

Dam Safety Quarterly Report

Executive summary

The purpose of this report is to update the Operations, Planning, Information & Technology Committee of the Board of Directors on key dam risk management activities during the period from April 1 to June 30, 2022 and to provide reasonable assurance that the safety of dams operated by BC Hydro continues to be managed to the established guidelines and criteria of the Dam Safety Program. To keep the Committee as fully abreast of the Dam Safety Program as possible, some notable developments that took place after June 30, 2022 but before the completion of this report have also been included.

This quarter's report introduces a new section that provides updates on activities to integrate the Site C Clean Energy Project's design and construction and the eventually constructed facilities into BC Hydro's Dam Safety Program.

The key highlights from F2023 Q1 documented in this report are:

















- The system's aggregated Vulnerability Index remained stable through F2023 Q1, with a small decrease of 1.9 through the quarter. See page 3.
- There is potential for a surcharge of Kinbasket Reservoir (Mica Dam) and an expectation of one at Downton Reservoir (La Joie Dam) in Q2. Interim Dam Safety Risk Management Plans have been prepared and are ready to be implemented. See pages 5 and 6.
- During the April monthly inspection, a hinge connecting two segments of the floating guidewall for the navigation lock at the Hugh Keenleyside Dam was observed to have failed. An emergent project has temporarily braced the connection and a newly fabricated replacement hinge will be installed in September. See page 6.
- Inspections and monitoring within the Surveillance program progressed to plan. A new use of the "Inspection App" to notify Dam Safety Engineers of any inspections that have not been completed by Thursday of each week was rolled out. This is expected to further improve the high completion rate of routine scheduled inspections. See pages 8 and 9.
- Maintenance on the civil and spillway gate assets progressed well with strong completion results through Q1. Strengthened oversight by Programs and Contract Management and increased collaboration by Dam Safety, Stations Field Operations and Programs and Contract Management in planning of the work programs appear to be yielding improved results. See pages 10-13.
- Functionality has been restored to a spillway gate at the Ruskin Dam and a low level outlet gate at the Terzaghi Dam. Closure of the database issues described in last quarter's report and adjustments to the Vulnerability Indices are pending. See pages 11 and 12.
- Construction of concrete basins at the top of each surge shaft at Bridge River 1 to contain potential overtopping flows was completed in Q1. See page 16.
- Recoating of the interior of Bridge River 2 Penstock 2 was completed slightly ahead of schedule. See page 17.

Presenter: Bob Schubak, Director, Dam Safety

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Dam Safety Program Dashboard

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

Risk Profile and Issues Management	 	<ul style="list-style-type: none"> • Vulnerability Index (pp. 3-4): The aggregated Vulnerability Index was reduced by 1.9 through Q1. • Program Non-Conformances (p. 5): The total number of non-conformances was reduced by 6 through Q1. • New and Current Issues (pp. 5-7): Recurring potential or forecasted reservoir surcharges of Kinbasket and Downton Reservoirs are being managed. A failed hinge on the Keenleyside Dam’s navigation lock floating guidewall has been temporarily braced and replacement is planned for September.
Regulatory Compliance	 	<ul style="list-style-type: none"> • Operation, Maintenance and Surveillance Manual Updates (p. 7): Work commenced to plan on scheduled Manual updates. • Dam Safety Reviews (p. 7-8): Two Dam Safety Reviews that were scheduled for completion in F2022 but were held in draft for improvements before issuing to the Comptroller of Water Rights remain in progress, to be issued in Q2.
Surveillance	 	<ul style="list-style-type: none"> • Dam Inspections (pp. 8-9): All 411 scheduled routine dam inspections were completed in Q1. Formal dam inspections progressed ahead of plan. • Reservoir Slopes (p. 9): Reservoir slopes inspections progressed ahead of plan in Q1.
Maintenance and Testing	 	<ul style="list-style-type: none"> • Civil Maintenance (pp. 10): Condition-based and preventative civil maintenance progressed essentially to plan in Q1. • Spillway Gates (pp. 11-13): All 195 scheduled gate tests were completed. Two gates failed to operate on demand. The number of outstanding maintenance tasks decreased by 16 (ten percent) over Q1.
Projects and Investigations	 	<ul style="list-style-type: none"> • Capital Projects (pp. 16-20): Recoating the interior of Penstock 2 at Bridge River 2 is complete, as is construction of surge spill containment basins at Bridge River 1 and drilling for the first of two holes to instrument the St. Cyr Landslide. Site investigations at La Joie Dam with Downton Reservoir drawn down to the toe of the dam have provided important design and constructability information to the project team. • Dam Safety Investigations (p. 20): Fourteen active investigations are underway.
Legend:	     	<p>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.</p> <p>One or more areas within the Program element exhibit or are at risk of underperformance and are being monitored.</p> <p>One or more areas within the Program element exhibit unsatisfactory performance and require correction.</p> <p>Status of the Program element has improved over the quarter.</p> <p>Status of the Program element was unchanged over the quarter.</p> <p>Status of the Program element deteriorated over the quarter.</p>

