7.0: 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 January 1 to March 31, 2024 (F2024 Q4) 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 March 31, 2024, but before the completion of this report have also been included.

The key highlights from F2024 Q4 and the beginning of F2025 Q1 documented in this report are:

- BC Hydro's audit of the Dam Safety Program has been completed and the Summary Audit Report has now been submitted to the Board of Directors' Audit and Finance Committee. Overall, the Audit Rating from the Dam Safety Program was "Green," with some minor issues and impacts identified and the further observation that the Program is applying industry leading practices in many areas. See page 7.
- The completion rate of dam inspections remained very high through F2024. All 71 formal, annual and semi-annual inspections and reports were completed, and 1640 of 1644 routine weekly, monthly and quarterly inspections were completed as scheduled. See page 8.
- The use of satellite remote sensing for landslide detection and monitoring around BC Hydro's reservoirs was expanded, providing new understanding of the landslide complex on Santa Claus Mountain on Seton Lake, confirming our understanding of the landslide activity around Kinbasket Lake Reservoir (Mica Dam), and showing no indication throughout the southern interior of British Columbia of any other large-scale landslides that could impact safe dam/reservoir operations. See page 9.
- High completion rates were achieved for civil maintenance. For the condition-base civil maintenance program, changes to the plan arising from the capitalization of some projects allowed for the late addition and completion more projects than were originally planned, and completion to within $3000 of the annual budget. See page 10.
- There were no missed tests of spillway gates in F2024. The number of outstanding maintenance tasks on spillway gates was held steady through the year, with a small net reduction from 104 to 100. See pages 11-13.
- Construction on the John Hart Dam Seismic Upgrade Project continued with completion of the plastic concrete cut-off wall on the Middle Earthfill Dam. Improved performance of the dam has already been observed. Greatly reduced flows through weirs and measured water pressures in the dam body are clearly demonstrating that the new cut-off wall is a significantly more effective water barrier than the dam's old slurry wall. See page 16.

Presenter: Bob Schubak (Director, Dam Safety)

7.0: 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. 3-4):** The aggregated Vulnerability Index increased by 8.2 through F2024 Q4, with the Terzaghi spillway out of service due to rockfall and recharacterization of the seismic deficiency of penstock supports at Kootenay Canal. • **Program Non-Conformances (p. 5):** The total number of Non-Conformances was slightly reduced by 2 through Q4. • **New and Current Issues (pp. 5-6):** Planning and preparations to clear the rockfall from the Terzaghi Dam spillway progressed.
Regulatory Compliance	G →	• **Operation, Maintenance and Surveillance Manual Updates (pp. 6-7):** All required updates were issued on time and in compliance with the Dam Safety Regulation. • **Dam Safety Reviews (p. 7):** All required Dam Safety Reviews were issued on time and in compliance with the Dam Safety Regulation. Five Reviews remained unfinished but draft reports are in review and are not due until the end of calendar year 2024. • **Dam Safety Program Audit (p. 7):** BC Hydro’s internal audit of the Dam Safety Program was completed with a rating of “Green”, with some minor issues and impacts identified.
Surveillance	G →	• **Dam Inspections (pp. 8):** Through the course of F2024, 1640 of 1644 scheduled routine inspections were completed and all 71 required formal inspection reports were issued. • **Reservoir Slopes (p. 9):** The use of satellite remote sensing was expanded, identifying no new large-scale landslides across the entire southern interior region of the province that could impact safe dam/reservoir operations and advancing our understanding of the Santa Claus Mountain landslide complex on Seton Lake.
Maintenance and Testing	G →	• **Civil Maintenance (p. 10):** Preventative and condition-based civil maintenance achieved strong results with high rates of completion in F2024. • **Spillway Gates (pp. 11-13):** Through F2024, all of nearly 1000 scheduled gate tests were performed; four gates failed to operate on demand, and the number of outstanding maintenance tasks held roughly steady (decreased by four).
Projects and Investigations	G →	• **Capital Projects (pp. 14-18):** Construction of the plastic concrete cut-off wall on the Middle Earthfill Dam at John Hart has been completed and improved performance of the dam has already been observed. • **Dam Safety Investigations (p. 18):** A pilot study to compare methodologies for modelling of landslide-induced waves in reservoirs was completed. Results have provided confidence in their use for future landslide generated wave assessments.

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 Q4 are identified in Figure 1 and described below.

1. An ***addition*** of 7.5 (Actual Normal deficiency) at ***Terzaghi Dam***.
   As reported in the F2024 Q3 Quarterly Dam Safety Report, a significant amount of rock has fallen into the lower portion of the spillway chute, partially blocking the spillway and preventing its safe use. BC Hydro has temporarily removed the spillway from service. The Vulnerability Index has been calculated following the same methodology as for out-of-service spillway gates, described in the F2022 Q4 Quarterly Dam Safety Report. Refer to "Update on Existing Issues", later in this report, for the status of this issue and work underway to address it in F2025.

2. An ***addition*** of 0.67 (Actual Unusual deficiency) at ***Kootenay Canal***.
   This issue was recharacterized and rated in Q4 of F2024. The concrete supports for the facility's four penstocks can resist the imposed loads from an earthquake having peak ground acceleration of approximately 0.1g, expected to occur at the site approximately once every 2500 years. This is less than the 0.24g peak ground acceleration corresponding to the facility's Safety Evaluation Earthquake expected to occur once every 10,000 years. A project to upgrade the penstock supports in planned for release in F2026.

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. As evident in Table 1, below, Vulnerability Index reductions did not meet the target pace in F2024, which was primarily due to the timing of the Program's portfolio of risk reduction projects.

