13-15):** 236 of 235 scheduled gate tests were completed; no gates failed to operate on demand. The number of outstanding maintenance tasks increased by 20 due to the reclassification of existing work orders and repairs deferred by wildfire and outage constraints.
Projects and Investigations	G →	• **Capital Projects (pp. 16-19):** Construction commenced on the John Hart Dam Seismic Upgrade and progressed on the Alouette Headworks Tower and Surge Tower Seismic Upgrade and the Lake Buntzen 1 – Coquitlam Tunnel Gate Refurbishment. • **Dam Safety Investigations (pp. 20-21):** Specialized laboratory testing facilities and program to investigate the performance of materials in BC Hydro’s large embankment dams have been commissioned at Powertech Labs.

Legend:	
G	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.
Y	One or more areas within the Program element exhibit or are at risk of underperformance and are being monitored.
R	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.

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. Notable changes in Vulnerability Index in F2024 Q2 are identified in Figure 1 and described below.

1. A ***reduction*** of 0.25 (Potential Unusual deficiency) at ***Ladore Dam***.
   Seismic triggers are located in the Ladore Generating Station to shut off generation and outflows to the John Hart Reservoir in the event of an earthquake; their intent being to prevent a potential post-earthquake flow imbalance with the John Hart Generating Station. These triggers had been located such that they were exposed to inundation and component failure if flooding were to occur. They have now been relocated away from potential inundation and the issue is closed.

2. A ***reduction*** of 0.5 (Potential Normal deficiency) at ***Revelstoke Dam***.
   A potential deficiency existed in the core the earthfill dam near two vertical movement gauges. Water level fluctuations in the casings for those gauges had been observed, raising concerns that leaky joints in the casings created hydraulic connections through the dam core and potential paths for seepage and internal erosion. As a part of the GM-0049 Mica & Revelstoke Rehabilitate Vertical Movement Gauges Project, these two and five other vertical movement gauge casings were fully grouted and instrumented with standpipe piezometers and/or fibre optics in 2020. The vertical movement gauges instrumented with standpipe piezometers are now recording piezometric elevations that are more consistent with expected pressures through the dam's core, and the water level fluctuations noted prior to 2020 appear to have ceased as the standpipes approach new, stable piezometric levels. This issue is closed.

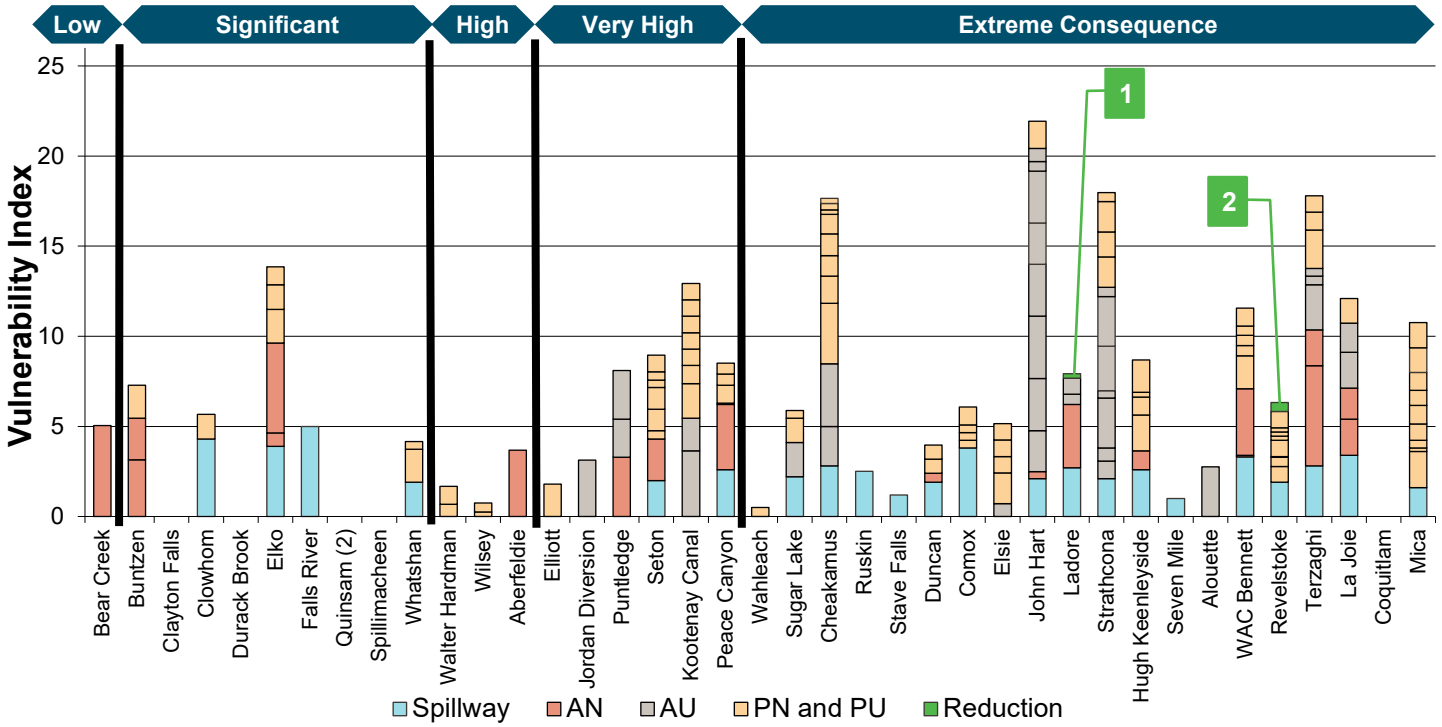

Figure 1 Dam Safety overall risk profile at the end of F2024 Q2, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

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	Deficiency related to operational reliability or serviceability of the dam's spillway and/or other flood discharge systems