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Risk Profile of BC Hydro’s Dams

Dam Safety Contribution to Enterprise Risk

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

Vulnerability Index Update

Identified physical deficiencies in BC Hydro’s dams and the degree of concern that exists with respect to their impact on the integrity and performance of the dam are characterized by the Vulnerability Index. The higher the value of the Vulnerability Index (scale of 0-10), the higher the likelihood of that deficiency leading to poor performance. The Vulnerability Index for each identified issue at each dam site is shown in Figure 1. Vulnerability Indices for the individual deficiencies are aggregated into stacked bars for each dam, and dams are sequenced from left to right in order of increasing downstream consequences per the BC Dam Safety Regulation. Changes in Vulnerability Index for actual and potential deficiencies (including those related to spillway reliability), aggregated across the entire fleet of dams, are tracked on a quarterly basis and shown in Figure 2.

There was one notable change in Vulnerability Index in F2023 Q1, as described below and identified in Figure 1.

- 1 A **reduction** of 1.9 (Potential Normal deficiency recharacterized as Potential Unusual deficiency) at **Sugar Lake Dam**.
 Concern for potential internal erosion on the dam’s right abutment has, in part, been related to higher than expected piezometric pressure measurements in the abutment. Recently completed seepage modelling found that high piezometric levels are explained by the abutment’s complex geometry and groundwater recharge coming from the mountain slope above the abutment, and that these piezometric levels are not an indication of defects or deficiencies in the right abutment seepage cut-offs under Normal Load conditions.

Over the last several years, new issues have added to the aggregated Vulnerability Index at a rate of approximately 12 per annum. To prevent deterioration of the overall risk position, reductions in Vulnerability Index through resolved issues should occur at the same pace or faster. Table 1 below confirms that this is presently the case; that Vulnerability Index reductions have far exceeded additions over the past four quarters and that forecast Vulnerability Index reductions through F2023 will just exceed the target.

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

		Actual / Forecast	Target
Dam Safety Vulnerability Index	Reductions - Last 4 quarters	69.7	12 ✓
	Forecast Reductions – Fiscal Year	18.6	12 ✓
	Additions - Last 4 quarters	16.1	

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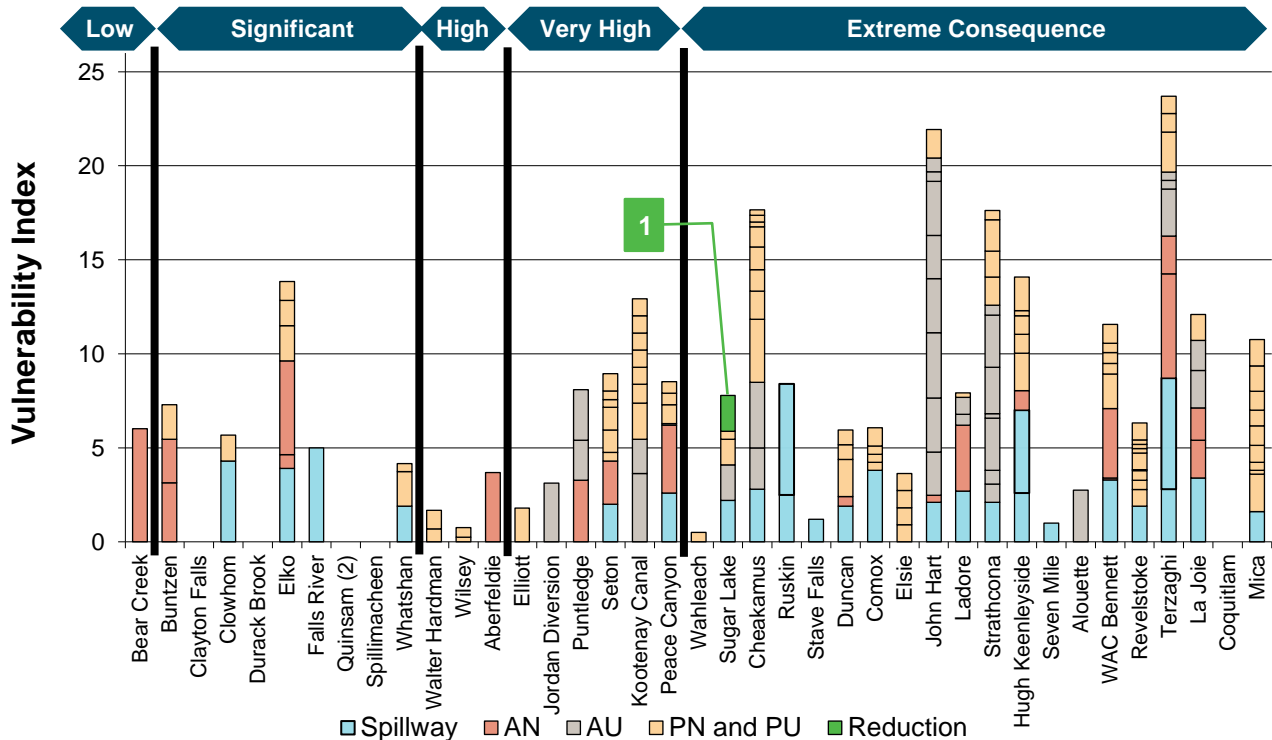


Figure 1 Dam Safety overall risk profile at the end of F2023 Q1, as represented by the Vulnerability Index. Changes this quarter are indicated by the numbered boxes.