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

		Actual	Target	
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	5.1	12	✘
	Reductions – Fiscal Year	5.1	12	✘
	Additions - Last 4 quarters	10.2		

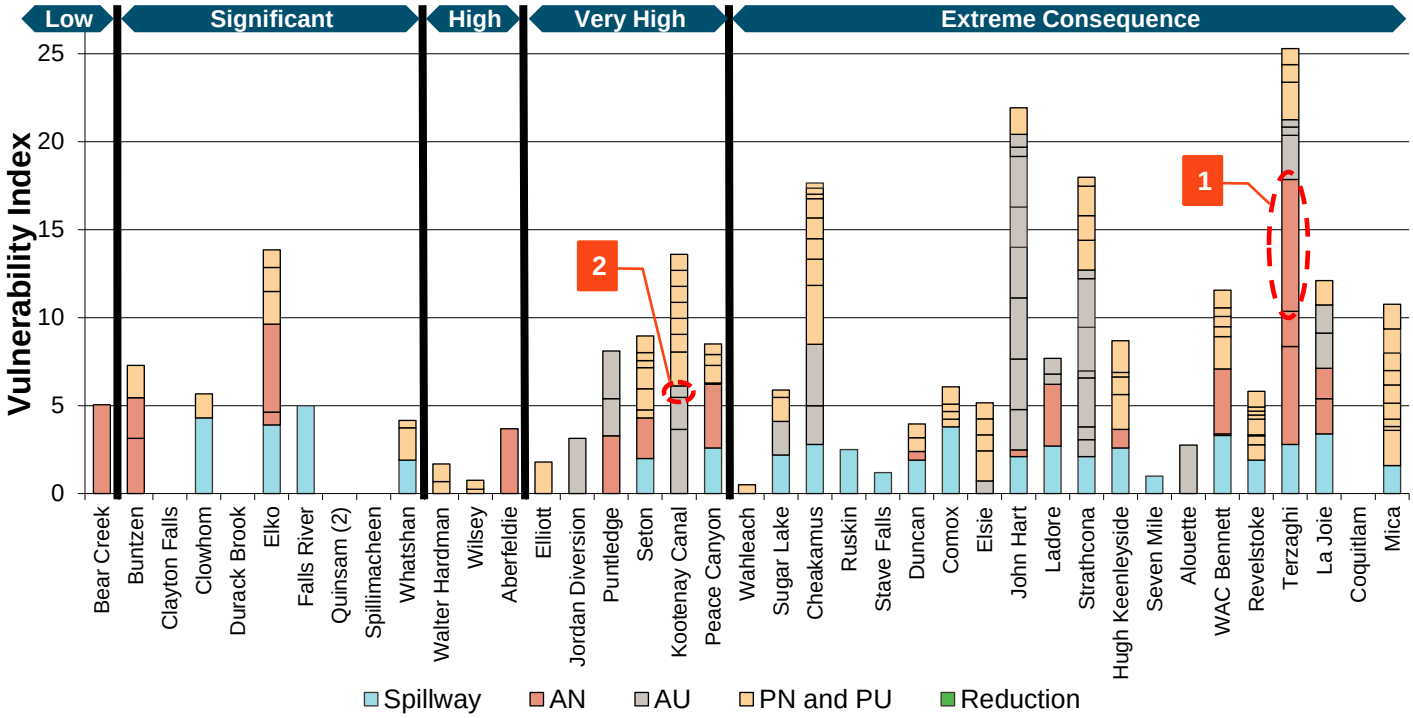

Figure 1 Dam Safety overall risk profile at the end of F2024 Q4, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

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.

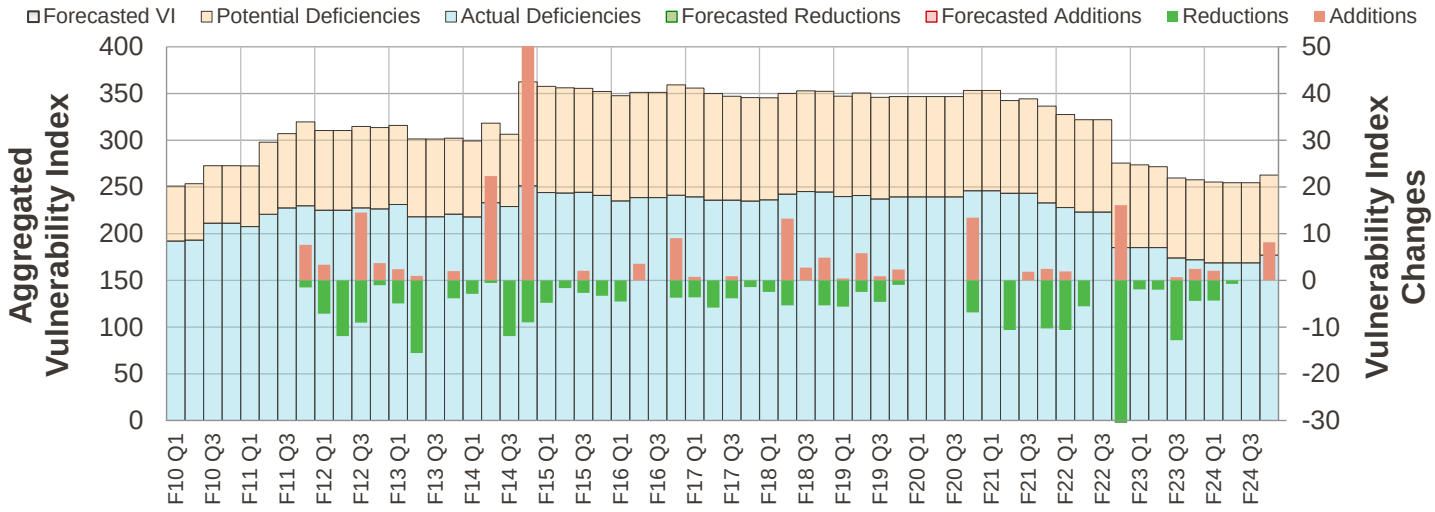

Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

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. In F2024 Q4, three Non-Conformance issues were resolved and closed, and one new Non-Conformance issue was identified. Figure 3, below, illustrates the ongoing reduction in the number of Non-Conformance issues within the Dam Safety Program.