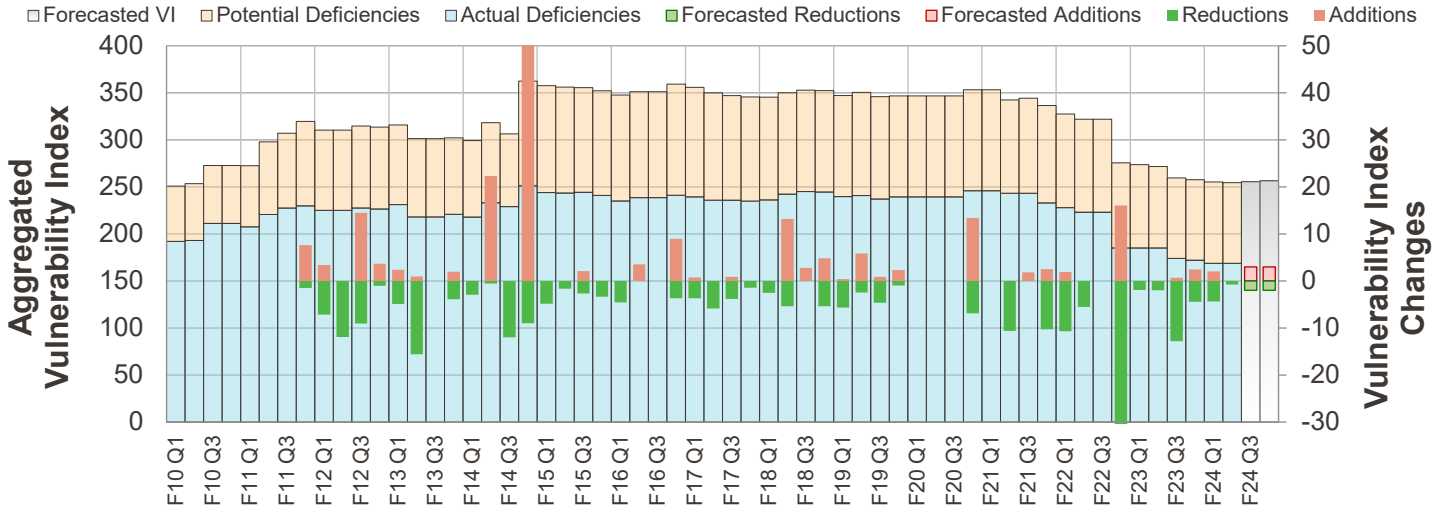

Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

Over the last several years, new issues have added to the aggregated Vulnerability Index at a rate of approximately 12 per year. 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 Vulnerability Index reductions have far exceeded additions over the past four quarters. Vulnerability Index reductions through F2024 are forecast to fall just short of the target, however.

Table 1 Trends and forecasts for Vulnerability Index changes in F2024.

		Actual / Forecast	Target	
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	22.3	12	✓
	Reductions – Fiscal Year	9.1	12	✗
	Additions - Last 4 quarters	5.2		

Non-Conformances in the Dam Safety Program

Non-Conformance issues arise where:

- the established procedures, systems and instructions of the Dam Safety Program Management System are not being followed at a particular dam; or
- where procedures that form part of established and generally accepted good practices have not been implemented within the Dam Safety Program Management System or at a particular dam.

The resolution of Non-Conformance issues is a priority within the Dam Safety Program, and steady progress in this regard has been made since F2019 Q1, as is evident in Figure 3. This has been achieved by focusing on Non-Conformances in regular reviews of the Dam Safety Issues Database for each dam site, and addressing them through investigations, planned maintenance and small capital projects. There has also been a focus on cleaning up the Database to close issues that had been previously resolved or found to have been improperly characterized as Non-Conformances, where instead they are instances of:

- uncertainties in the information available (and obtainable) to assess the safety of a dam are larger than are normally expected or desired; or
- potential improvements that may exceed current “good practice” or are not at this time demonstrably beneficial.

To stop mischaracterizing these issues as non-conforming yet retain and periodically review them for potential improvements in the future as circumstances warrant, technologies advance and opportunities arise, two new categories of issues – Information Uncertainties and Potential Improvements – have been defined and added into the Dam Safety Issues Database. (Note that this required, as a precondition, modifications to the Database platform itself.) Moving forward, they will be tracked and managed by Dam Safety, but they will not be included in formal issues reporting.

In F2024 Q2, Dam Safety Engineers closed or recharacterized 54 issues (as described above) at nine facilities, leaving a total of 275 outstanding Non-Conformances, which is just under one-half of the number in the Database at the end of F2019 Q1. Similar reductions in the number of Non-Conformance issues are expected through the remainder of F2024 as the issues at the other facilities are reviewed and, as warranted, closed or recharacterized to Information Uncertainties and Potential Improvements.