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

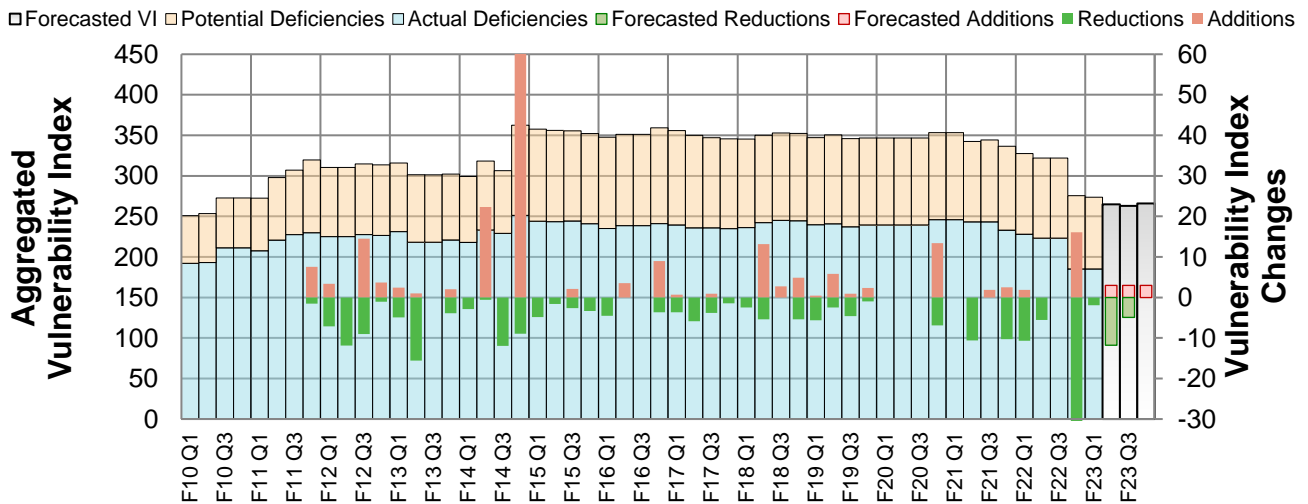


Figure 2 Historical and forecast changes and trends in the Vulnerability Index aggregated across the BC Hydro system.

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Non-Conformances in the Dam Safety Program

Activities to identify, review, resolve and close non-conformance issues continued in F2023 Q1. This quarter, the Dam Safety Engineers issued two sealed memoranda documenting the changes to the Issues Database. As a result, six (6) non-conformance issues were completed. There are currently 377 outstanding non-conformance issues in the database.