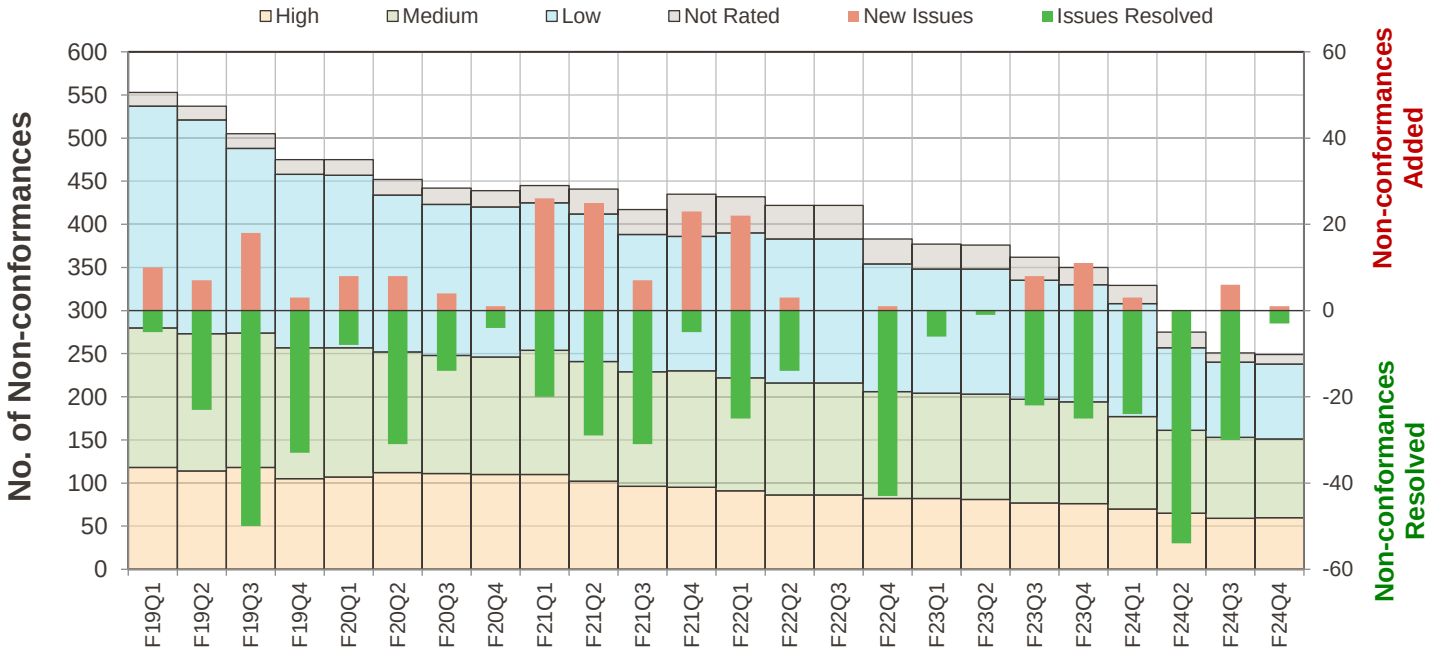

Figure 3 Changes and trends in the total number of Non-Conformance issues (characterized by level of importance) within the Dam Safety Program.

New Issues

The only new issue that arose in F2024 Q4 was the rockfall into the Terzaghi Dam spillway chute, which was reported in the F2024 Q3 Quarterly Dam Safety report. See below for an update on progress to address this issue.

Update on Existing Issues

Rockfall in Terzaghi Dam Spillway Chute

As described in the F2024 Q3 Quarterly Dam Safety report, at some time between January 11 and January 15, 2024, several hundred cubic metres of rock fell from the steep slope adjacent to the spillway at Terzaghi Dam, blocking the spillway.

The planning to remove this rock from the spillway has progressed significantly. The work is expected to be performed by lowering remotely controlled units – specialized for demolition and excavation in hazardous environments – to break up and move the rock so that it can be removed by a crawler crane from the side of the spillway. No personnel will be

required to enter the spillway. The designs for the required access road and crane pad have been completed and road materials are being sourced; a First Nations contractor has been retained and is actively working with BC Hydro to prepare detailed work plans; and the specialized equipment has been identified and is being procured.

The project team is targeting late May or early June to mobilize for road construction, and late July or early August to begin the rock removal with completion in September or October.

Puntledge Penstock Overpressure

The F2024 Q3 Quarterly Dam Safety report described an overpressure event in the penstock at the Puntledge Generating Station that occurred during a manual shutdown of the generating unit in December 2023. This overpressure was determined to have arisen from a time lag between closing of the generator's wicket gates and opening of the facility's pressure relief valve.

The root cause analysis has been completed and has concluded that a combination of minor adjustment issues in the mechanical linkages and failure of the unit speed signal combined to cause the delay in relief valve opening. Repairs and maintenance to the governor and pressure relief valve were completed and the generating unit at Puntledge was returned to service on January 25, 2024.

Hugh Keenleyside Dam – Navigation Lock Floating Guide Wall

The F2020 Q4 Dam Safety Quarterly Report described the January 13, 2020 sinking of two pontoons of the upstream floating guide wall that directs marine traffic safely into the navigation lock. The project to salvage the sunken pontoons and move them to another location – where the pontoons can be safely inspected and potentially rehabilitated for return to service in an upgraded guide wall – was initiated and progressed through Q4. Effort was made to complete the salvage prior to a required increase of flows through the dam commencing June 1, 2024. In April the project team determined that the engineering was not yet sufficiently advanced to safely undertake the work in the spring of 2024. Engineering and construction planning work will continue in efforts to enable salvage operations within a potential window in the late summer or early fall of 2024.

Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

Work continued on the Evidentiary Update for the Ladore Spillway Seismic Upgrade Project and the Strathcona Discharge Upgrade Project Application that is due for submission on May 31, 2024.

Regulatory Communications – Comptroller of Water Rights

BC Hydro had requested clarification from the Provincial Dam Safety Office on whether an Independent Engineer will be required for the Ladore Dam Spillway Seismic Upgrade Project and, in Q4, the response that an Independent Engineer will be required was received. A request for acceptance of the instrumentation work at Peace Canyon Dam was submitted and approved. A request for acceptance of instrumentation at Wahleach Dam was submitted in February. The plan for decommissioning Durack Brook Dam was submitted for acceptance in March.

Follow-up reports were provided for the La Joie Dam investigation results, the Casper Creek Fire (Bridge River) response, and the Blind Slough Dam Gantry Crane Rail repairs, as requested by the Dam Safety Office.

7.0: Quarterly Dam Safety Report

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. All five Manual updates that were required by the Dam Safety Regulation in F2024 were completed and issued prior to their regulatory deadline of December 31, 2023.

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.

The Dam Safety Review report for Ruskin Dam was issued in November 2023 and the final Stave Falls Dam report was received from the consultant and issued in March 2024. Five other reviews will be due on December 31, 2024 per the Dam Safety Regulation, but were targeted for early completion in Q4 of F2024. Of these five, the final report for Cheakamus Dam was received from the consultant and issued in April, and the final draft report has been received for Wilsey Dam and is expected to be issued in Q1 of F2025. Draft reports have been received for Comox, John Hart, and WAC Bennett Dams but require further work before finalizing.

In F2025, Dam Safety Reviews are scheduled for Alouette, Duncan, Elliott, Revelstoke, and Seven Mile Dams. Consultants have been selected for these reviews and work orders are currently being set up.

Dam Safety Program Audit

BC Hydro's audit of the Dam Safety Program, performed on a five-year recurrence and last performed in F2019, has been completed. The audit was conducted by BC Hydro Audit Services and supported by three external subject matter experts: Tony Bennett, formerly Director of Dam and Public Safety for Ontario Power Generation, and Tom McDermott and Susan Steyn of the Woodhouse Partnership, a highly recognized asset management consulting firm.

The Summary Audit Report has now been submitted to the Board of Directors' Audit and Finance Committee. Overall, the Audit Rating from the Dam Safety Program was "Green", with some minor issues and impacts identified. The salient findings summarized within that report are:

- The Dam Safety Program is effectively managing risks, complies with regulatory requirements, and is applying industry-leading practices in many areas;
- Effective governance processes are in place to enable oversight of the Dam Safety Program; and
- Some opportunities for improvement – principally relating to management of the Dam Safety Issues Database, maintenance practices, and emergency management processes – exist and have been detailed in an accompanying Management Audit Report. These recommendations have been reviewed and action plans to address them have been prepared.

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 Q4		Fiscal Year F2024	
		Actual	Target	Actual	Target
Routine dam inspections	Completed	411/411 = 100%	100%	1640/1644 = 99.8%	99.5% ✓
	Missed	0		4	
Formal (annual and semi-annual) dam inspections	Field work completed	0	0	71	71 ✓
	Reports issued	36	40	71	71 ✓
Instrumentation data checks		196/195 = 100%	97%	778/780 = 99.7%	97% ✓
Reservoir slopes inspections	Field work completed	0	0	17	19 ✗
	Reports issued	11	7	19	19 ✓

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. All 411 of the scheduled routine inspections were completed in Q4.

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. All 71 of these required inspections and reports were completed in F2024.

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. 196 checks were completed against a plan of 195 in Q4.

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.

As was noted in the F2024 Q3 Quarterly Dam Safety Report, the inspections of the landslides at Santa Claus and Wedge Drop Mountains could not be performed due to the wildfires in the Bridge River region. Reports for these landslides were nevertheless issued, documenting that the inspections could not be completed and, as available, the assessment of satellite-acquired remote sensing (Interferometric Synthetic Aperture Radar, or “InSAR”) data. For the Santa Claus Mountain landslide, the analysis identified landslide displacement rates that agree closely with historical site survey data. It further identified that the active landslide complex is larger than previously assessed in a 1988 investigation, extending from the ridge crest down to the reservoir level and covering an area of about 20 square kilometres. This information will advance our understanding of that landslide complex and the potential hazard it poses to the Seton Reservoir.

Continuing use of satellite data to monitor the southern Revelstoke Reservoir, focused on the St. Cyr landslide, confirmed landslide activity continues at rates generally consistent with previously identified trends.

The use of satellite data for landslide detection and monitoring around BC Hydro’s reservoirs was expanded to include Kinbasket Lake Reservoir (impounded by Mica Dam), for which the data confirmed landslide activity in areas that were previously identified and, importantly, that no other large scale landslides are evident.

Satellite remote sensing coverage was further expanded to a large portion of the province’s Southern Interior region, extending south from the Revelstoke Reservoir to the International Boundary and encompassing the reservoir slopes for Revelstoke, Hugh Keenleyside, Sugar Lake, Walter Hardman, Whatshan, Duncan, Kootenay Canal, Seven Mile and Waneta Dams. No new large-scale landslides that could impact safe dam/reservoir operations were identified.