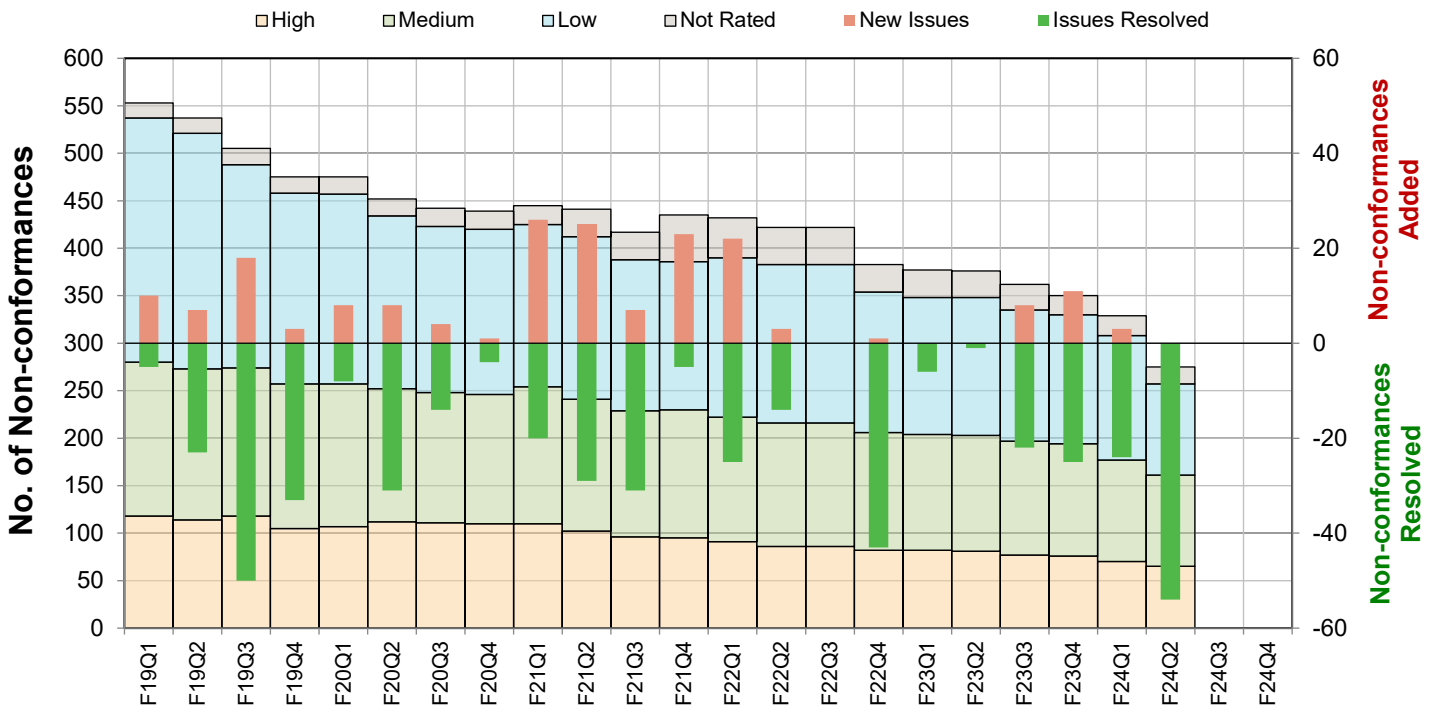

Figure 3 Changes and trends in the total number of Non-Conformance issues (characterized by level of importance) within the Dam Safety Program.

New Issues

Bridge River Wildfires

Two very significant wildfires impacted the Bridge River System, comprising La Joie Dam and Generating Station, Terzaghi Dam, Bridge River 1 and Bridge River 2 Generating Stations, and Seton Dam and Generating Station. The Downton Lake wildfire burned large extents of reservoir shoreline along Downton Lake, impounded by La Joie Dam. The Casper Creek wildfire burned areas around and immediately adjacent to Terzaghi Dam and the facilities of the Bridge River 1 and 2 Generating Stations. See Figure 4 for the wildfire extents.

The fires damaged or destroyed much BC Hydro infrastructure. Damage to power supplies and lines of communications has impacted Dam Safety operations, though backup systems are functioning.

- Power to Terzaghi Dam via BC Hydro distribution line was lost on August 15th and repairs are not expected to be completed until late 2023/2024.
    - The power line provides power to Terzaghi Dam for the spillway gate equipment, auxiliary buildings, and the two intake structures/gates for the water conveyance tunnels to the generating stations. The dam spillway gate equipment is now primarily powered by the backup diesel generator. A portable diesel power generator was rented and brought to the dam on October 5th to provide a redundant power source for the spillway gate equipment. The two intake buildings currently do not have power but in an emergency the portable power generator at the spillway can be moved to the intakes to power operation of the intake operating gates.