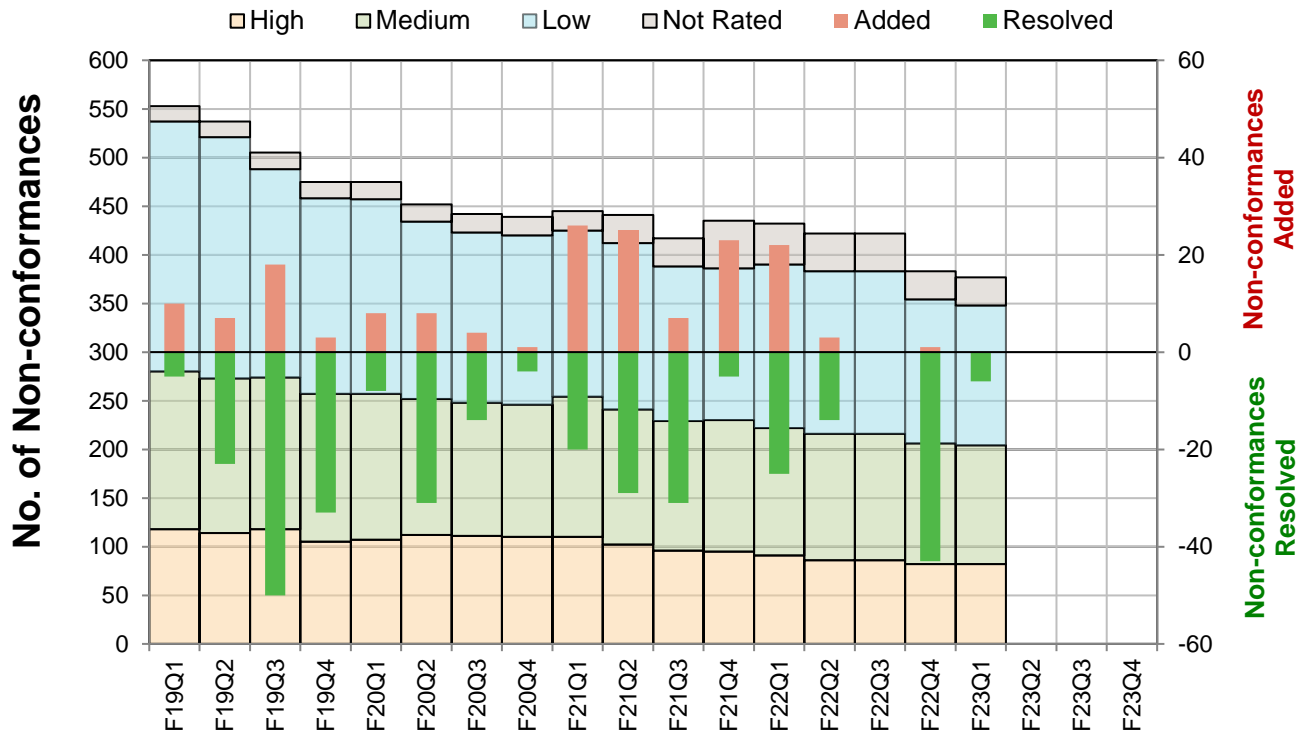


Figure 3 Changes and trends in the total number of non-conformances (characterized by level of importance) within the Dam Safety Program.

New Issues

Mica Dam – Potential Kinbasket Reservoir Surcharge

Due to a combination of record high snow accumulations in many parts of the Columbia basin, late spring snow accumulation, and an unusually late freshet, the June 1, 2022 residual water supply forecast for Mica was 130% of normal. Based on the June forecast, there is a 30 - 50% probability of exceeding the Normal Maximum Reservoir Level (*i.e.*, “surcharging”) and/or spilling. To have the flexibility to best manage the excess water and mitigate any negative effects, BC Hydro applied to the Comptroller of Water Rights for a surcharge order permitting BC Hydro to operate up to 0.3 metres above the Normal Maximum Reservoir Level from July 15 through September 15, 2022. That order was granted by the Comptroller’s office on July 5, 2022. If required, surcharge will take place under an Interim Dam Safety Risk Management Plan similar to the one implemented in 2020 and, with the plan in place, is not expected to incur significant incremental risk at Mica Dam.

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La Joie Dam – Downton Reservoir Surcharge

With an above-normal water supply forecast for the Bridge River system, and to prevent or mitigate spilling down the Lower Bridge River in the environmentally sensitive fall period, there will be a need for a surcharge of Downton Reservoir this year. The current forecast places Downton Reservoir in surcharge from the beginning of August through October. Such surcharges have occurred in each of the previous two years and, as in both of those years, surcharge above the current Normal Maximum Reservoir Level of 734.0 m to a maximum elevation of 740.0 m will be undertaken under an Interim Dam Safety Risk Management Plan that protects against the risk of a cascading failure of Terzaghi Dam in the unlikely event of a failure of La Joie Dam following a major earthquake. See the F2021 Q2 through F2022 Q2 Dam Safety Quarterly Reports for descriptions of those surcharges and additional details regarding the provisions within the Interim Dam Safety Risk Management Plan.

Hugh Keenleyside Dam – Floating Guidewall Hinge Failure

The floating guidewall at the Hugh Keenleyside Dam is made up of four large concrete pontoons that separate the navigation lock from the spillway gates and guide vessels towards the navigation lock. The pontoons are each connected to one another by two large hinges. On April 7, 2022, during a monthly inspection, one of the hinges connecting pontoons 3 and 4 was observed to be cracked and deformed; essentially failed. If the second hinge were to fail, pontoon 4 would detach from the remainder of the guidewall. The pontoon would then be held in location solely by anchor cables to the reservoir bed, allowing sufficient movement that it could impact and damage pontoon 3, further damage itself, or damage or break the spillway debris boom that is connected to it.

An emergent project was promptly initiated to fabricate and install a replacement hinge. Replacing the broken hinge will require a controlled separation of the two pontoons and the use of divers to oversee the work. Engineering has designed a bracing frame to attach to the top of the pontoons to hold the pontoons apart so that the hinge replacement can be carried out safely. The bracing frame was delivered to site and installed in July and is currently serving as a temporary replacement of the failed hinge. Delivery of the replacement hinge is planned for August; installation is planned for September. An Interim Dam Safety Risk Management Plan will remain in place until the hinge is replaced.



Figure 4 Fabricated replacement hinge components (top) and installed bracing frame (bottom).

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Update on Existing Issues

Dam Safety Response to COVID-19

Dam Safety critical work continued through Q1 of F2023 without significant impact. Dam Safety personnel returned to working and dispatching to dam sites from their offices on April 11, under the new Flexible Work Model.