Unusual Events or Observations

The Dam Safety On Call Person responded to 151 calls in Q4, which typically includes instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications. This number of calls and responses is higher than normal, but is primarily due to instrumentation alarms being triggered by work activities, including:

- Significant (and desirable) changes in instrumentation readings at John Hart due to the completion of the plastic concrete cut off wall within the John Hart Dam Seismic Upgrade Project (see the description under the “Capital Projects” section of this report), which were expected and indicate good performance of the newly constructed cut off wall; and
- False instrumentation alarms triggered by ongoing maintenance work at a number of sites.

This additional alarm activity is not indicative of any developing performance concerns but, rather, a temporary consequence of BC Hydro’s work to improve the performance of our dams.

Civil Maintenance

Results for the Preventive and Condition-Based Civil Maintenance programs are summarized in Table 3, below.

Table 3 Dam Safety and Generation Civil Maintenance for F2024.

		Quarter Q4		Fiscal Year F2024	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Spend ($k)	965	560	3502	3500
	Work Orders Completed	11	3	32	29
Preventative Maintenance	Tasks Completed	136	66	737/759 = 97%	

Preventive Maintenance

For various reasons, including wildfire impacts and changed outages to meet operational imperatives, 100 preventive maintenance tasks could not be completed in F2024, and in Q4 an approved Change Notice deferred their completion to F2025. Of the 759 tasks that remained in F24 plan, strong results were achieved with 737 (97%) of those tasks completed.

Corrective and Condition-Based Maintenance

As was described in the F2024 Q3 Quarterly Dam Safety Report, there were significant changes to the plan with the capitalization of various work orders and the addition of four new work orders to make use of the available budget. Despite these late changes, the adjusted program was precisely on budget (to within $3000) and fully delivered by the Programs and Contract Management team.

One of the late additions was to repair deteriorated concrete on the Bridge River 2 Penstock Inlet Valve pedestals. Because these pedestals are indoors, the work could be completed over the winter. Stations Maintenance Engineering developed the repair procedure and BC Hydro Construction Services performed the repairs. See photos in Figure 4 at right.

Figure 4 Top: deteriorated concrete pedestal at Bridge River 2 Generating Station. Bottom: concrete pedestal after completed repairs.

Spillway Gate Testing and Maintenance

Spillway Gate Testing

During Q4 of F2024, all 242 scheduled gate tests were completed, including annual gate tests of 26 gates. Table 4 below provides key metrics related to spillway gate testing.

Table 4 Spillway gate testing results for F2024 Q4.

		Quarter Q4		Fiscal Year F2024	
		Actual	Target	Actual	Target
Monthly Tests	Completed	242/242 =100%	100% ✓	953/951 =100%	98% ✓
	Missed	**0**		**0**	
Gates Failing to Operate on Demand during Testing	No. of failures	**3**		**4**	
	Failure rate	3/242 = 1.2%		4/953= 0.4%	

Three gates failed to operate on demand in Q4:

- In January, the Cheakamus low level outlet gate was frozen, and operators were unable to move the gate. This has occurred previously and appears to be a design limitation of the gate system.
- Terzaghi low level outlet gate 1 was successfully tested on March 6 but during routine adjustments to environmental flows in the week of March 25 the gate would not open beyond 80.5 mm. The gate was cycled several times with no improvement. Environmental flows continued to be provided through this gate but were restricted to the 80.5 mm gate opening. Crews were subsequently able to open the gate further and restore it to service in the week of April 2. This gate position is known to be a “sticky point” for operation. Options for troubleshooting and improving the gate’s operation until permanent upgrades are completed (see page 12) will be investigated.
- In March, Falls River spillway operating gate 2 failed to operate using remote controls with power from the spillway diesel, the scheduled configuration for the monthly testing. (The gate was successfully operated through local control, but still considered to be a failed test.) This issue with remote operation while using the spillway diesel at Falls River was previously investigated and a solution was implemented, but commissioning of the solution in January 2024 and this March test show the issue was only partially corrected. Further investigation is in progress.

Exceptions to Gate Testing Program

As described in the F2024 Q3 Quarterly Dam Safety Report, the elevator to the Hugh Keenleyside Dam gate hoist house was out of service in January and February, so the scope of monthly spillway gate testing was reduced; the four spillway gates were operated from the control room, but the other monthly maintenance set out in the maintenance program was not performed. The elevator was returned to service in Q4, and annual maintenance and testing was completed on the four spillway gates in March. Testing of the eight low level outlet gates continued unaffected.

Gate testing scopes were reduced to exclude gate movements at:

- Terzaghi Dam for one low level outlet gate because the position transducer is broken, and operators are unable to determine gate position.

- John Hart Dam for the three spillway gates due to construction for the John Hart Dam Seismic Upgrade Project.
- Various sites, for a total of fifty gate tests, due to winter conditions.

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. At the time of writing this report, all spillway gates and flood passage devices are in service except at Terzaghi Dam. The Terzaghi Dam discharge facilities include a spillway with two spillway operating gates and a free overflow crest, and two low level operating gates. The low level outlets are used for both flood routing and ongoing environmental flows.

- As described in the F2024 Q3 Quarterly Dam Safety report, the two spillway gates at Terzaghi Dam are operational, available and being maintained, but the rockfall into the spillway chute (see Update on Existing Issues, pages 5-6) means the spillway should not be used to release flow until the rockfall is cleared, targeted for completion in late summer or early fall of 2024.
- The gate position of one of the two low level outlet gates at Terzaghi Dam is not visible to operators. The gate remains operable for large releases, since gate position is not critical for large releases, but it has not been regularly tested through the winter and is not useable for the required environmental flows. As the gates are inaccessible in the winter due to safety concerns, repair of the position indication has not yet been undertaken but is currently scheduled for July 2024. In the longer term, the Terzaghi Low Level Discharge Reliability Improvement Project is in progress with a planned in service date in 2030.