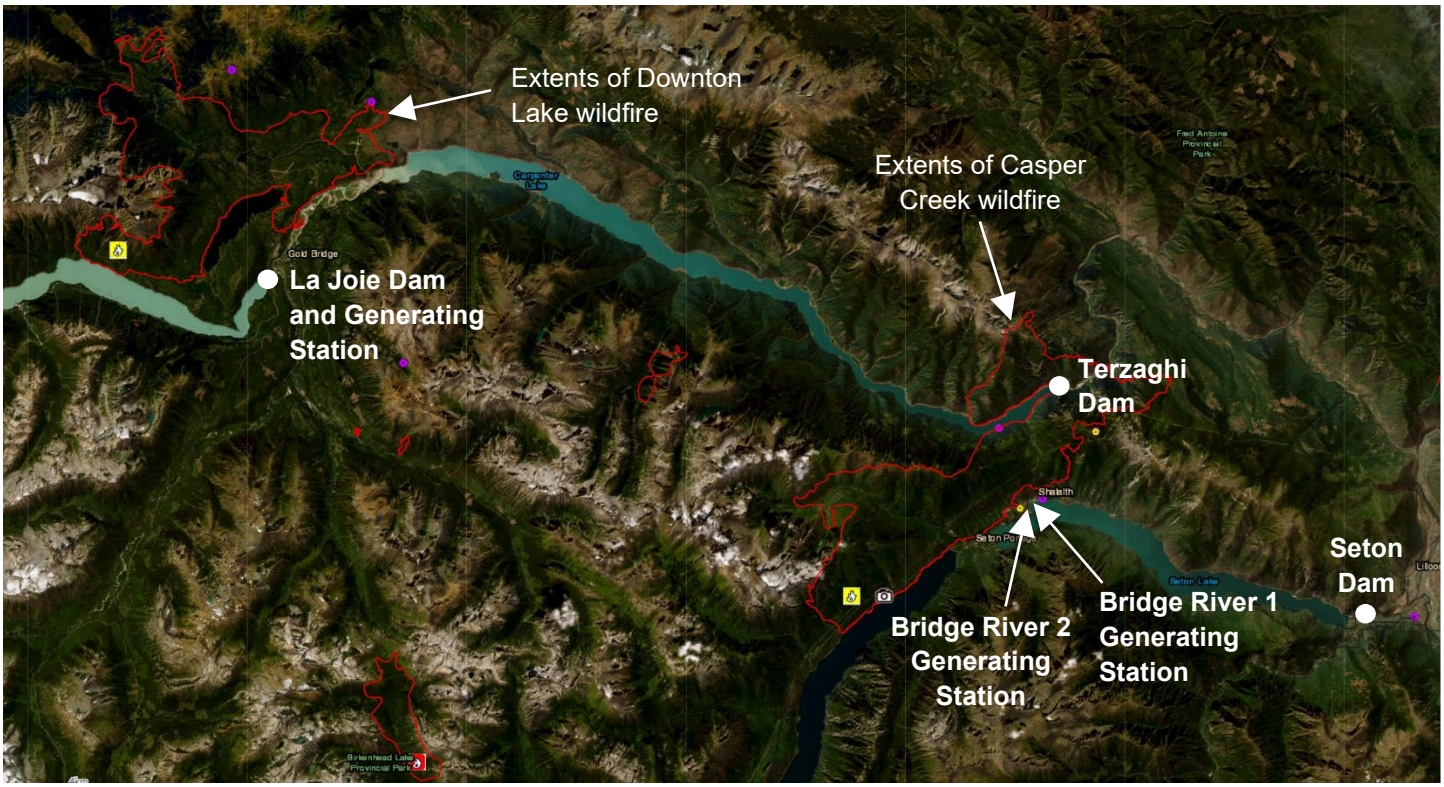

Figure 4 Extents of the Downton Lake and Casper Creek Wildfires in the Bridge River system.

- Dam Safety instrumentation at the dam crest, spillway, and the Bridge River 2 intake was forced to run on internal logger batteries, which ran dry by August 27th. Dam Safety Technologists were able to safely access the dam and install external batteries and small solar panels on the instrumentation on August 30th but were unable to access the intake building until September 13th to bring the reservoir monitoring instrumentation back online. In the interim, a piezometer installed upstream of the dam's core was monitored to provide a reasonable indication of reservoir level.

- The main communication path for instrumentation data at Terzaghi Dam is a radio link over Mission Mountain and down to the Bridge River 1 powerhouse. The Mission Mountain repeater station was damaged by fire around August 15th along with the cellular communications tower beside the intake structures on Carpenter Lake, requiring use of the backup satellite communication system for remote monitoring of instrumentation until radio or cellular communications are restored.

The Casper Creek wildfire advanced very close to the Bridge River 1 and 2 Generating Stations and particularly close to the penstocks, which forced evacuation of the stations, shut-down of the generators and isolation and dewatering of the penstocks, due to concerns that the fires could damage penstock joints and potentially lead to their rupture. Driving these decisions was the necessity to leave the stations in an inherently safe state, such that the worst-case scenario for damage to the facility would not lead to a loss of safe containment or control of water in the penstocks, tunnels and the reservoir. Taking lessons from this event and the Battleship Mountain wildfire of 2022, Dam Safety Engineers have since been directed to determine and document inherently safe states for their assigned dams in case of wildfire and required evacuation, which will be used to augment the emergency plans for their facilities.

Blind Slough Dam Spillway Gantry Crane

Blind Slough Dam is a part of the Stave Falls facility. A public roadway runs along the crest of the dam, as does a set of rails for a gantry crane that is used to raise and lower ten bulkhead gates that are used for spilling in the event of large inflows. Four other radial gates at the dam are more typically used for spills, however. The crane rails run into the roadway, and deterioration of filler materials surrounding them presented an ongoing hazard for cyclists and motorists.

In Q2, a maintenance project to replace those failed materials and improve the safety of the roadway was undertaken. An Interim Dam Safety Risk Management Plan was in place for the work. The work required saw cutting and removal of concrete parallel to the rails. In performing this work, the crew accidentally damaged a large number of rail anchors and retainers, leaving the rail unable to safely support the crane, forcing the crane out of service while Engineering developed a solution and repairs were undertaken. A new Interim Dam Safety Risk Management Plan was put in place, specifying triggers for stationing a mobile crane at site to operate the bulkhead gates. While unfortunate, this situation highlights two strengths in design of the Stave Falls Dam flood discharge gate system. First, Stave falls has four radial gates and ten bulkhead gates. The four radial gates are operated independently from the bulkhead gates so are unaffected by this issue. Second, the bulkhead gates are designed to be operated by either the spillway gantry crane or a mobile crane and are regularly tested using both methods. This redundancy made it straightforward to keep the spillway and all 14 of its gates operational.

The repairs are now complete, and the gantry crane has been returned to service. A root cause analysis is underway to better understand the incident and contributory factors, including the actions of Construction Services, Engineering Design and Dam Safety.

Update on Existing Issues

Hugh Keenleyside Dam – White Sturgeon in Low Level Outlets

As reported previously, white sturgeon have been observed entering the dam's low level outlet ports and swimming up the operating gate slots to access the tops of the gates during the summer months. To avoid injury or mortality to these fish, which is an Endangered Species under the Federal Species at Risk Act, BC Hydro is continuing to monitor for the presence of white sturgeon before any operation or testing of the gates. An engineering solution to prevent sturgeon from entering the gate slots has now been developed. Materials are on site for a prototype to be installed on one gate to evaluate the effectiveness of the design and to ensure that it doesn't interfere with gate operation. Dogging beams to support the gates for worker safety are being fabricated and installation of the prototype is planned for November.

Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

Round 1 Information Requests for the Ladore Spillway Seismic Upgrade Project and the Strathcona Discharge Upgrade Project were received on August 29 and September 6, 2023, and responses were submitted on October 17, 2023. In Round 1, there were 654 responses and attachments submitted with 176 coordinated through Dam Safety.

Regulatory Communications – Comptroller of Water Rights

One submission was made to the Provincial Dam Safety Office in Q2, requesting acceptance of drilling investigations in La Joie Dam. This was approved in August. Information was also provided on the forest fires in the vicinity of the Bridge River facilities and the damage to the Blind Slough gantry crane rails, as described under "New Issues".