Compliance with Processes and Regulations

Regulatory Communications – British Columbia Utilities Commission

In F2023 Q1, Round 1 Information Requests for the John Hart Dam Seismic Upgrade Project were received on March 31 and April 7, 2022 and responses submitted on May 13, 2022. In Round 1, there were 600 responses and attachments submitted with 168 coordinated through Dam Safety. Round 2 Information Requests were received on June 7, 2022 and responses were submitted on July 8, 2022. There were 198 responses and attachments submitted in Round 2, with 57 coordinated through Dam Safety.

Regulatory Communications – Comptroller of Water Rights

Regulatory Communications with the Provincial Dam Safety Office consisted of a request for approval to carry out invasive investigations at Puntledge Dam, which was approved in May. A letter from the Director of Dam Safety to the Comptroller of Water Rights was sent in June in support of Generation System Operations request for authorization to surcharge Kinbasket Reservoir at Mica Dam. (See “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 a requirement under the Dam Safety Regulation and must be updated every seven to ten years, depending upon the dam’s failure consequences classification.

Updates to seven Manuals are scheduled to begin in F2023. Work on the first three Manuals – for Revelstoke Dam, Cheakamus Dam, and Comox Dam – began in Q1.

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.

Two Dam Safety Reviews (La Joie Dam, Seton Dam) that were scheduled for completion in F2022, as described in the F2022 Q4 report, remain in progress. Revised drafts of the reports for those two Dam Safety Reviews have been received and they are on track for completion and issuing in Q2. Two other Dam Safety Reviews (Terzaghi Dam, Wahleach Dam) that were begun in F2022 are also on track for completion and issuing of the reports in Q3.

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Two additional Dam Safety Reviews are commencing in F2023: Elsie Dam and Ruskin Dam. The site visit for Elsie Dam has been planned for the end of August and completion of the report is scheduled for F2023 Q4. The Dam Safety Review of Ruskin Dam will be started in Q4 and will be completed in 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 Q1		Year-To-Date	
		Actual	Plan	Actual	Target
Routine dam inspections	Completed	411/411 = 100%	100%	411/411 = 100%	99.5% ✓
	Missed	0		0	
Formal (annual and semi-annual) dam inspections	Field work completed	35	20	35	20 ✓
	Reports issued	1	0	1	0 ✓
Instrumentation data checks		199/195 = 102%	95%	199/195 = 102%	95% ✓
Reservoir Slopes inspections	Field work completed	8	4	8	4 ✓
	Reports issued	0	0	0	0

Dam Inspections

Routine Inspections

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

In Q1, all of the 411 scheduled site inspections were completed.

Although there is a very high level of compliance for site inspections, Dam Safety's Data Technology team has implemented a system improvement to automatically notify the Dam Safety Engineer of any impending missed inspections. The work history function of the Inspection App is being used to generate emails to the Dam Safety Engineers of any dam inspections that have yet to be completed. The emails are sent on Thursdays in sufficient time for inspectors and their managers to take any necessary corrective actions to complete the inspections before the end of the week.

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Formal Inspections

Formal inspections of the dams are regulatory inspections completed by Dam Safety Engineers on a semi-annual or annual frequency, as dictated by each dam's Consequence Classification. These inspections include a comprehensive visual inspection, a review of the monitoring data and an assessment of the condition of the water containment and conveyance structures. The Dam Safety Engineers are required to complete 71 of these inspections and reports annually. At the end of Q1 the field work for 35 inspections and one inspection report had been completed, which is ahead of the work plan.

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. 199 of these checks were completed in Q1, which is slightly above the target of 195.

Reservoir Slopes

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

Eight (8) reservoir slope inspections were completed in F2023 Q1, ahead of the work plan, with reports pending. From these inspections, no new landslide issues were identified. Additionally, the one incomplete slope inspection report from F2022 Q4 (see last quarter's report) has now been completed.

Dam Safety is continuing its work to advance the use of satellite-acquired remote sensing (Interferometric Synthetic Aperture Radar, or "InSAR") data for landslide detection and monitoring. The focus of the F2023 program will be the reservoir slopes of the Bridge River system – particularly on Wedge Drop and Santa Claus Mountains – and further monitoring of the St. Cyr Landslide. Any notable results from those efforts will be provided in future reports to this committee.

Unusual Events or Observations

The Dam Safety On Call Person responded to 87 calls in Q1, which typically includes instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications. This number of calls and responses is consistent with expectations and past experience. None were sufficiently noteworthy for inclusion in this report.

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Maintenance and Testing

Civil Maintenance

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

Table 3 Dam Safety and Generation civil maintenance for F2023.