Spillway Gate Maintenance

Spillway gate maintenance results for Q4 and F2024 overall are shown in Table 5. Completion of planned condition-based maintenance tasks was less than 60 percent through the year but was offset by completion of unplanned, emergent tasks. In efforts to improve the completion of planned maintenance, Dam Safety has reviewed the F2025 plan with Operations in consideration of required outages and resourcing, availability of equipment and parts, and understanding of the work scope. Currently, 36 condition-based maintenance tasks are included in the F25 plan and have been accepted by Operations, and a number of additional tasks are being discussed for potential inclusion in the plan.

Table 5 Spillway gate maintenance results for F2024.

Corrective and Condition-Based Maintenance Tasks	Quarter Q4		Fiscal Year F2024
	Completed	Planned	
Planned Tasks	5	15	28/48 = 58%
Emergent Tasks	13		24

The number of outstanding gate maintenance tasks is shown in the chart in Figure 7. Following significant decreases in each year from F2020 through F2023, the inventory only decreased slightly this year; from 104 outstanding tasks at the end of F23 to 100 at the end of F2024.

Dam Safety identifies “high priority” spillway gate maintenance tasks as those where the asset either shows moderate to severe signs of deterioration or its ability to perform its intended function may be compromised, and where the asset’s failure could lead to loss of reservoir control, though perhaps with a long intervention time available. The number of high

priority tasks at the end of F2024 was 12; an increase from 9 in Q4 but a decrease from 14 from F2023. Eight of these outstanding high priority tasks are included in the F2025 maintenance plan. The other four high priority tasks cannot be completed in F2025 but have been reviewed and can safely be deferred to a future year.

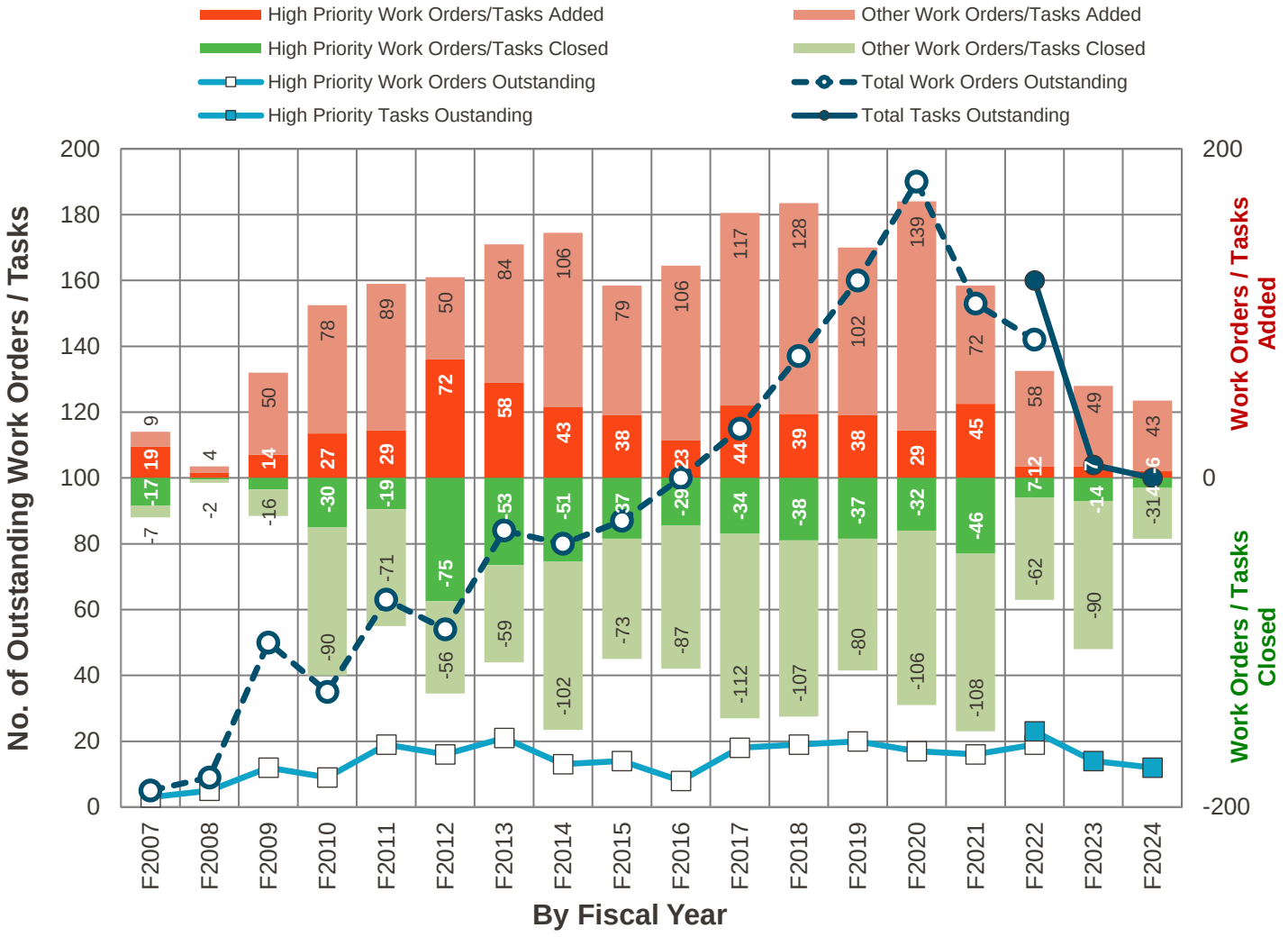

Figure 7 Number of outstanding corrective and condition-based spillway gate maintenance work orders and tasks, new work orders and tasks added, and work orders and tasks closed as at the end of each previous fiscal year.

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

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.

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.