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.

The updated Manual for Revelstoke Dam was completed and issued in September. Five more Manual updates are planned for F2024.

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.

Seven Dam Safety Reviews are planned for completion in F2024. In Q2, the draft Ruskin Dam Safety Review Report was received, and the final report will be issued in Q3. Site visits and staff interviews were completed for Comox, Cheakamus, John Hart, Stave Falls, WAC Bennett, and Wilsey Dams and the preparation of draft reports is on track.

Dam Safety Program Management System

A general revision to the Dam Safety Program's Management System has been developed. It is significantly expanded over previous versions to better recognize the many interdependencies and arrangements required for the safe operation of BC Hydro's dams, both within BC Hydro and with our regulators and the communities we serve and impact. It also explicitly incorporates the full breadth of asset management of our dams and related assets, integrating with BC Hydro's *Asset Management Policy* and establishing connections to and enterprise Asset Management System that is under development. Salient features of the Management System include:

- BC Hydro's corporate governance structure for dam safety, starting from the level of the Board of Directors;
- Responsibilities for the breadth of the Dam Safety Program being distributed across a wide cross-section of the company; and
- An accounting of all activities that materially impact the safety of the dams through operations, surveillance, monitoring, maintenance, capital improvements, risk mitigations, and assurance and acknowledgement of accountability to the public and regulatory bodies.

The Management System's new *Governance Manual* was issued at the end of Q2.

The Management System's *Implementation Manual* has been completely restructured from a single document into a series of more than one hundred documents that each separately describe one aspect or "section" of the Dam Safety Program Management System. These documents are being prepared and issued on a priority basis; those pertaining to the traditional core aspects of the Dam Safety Program and to the essentials of Dam Safety's new asset management responsibilities being prioritized first. At writing, more than fifty "sections" of the Implementation Manual have been issued, several more are being reviewed by other business units for acceptance of their role descriptions, and two dozen others are in various states of draft. Additional sections of the new *Implementation Manual* will be issued through the remainder of F2024.

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 Q2		Year-to-date		
		Actual	Target	Actual	Target	
Routine dam inspections	Completed	410/411 = 99.8%	100%	821/822 = 100%	99.9%	✓
	Missed	1		1		
Formal (annual and semi-annual) dam inspections	Field work completed	16	35	49	55	✗
	Reports issued	9	10	20	10	✓
Instrumentation data checks		194/195 = 99.5%	97%	383/390 = 98%	97%	✓
Reservoir slopes inspections	Field work completed	2	12	11	16	✗
	Reports issued	4	4	4	4	✓

Routine Dam 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.

410 out of 411 of the scheduled routine inspections were completed this quarter. The single missed inspection was at La Joie Dam during the week of August 21, while the facility was under evacuation order due to the Downton Lake Wildfire.

Formal Dam 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. 71 of these inspections and reports are to be completed annually. As at the end of Q2, Dam Safety Engineers have completed the field work for 49 facilities, which is slightly behind the work plan target of 55. The remaining inspections will be completed in October and November and there is no risk of missing any inspections at this time. A total of 20 reports were issued by the end of Q2, exceeding the work plan target of 10 reports.

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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. 194 of the 195 planned checks were completed in Q2.

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. Each inspection generally consists of a review of all monitoring data, a visual inspection completed from helicopter with boots-on-ground assessment of identified areas of concern, and documentation by a sealed engineering report.

Although the field work was ahead of schedule at the end of Q1, delays due to the impacts of wildfires resulted in field work being carried out at only two of the sites, with a total of 11 sites being completed at the end of Q2 compared to a work plan target of 16. Four additional inspections have been completed in the first two weeks of October and three inspections are left to be completed by the end of the year. Two of these sites are in the Bridge River Area. These inspections are planned for late October or early November depending on weather conditions.

Unusual Events or Observations

The Dam Safety On Call Person responded to 61 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 in line with typical activity.

Civil Maintenance

Civil maintenance on Dam Safety and Generation assets progressed well in F2024 Q2, per Table 3.

Table 3 Dam Safety and Generation Civil Maintenance for F2024.

		Quarter Q2		Year-to-date	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Spend ($k)	1865	1716	2572	2508
	Work Orders Completed	7	4	9	5
Preventative Maintenance	Tasks Completed	220	296	345/417 = 83%	

Preventive Maintenance

Stations Field Operations and Engineering Services have performed well on the Civil Preventive Maintenance Program. Although showing only 83% complete, there were an additional 31 tasks forecast to be complete in early October, and another 54 tasks with their field work complete but waiting engineering reports before setting to Complete.

Corrective and Condition-Based Maintenance

The Corrective and Condition-Based Civil Maintenance Program is on plan with a year to date spend of $2.57 Million and project (Work Order) completion ahead of schedule in F2024.

A significant project completed in Q2 was the repairs to the concrete “steps” and left abutment structures on the Ruskin Dam spillway that were damaged during historically high inflows in the fall of 2021.

These repairs required extensive planning and coordination with Environmental Field Services, Generation System Operations, Construction Services and Stations Field Operations. For the left abutment portion of the work, a full 5-bay spillway outage was required.

Construction Services Vernon performed the concrete repairs following procedures provided by BC Hydro Stations Maintenance Engineering. All repairs on the steps and the largest, high priority, repairs on the left abutment were completed.

Other work completed in Q2 included Alouette Dam spillway repairs, Wahleach fish siphon concrete repairs, Downie Slide adit portal scaling, Elko Dam intake building slope remediation, and the Kootenay Canal headworks bridge repairs.