		Quarter Q1		Year-To-Date	
		Actual	Target	Actual	Target
Corrective and Condition-Based Maintenance	Spend (\$k)	936	1,364	936	1,364
	Work Orders Completed	0	0	0/0	
Preventative Maintenance	Tasks Completed	117	130	117/130 = 90%	

Corrective and Condition-Based Maintenance

The corrective and condition-based civil maintenance program was underspent at the end of Q1 by \$428k. This was largely due to a financial reporting error that has since been resolved (\$265k), and to maintenance funding allocated for smaller repairs within the WAC Bennett Dam Spillway Concrete Upgrade Project that will be completed through the summer (\$70k). Overall, this work program is on schedule with the field work for two projects field complete and many other projects well under way.

A comprehensive inspection of the low level outlet at the Alouette Dam was completed in Q1. The inspection included dewatering the low-level outlet that runs under the dam for a detailed pipe inspection and dredging at the intake to perform a diver inspection of the intake's timber bulkhead. This project required significant planning and coordination with Operations, Engineering, Environment, and Indigenous Relations. The inspection was completed in June. No significant defects in the low level outlet were observed.



Figure 5 Alouette Dam low level intake with dredging underway.

Preventative Maintenance

In Q1 of F2023, Stations Field Operations and Engineering Services completed 117 inspections against a plan of 130, a 90% completion rate.

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Spillway Gate Testing and Maintenance

Spillway Gate Testing

Table 4 below provides key metrics related to spillway gate testing.

Table 4 Spillway gate testing results for F2023.

		Quarter Q1		Fiscal Year F2023	
		Actual	Target	Actual	Target
Monthly Tests	Completed	195/195 = 100%	100% ✓	195/195 = 100%	98% ✓
	Missed	0		0	
Gates Failing to Operate on Demand during Testing	No. of failures	2		2	
	Failure rate	2/195 = 1.0%		2/195 = 1.0%	

During Q1 of F2023, 195 of 195 scheduled gate test operations at 23 sites were completed. Normal planned monthly testing of the Mica Dam spillway gates and Low Level Outlet Gate 5 at the Hugh Keenleyside Dam were cancelled in June because they were under lockout for other work.

In Q1, two gates at Mica Dam failed to operate on demand during testing:

- Mica Dam, April 2022 – Control Interface Lost Communication
 During monthly testing in April, the East and West Outlet Works Operating Gates failed to operate on demand. Upon investigation it was found that the control interface did not have power due to a blown fuse that had an incorrect rating. The fuse was replaced with one of the proper rating, after which the gates were able to operate.

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. This section provides updates on any spillway gates or flood passage devices that are out of service or under restricted service.

- Hugh Keenleyside Dam – Low Level Outlet Gate 7
 In F2022 Q4 it was reported that Low Level Outlet Gate 7 was put into restricted service due to a kinked hoist rope. The gate remains on restricted service with replacement of the damage wire rope planned for Q3 of this year, as dictated by material procurement timelines.
- Terzaghi – Low Level Outlet Gate 1 returned to service
 In F2022 Q4 it was reported that Low Level Outlet Gate 1 was unable to open freely, achieving only limited openings. In June, an oil change and oil system flush were completed to improve the gate’s operation. It was successfully opened in June and July for planned spills into the Lower Bridge River. Engineering work is under way to develop a work plan for further interim improvements to the gate’s reliability through the replacement of the gate wheels, shaft, and bushing.

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The Gate Serviceability deficiency (with associated Vulnerability Index of 5.9) in the Dam Safety Issues Database will be reviewed and reassessed in Q2.

- **Ruskin Dam – Spillway Gate 3 returned to service**

In February 2022 a significant oil leak from the hydraulic cylinder of Spillway Gate 3 was discovered and the gate was placed out of service. The sealing arrangement for a cable leading to a linear transducer used to measure gate position had failed, allowing water ingress and hydraulic oil leakage. The gate was placed back into service in June following the replacement of the damaged hydraulic cylinder.

The sealing arrangement that led to the hydraulic cylinder failure on Gate 3 was identified as a common cause failure for all the Ruskin spillway gates. In response, the linear transducers have been removed from the cylinders of all five gates and the cylinders have been capped and sealed to prevent further ingress of water that could lead to another failure. A capital project has been initiated to modify the cylinders to ensure ongoing reliable operation and to restore their full design functionality that includes redundant gate position monitoring. In the interim, spillway gate operations will require visual confirmation of gate positioning by a second crew member.

The Gate Serviceability deficiency (with associated Vulnerability Index of 5.9) in the Dam Safety Issues Database will be closed and reported in Q2.

Spillway Gate Maintenance

To align reporting with our delivery partners and with other asset portfolios, tracking of completed and outstanding spillway gate maintenance work has been changed from reporting on work orders to reporting on tasks. A task is a subset of a work order, where each task represents a different scope of work and there may be one or multiple tasks to a single work order. This change resulted in the year end figures from F2022 being restated from 142 work orders to 160 tasks in total, and from 19 high priority work orders to 23 high priority tasks. The adjustment of the F2022 year end figures is shown by a separate line so that trending can be observed from F2022 to F2023.

Table 5 Spillway Gate Maintenance Results for F2023.