The recently hired Dam Safety Engineer and Dam Safety Technologist were onboarded and are familiarizing with the facility. The facility's second Technologist has now also been onboarded and is joining the others in familiarizing and preparing for reservoir fill.

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

This project is upgrading various components of the tunnel that diverts water from Alouette Lake to Stave Lake to assure post-earthquake control of the Alouette Lake Reservoir following a major earthquake. Components being upgraded 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 operation of the tunnel's operating gate on the tunnel's Stave Lake end.

The first stage of construction comprising upgrades on the Stave Lake end of the tunnel continued in Q4 of F2024 with stabilizing the slopes above the surge tower, improving the surge tower superstructure, and preparing the back-up power and communications site. The supplier of the backup power and communications system recently filed for bankruptcy and the contractor was forced to secure a new supplier for the equipment. As a result, the installation of the backup power and control equipment will not meet the planned in-service date. While the remainder of the first stage civil works will be placed into service in October 2024, as planned, the backup power and control system will now be placed into service in March 2025.

Bridge River 1 Penstock Concrete Foundation Refurbishment

The concrete foundations of the four penstocks at Bridge River 1 Generating Station have visible cracks and spalls, and their steel supports have physical defects such as corrosion and deformations due to rock impacts. Inadequate and deteriorated slope protection measures along the penstocks' alignment had led to much of the foundations and penstocks being buried in loose rock and other debris, preventing the necessary refurbishment of the foundations and steel supports and the planned recoating of the penstocks in 2026. This project was initiated in 2021 to remove the rock debris, refurbish the concrete foundations and steel penstock supports, and refurbish and upgrade the slope protection and stabilization works to ensure the continued serviceability of the penstocks.

Debris removal was completed in May of 2023 and slope stabilization along the penstock alignments was completed in December of 2023. In F2024 Q4, Construction Services completed the penstock foundation refurbishment work in the powerhouse tunnels. A First Nations contractor has now mobilized to site to perform the penstock foundation refurbishment work on the slope. The project is forecasting to be in service in December 2024.

Figure 6 Refurbishment of the Bridge River 1 penstocks. Left: aerial view of the penstocks. Top right: accumulated debris prior to removal. Middle right: penstock trench after debris removal. Bottom right: shotcrete stabilization of penstock trench wall.

John Hart Dam Seismic Upgrade Project

On the Middle Earthfill Dam, construction of the new plastic concrete cut-off wall has been completed. The procedure for constructing this new seepage barrier in the dam was described in the F2024 Q3 Quarterly Dam Safety report. With its completion, improved performance of the dam has already been observed. Flows through weirs downstream of the Middle Earthfill dam have been reduced to approximately one-half of the historical measured lows, and piezometers measuring water pressures in the dam body have recorded significantly reduced water levels downstream of the wall and increased water levels – essentially at reservoir level – upstream of the new wall and downstream of the old “slurry wall” water barrier; all of which demonstrate that the new cut-off wall is a significantly more effective water barrier than the old one.

On the North Earthfill Dam, in-water excavation and riprap removal has been completed and placement and densification of the dam’s upstream stabilizing berm is underway, as are preparations for the placement of the dam’s downstream stabilizing berm. On the Concrete Main Dam, construction to build a new right training wall, and place infill concrete under the roadway on blocks 13-15 on the left side of the spillway is underway, and construction to raise the spillway’s left training wall is complete.

See Figure 7 at right.

Figure 7 Top: View of the North Earthfill Dam at John Hart, with the upstream berm densification work taking place on the far right and, in the foreground, preparations for the placement for the downstream berm. Bottom: the completed left training wall and concrete placement for the right training wall (inset).

G.M. Shrum Intake Operating Gate Hydraulic Upgrade and Gates Refurbishment

This project at G.M. Shrum Generating Station will upgrade the intake operating gates hydraulic systems to address deficiencies and improve gate system reliability and will refurbish the intake operating and maintenance gates to extend their service life. The project progressed to Feasibility Design in F2024 Q4 with the leading alternative to replace the hydraulic cylinders, hydraulic power units, hydraulic control cabinets, high pressure piping and the DC power supply, and refurbish the intake operating and maintenance gates, lifting beam, gate embedded guides and the dogging devices. Although the leading alternative for the intake operating gates is refurbishment, the project strategy is to first fabricate two new intake gates to replace two gates with minimized outage duration. The removed gates will then be refurbished and then used to replace the next two gates with minimized outage durations and cost. This cycle will be repeated for the remainder of the gates. Construction is planned for F2028 through F2033.

Mica Unit 5 and Unit 6 Water Passage Coatings Restoration

Mica Generating Station has six water passages with 256 metre long steel penstocks, each feeding a single generating unit. The first four units went into service between 1976 and 1977 while Units 5 and 6 were commissioned between 2015 and 2016. As the water passages for Units 5 and 6 sat empty for an extended period, their coatings deteriorated and are now considered to be in poor or unsatisfactory condition. The coatings need to be replaced in order to preserve the structural integrity of the underlying metal. This project to restore the coatings of the Unit 5 and Unit 6 water passages was released in F2024 Q4.

Terzaghi Spillway Chute Access Improvement

The objective of this project is to sufficiently mitigate the hazard of rockfall into the Terzaghi Dam spillway to safely allow detailed in-chute inspection of the Terzaghi Dam spillway structure, drain maintenance, concrete repairs, and, if required, subsequent capital projects to improve the spillway.

In F2024 Q4, the project secured endorsement to proceed to Definition Phase. Presently, the project team members are leading the work to clean up the rockfall that is discussed in the “Update on Existing Issues” (pp. 5-6). Project scope to build a ramp and crane pad alongside the spillway chute, originally required for project construction logistics, will be advanced to support that clean-up effort.