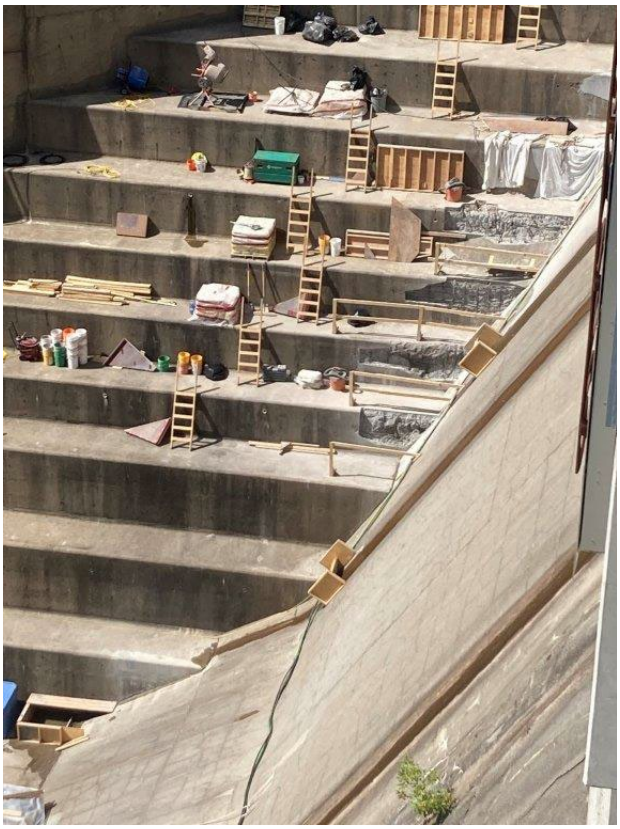

Figure 5 Repair setup on the Ruskin Dam spillway steps.

Spillway Gate Testing and Maintenance

Spillway Gate Testing

During Q2 of F2024, 236 of 235 scheduled gate tests were completed, including annual gate tests of 15 gates. The extra test was performed at Elko Dam in August, with the annual test being performed before coming due. Table 4 below provides key metrics related to spillway gate testing. No gates failed to operate on demand in Q2.

Table 4 Spillway gate testing results for F2024 Q2.

		Quarter Q2		Year-to-date	
		Actual	Target	Actual	Target
Monthly Tests	Completed	236/235 =100%	100% ✓	473/471 =100%	98% ✓
	Missed	**0**		**0**	
Gates Failing to Operate on Demand during Testing	No. of failures	**0**		**1**	
	Failure rate	0/235 = 0 %		1/473 = 0.2%	

Exceptions to Gate Testing Program

Gate testing scopes were reduced to exclude gate movements at some dams, as described below.

- 13 gates at various sites were not operated due to conflicts with other work, such as construction downstream.
- At Hugh Keenleyside Dam, two low level operating gates were not operated due to the presence of sturgeon above the gate. See “Update on Existing Issues” for more information.
- At WAC Bennett Dam, the three spillway gates were not operated this quarter pending resolution of the deficiencies discover during gate testing in May and described in the F2023 Q1 Quarterly Dam Safety Report. The GZ-0274 GMS Spillway Gate Upgrade Project Team has addressed the deficiencies arising from that project’s work and the repairs are scheduled to be tested during annual gate testing in early November. A root cause analysis to better understand the malfunctions and identify potential corrective actions beyond the immediate repair is in progress.
- At Blind Slough Dam, one bulkhead gate was not operated due to damage to a gantry crane rail. See “New Issues” for more information.
- At Terzaghi Dam, the two spillway gates were not operated in August due to the buildup of debris at the gates that could not be cleared as intended because of the Casper Creek wildfire. See “New Issues”.

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. As at the time of writing this report, all spillway gates and flood passage devices are in service.

Spillway Gate Maintenance

Spillway gate maintenance results for Q2 and F2024 year-to-date are shown in Table 5. The number of outstanding gate maintenance tasks is shown in the chart in Figure 6.