Corrective and Condition-Based Maintenance Tasks	Quarter Q1		Year-To-Date
	Completed	Planned	
Planned Tasks	17	16	17/16 = 106%
Emergent Tasks	9		9

Twenty-six (26) planned and emergent spillway gate maintenance tasks were completed in Q1. The net result was a decrease of 16 tasks in the outstanding work inventory in Q1. Although a significant inventory of work still exists, Q1 showed strong completion results. As reported last quarter, Programs and Contract Management has assigned a program manager to oversee this program of work and to work closely with Operations to ensure that any issues are identified early and that the program remains on track. Early indications, based on these Q1 results, are that this approach is yielding improvements in work completion.

The number of outstanding gate maintenance tasks is shown in the chart in Figure 6. The total number of outstanding maintenance tasks decreased from 160 to 144 in F2023 Q1. The number of

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“high priority” maintenance tasks has decreased from 23 to 22. “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.

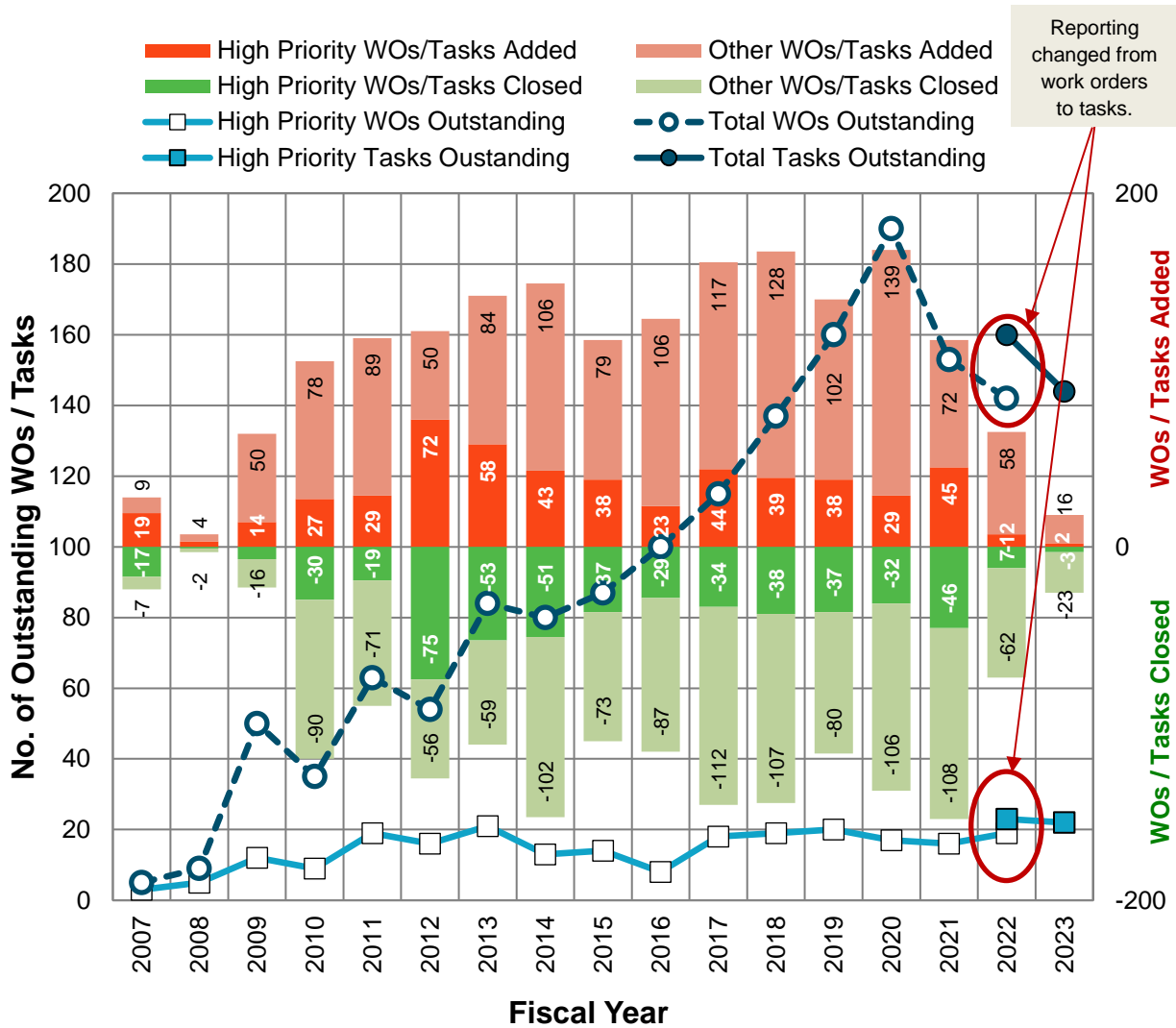


Figure 6 Number of outstanding corrective and condition-based spillway gate maintenance work orders and tasks, new work orders and tasks added, and work orders and tasks closed as at the end of each previous fiscal year.