The full impacts of the rockslide on project scope and schedule are still to be confirmed. The project has added scope to complete removal of burned and hazardous trees from the slope due to the 2023 Casper Creek Wildfire and, as a priority, to address a small added rockfall area over the tunnel portal that presents a potential risk to workers and the public using the road. See Figure 8, below.

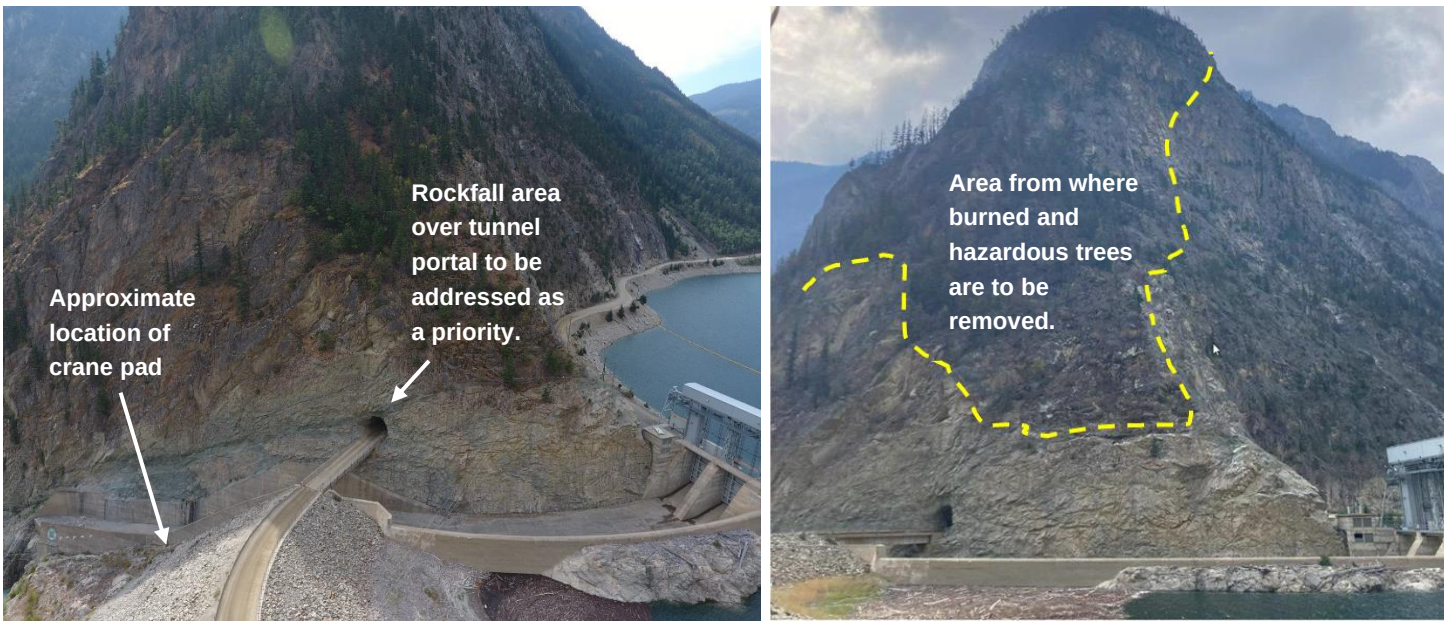

Figure 8 Spillway chute and adjacent rock slope at Terzaghi Dam, with locations of project scope items identified.

Terzaghi Dam Instrumentation Upgrade

The instrumentation system at Terzaghi Dam requires upgrading or replacement. The system is not sufficient to monitor for and detect conditions that could lead to the progression of internal erosion or piping within the foundation, or to support detailed engineering investigations of the dam's performance. Moreover, some of the originally installed instruments are no longer functioning. This project to upgrade the dam instrumentation at Terzaghi Dam was released in F2024 Q4.

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.

Mica – Dutchman's Ridge Slide Generated Wave Modelling

The Quarterly Dam Safety report routinely reports on the Program's surveillance of reservoir slopes. Page 9 of this current report describes recent use satellite-acquired remote sensing (Interferometric Synthetic Aperture Radar, or "InSAR") data to monitor displacements of slopes and to improve our understanding of the locations and extents of landslide complexes. Other recent reports (*e.g.*, F2022 Q2) have described the installation of continuous Global Positioning System ("GPS") towers to augment our abilities to monitor landslide displacements. Along with these new capabilities to identify and monitor landslides, the Dam Safety Program is also turning attention to updating and improving our understanding of the hazards posed by landslides on reservoirs and their potential consequences.

This investigation is a pilot project initiated in F2024 to simulate a landslide into a reservoir and the resultant wave using two different numerical approaches and to compare the results with those from empirical and physical hydraulic models. The investigation is intended to establish a standard methodology for future BC Hydro landslide wave modelling studies. It is being conducted by the Hydrotechnical Engineering Team in BC Hydro's Generation Stations Civil Engineering Division in consultation with Polytechnique Montréal.

The pilot study simulated a postulated 38 million cubic metre landslide into Kinbasket Lake from Dutchman's Ridge, located approximately 1.5 km upstream of Mica Dam. The study applied two different numerical modelling approaches – the Smoothed Particle Hydrodynamics modelling approach as well as preliminary testing with conventional Computational Fluid Dynamics software – to predict wave heights for the Dutchman's Ridge Slide. These approaches were compared to results from a 1970 physical hydraulic model study and to several empirical calculation methods. Comparable maximum wave heights were obtained using different approaches during this study, which has increased confidence in the use of these numerical tools for landslide generated wave assessments.

Dam Safety and Hydrotechnical Engineering are planning to further employ these tools to assess landslide generated waves identified in the Upper Columbia region that may impact Mica and/or Revelstoke Dams.