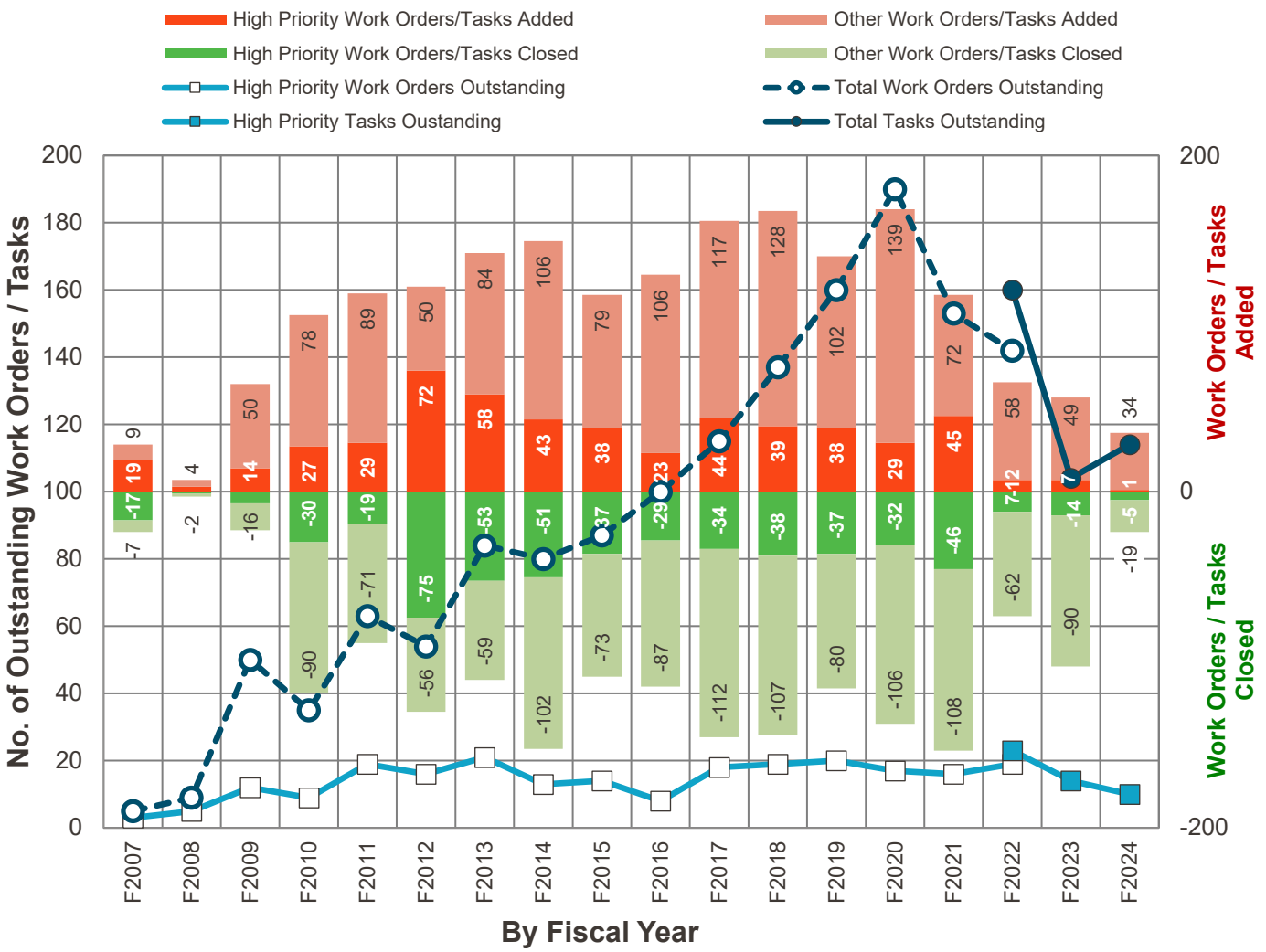

Figure 6 Number of outstanding corrective and condition-based spillway gate maintenance work orders and tasks, new work orders and tasks added, and work orders and tasks closed as at the end of each previous fiscal year.

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

Work on planned tasks was significantly behind plan in Q2, with only three tasks completed compared to a plan of eighteen. No emergent tasks were completed in Q2. The tasks that were not completed include six on the Bridge River system that were prevented by the wildfire and eight that are being deferred due to outage or resource constraints.

Table 5 Spillway Gate Maintenance Results for F2024.

Corrective and Condition-Based Maintenance Tasks	Quarter Q2		Year-to-date
	Completed	Planned	
Planned Tasks	3	18	17/30 = 57%
Emergent Tasks	0		3

The number of outstanding gate maintenance tasks is shown in the chart in Figure 6. Through Q2, the total number of outstanding maintenance tasks increased from 94 to 114. This increase is primarily due to the reclassification of existing work orders as part of the F25 maintenance planning process; few new work orders were created.

“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. The number of high priority tasks remained steady at 10 though Q2.

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 Quarterly Safety & Emergency Management Report, submitted to the Operations, Planning, and Information & Technology Committee, for updates on emergency preparedness and public safety.

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. In Q2, in preparation for tailrace and reservoir filling, the Site C Dam Operation, Maintenance and Surveillance Manual and the Interim Dam Safety Risk Management Plan for Peace River Operations were updated and the Construction Readiness Form to confirm readiness and authorize filling of the tailrace was prepared, reviewed and finalized.

For the period during and following reservoir fill but prior to completion and commissioning of the complete spillway gates system (including all modes of control, communications, main and backup power supplies, *etc.*), operation of the gates will follow stringent engineering and management procedures under local control by the Project and its Contractor, to be described and enforced by an Interim Dam Safety Risk Management Plan. Development of this Plan commenced in Q2.

Personnel from Dam Safety continued collaborations with Stations Asset Planning, Engineering Services, Stations Field Operations and the Site C Clean Energy Project team to plan and prepare for the project acceptance processes, and a project acceptance governance plan was completed and signed off by all parties.

Finally, a new Dam Safety Engineer and one of two Dam Safety Technologists for the new dam have been hired and are presently being onboarded and trained.

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 where milestones were achieved.

Alouette Headworks Tower and Surge Tower Seismic Upgrade

The objective of this project is to ensure that operation of the tunnel that diverts water from the Alouette Lake Reservoir to Stave Lake can be relied upon for control of the Alouette Lake Reservoir after a major earthquake. The components of the tunnel’s discharge facilities include the headworks tower and shaft, the headworks operating gate, the surge tower and shaft, the slopes adjacent to these structures, the power tunnel concrete lining, and mechanical, electrical, protection and control, and communications equipment required for local and remote operational capability.

The first stage of construction comprising upgrades on the Stave Lake end of the tunnel and discharge facilities is now underway. The project made significant progress on the in-tunnel geotechnical and civil scope during the first tunnel outage during the summer. Most of the contact grouting and drilling for passive anchors for the surge shaft walls was completed, as well as rock scaling and bolting in the adit tunnel. Outside of the tunnel, the project progressed the slope upgrades above the surge tower, as well as upgrade of the surge tower structure itself and preparation of the site for back-up power and communications. See Figure 7.

Figure 7 Seismic upgrades underway on the structures of the Alouette Tunnel. At left: surge tower superstructure. At right: surge shaft concrete lining; work being performed from suspended platform that is raised and lowered along the shaft as required.

Kootenay Canal – Canal Liner Joints Upgrade

Kootenay Canal parallels the Kootenay River to convey water 4.5 km from the headpond of Fortis BC's Corra Linn Dam to the intake to the Kootenay Canal Generating Station. The majority of the canal's cross section is in unlined bedrock, however upper portions of the canal's north side are contained by concrete faced rockfill dams. The inner surfaces of the rockfill dams were made watertight by placement of over 500 concrete liner slabs, where the joints were sealed using PVC water stops. The joints between the canal's concrete liner slabs are now nearly 50 years old are degrading, and leakage through them is increasing. This project was released in F2024 Q2 to upgrade and improve those joints.

Lake Buntzen 1 – Coquitlam Tunnel Gates Refurbishment

The Coquitlam-Buntzen Tunnel Inlet was built in 1903 and modified in 1911. It is constructed in natural rock with all gates installed in fixed locations 27 metres underground. The original facility had one maintenance gate that was partially refurbished in 1955 and two downstream operating gates that were original from 1911. This project is replacing those original gates and upgrading the mechanical and electrical systems and several of the intake's structures to ensure the reliable operation of the intake operating gates for management of the Coquitlam Reservoir elevations and water conveyance for generation at Lake Buntzen 1 Generating Station.

Figure 8 Coquitlam-Buntzen Tunnel Inlet refurbishment. Left: new concrete pier nose between the two intake operating gates. Right: power and control buildings being installed; slope stability upgrade in foreground.

At the time of writing, all three gates have been replaced, with the new intake maintenance gate and the two new intake operating gates installed and in use under temporary power with local control. Demolition and removal of the old maintenance gate is scheduled for November. Stability upgrades to the slopes at and approaching the intake's access adit are complete and new power and control buildings have been installed (Figure 8). Final construction and commissioning will take place through Q3 and into Q4.

John Hart Dam Seismic Upgrade Project

Construction on the John Hart Dam Seismic Upgrade Project is well underway. Berms that will contain dredgeate material from the reservoir along the former penstock corridor are nearing completion. The double silt curtain has been installed around the North Earthfill Dam and dredging of material upstream of the dam will commence in Q3. Construction of the temporary concrete guides for placement of the plastic concrete cutoff wall in the Main Earthfill Dam is progressing as well. See Figure 9.

Figure 9 Construction on the John Hart Dam Seismic Upgrade Project is underway, as seen in these September 8 photos from the site. Top: Work area on the Middle Earthfill Dam (foreground) and installation of the silt curtain upstream of the North Earthfill Dam (background). Bottom: Construction of one of three containment berms along the old penstock corridor, where dredgeate from the reservoir will be placed.

Mica - Little Chief Inclinometers Installation

The Little Chief Slide is a 900 million cubic metre, slow-moving rockslide located upstream of Mica Dam. Dam Safety actively monitors the slide with subsurface instruments to measure slide displacements (inclinometers) and groundwater pressures (piezometers) to provide warning of deteriorating conditions, should they occur, and to provide verification of current subsurface interpretations between movement, water pressures and reservoir operation. Over time the ongoing slide displacements damage and destroy the instruments that cross the slide interface.

This project was released to replace instrumentation that had already failed or was expected to fail in the near-term. In Q2 the project completed all drilling activities and the installation of the in-ground piezometers and inclinometers, as well as the associated Instrumentation shacks. See Figure 10. Following successful piloting use at Downie Slide, the project is also installing continuous operating global navigation satellite system towers that will not be susceptible to damage from ongoing slide movements. These towers and automatic data acquisition system equipment will be installed in F2025.

Figure 10 Drilling (left) and installed instrumentation shacks (right) at Little Chief Slide.

Ruskin – Spillway Operating Gates Cylinder Refurbishment

In February of 2022, Spillway Gate 3 at Ruskin Dam was forced out of service when one of the hydraulic cylinders that lifts the gate was damaged due to ingress of water and subsequent freezing. The issue was subsequently found to be a common cause failure for all of the hydraulic cylinders where the entry port for the wiring of the linear transducers created a pathway for water ingress. See the F2022 Q4 and F2023 Q1 Quarterly Dam Safety Reports for additional information. The linear transducers were installed to measure gate position. A project was released to restore function to Spillway Gate 3, to prevent reoccurrences on any of the other gates by removing the linear transducers and sealing the entry points, and to correct the design issues that led to the failure while restoring the gates to their full design intent.

The project has identified a different means to measure gate position by using a rotary inclinometer attached to the gate arms. The advantage of this technology is that it would not be installed inside of the hydraulic cylinders and would therefore not introduce a failure mechanism to the operating components of the gate. Two new rotary inclinometers were installed on Spillway Gate 5 during an outage in mid-September. These units will be assessed for performance for a period of one year. If they prove effective, the rotary inclinometers will be installed on the remaining four gates.

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.

Large Embankment Dam Special Investigations

These Investigations were initiated in F2014 to gather data and develop tools and methodologies for the performance assessment of BC Hydro's portfolio of large embankment dams, such as the WAC Bennett and Mica Dams. One product of these Investigations has been the development of comprehensive and highly detailed three-dimensional, Geographic Information System-based models that are referenced by the Dam Safety Information System, described in the F2023 Q3 Quarterly Dam Safety Report.

Another aspect has been the development of a specialized laboratory testing program – including new testing facilities – at Powertech Labs. The testing program comprises three types of test: the Internal Stability test, the Crack Holding test, and the Continuing Erosion Filter test, as shown in Figure 11, below.

Figure 11 Newly developed and commissioned apparatus for Internal Stability Test (left), Crack Holding Test (center), and Continuing Erosion Filter Test (right) at Powertech Labs, developed under the Large Embankment Dams Special Investigations.

The apparatus for these tests were designed and fabricated by BC Hydro Generation Stations Civil Engineering and Powertech Labs working in collaboration. Owing to the presence of large rocks in the glacial till cores of some of our key dams, the apparatus had to be constructed to an unprecedented scale. One of the “permeameters” developed for the Internal Stability Tests, for example, is a full one metre in diameter which is double the size of any previous, similar equipment. The Crack Holding Test apparatus, as well, is an entirely new design that provides a more realistic assessment of the post-earthquake behaviour of dam cores. These new testing facilities provide BC Hydro with unique capabilities and are drawing international attention.

In September, Dr. Mark Foster from Australia and Dr. Jonathan Fannin from the University of British Columbia, internationally recognized experts in the internal erosion of dams, reviewed the laboratory testing program. They confirmed that the facilities have been successfully commissioned and that the facilities and personnel are ready to progress to production-level testing for the intended goal of informing the performance assessment of BC Hydro’s extreme and high consequence embankment dams, like WAC Bennett, Mica, Strathcona, and others. They further commented that the adopted innovations and refinements to analysis of the test data have advanced the state-of-practice in laboratory testing for all three types of test.