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

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Emergency Preparedness and Public Safety

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

Flow Management Downstream of Duncan Dam

In late May and early June, rainfall combined with a melting snowpack increased flows into the Duncan Dam Reservoir as well as in the unregulated rivers in the area. During this event, the Duncan Reservoir was near its annual low point but due to higher-than-normal snowpack levels the outflows from the Duncan Dam were increased to balance flooding risks between that time and later in the summer when levels in Kootenay Lake (just downstream of Duncan Dam) peak.

There are eight properties along the Duncan River between the Duncan Dam and Kootenay Lake that are vulnerable to flooding due to a combination of releases from Duncan Reservoir and flows from the unregulated Lardeau River and other watercourses downstream of the dam. Releases from the Duncan Reservoir were maximized to maintain the flows near “bank full” without flooding the vulnerable properties. Stations Field Operations crews and Dam Safety staff monitored river levels and reported back to Generation System Operations so the flows from the Duncan Dam could be optimized.

To manage the event and to facilitate consistent and effective communications with downstream stakeholders, the Castlegar Emergency Operations Centre was virtually activated from June 1 to June 9 and supported by staff from Strategic Emergency Planning, Stations Field Operations, Generation Systems Operations, Environment, Communications, Indigenous Relations and Dam Safety.

The event was successfully managed with no overland flooding of the vulnerable properties.

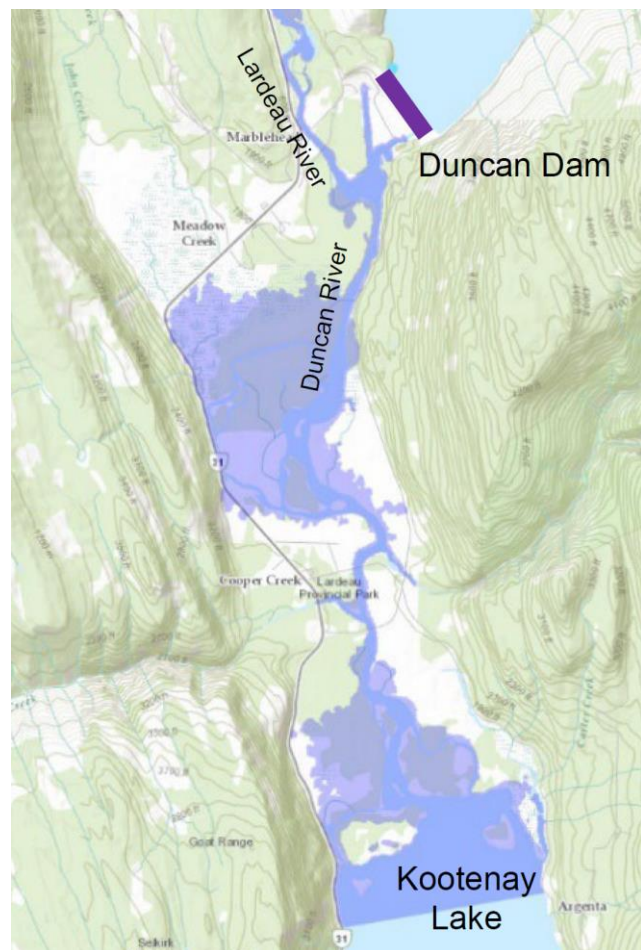


Figure 7 Areas vulnerable to flooding during the June 1-9, 2022 high inflow event on the Duncan River.

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Site C Clean Energy Project

Dam Safety, 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. This new section of the report will provide quarterly updates on those collaborations.

The Project is currently advancing through Stage 2 river diversion under an Interim Dam Safety Risk Management Plan for Peace River flow management that was prepared and reviewed by the three business units as well as an Operation, Maintenance and Surveillance Manual for the construction cofferdam and other river diversion works. During and in support of construction:

- The Peace Region Dam Safety Engineer is completing weekly inspections of the debris management system as well as completing "independent" site inspections during construction.
- Dam Safety Surveillance provided input and review into the recent revisions of the Site C Emergency Action Plan, which lays out BC Hydro's response activities and communications in the event of an emergency, and the Peace Region Emergency Planning Guide, which is distributed to downstream authorities to facilitate their emergency response planning.

There are several dam safety activities underway in preparation for reservoir filling.

- Dam Safety, Operations and the Site C Project Team are preparing a new Interim Dam Safety Risk Management Plan – based on construction plans and a Reservoir Fill Plan also under development – that will take effect on closure and conversion of one diversion tunnel and will remain in effect through reservoir filling, and through commissioning and bringing on-line the generating units.
- Dam Safety's Reservoir Slopes team is supporting the Project in development of the reservoir slope monitoring program and a Trigger Action Response Plan related to Highway 29 users and its infrastructure.
- Dam Safety Surveillance is working with the Project to develop operational surveillance plans for the remaining stages of the Project from tunnel conversion through to the end of construction and commissioning.
- The Dam Safety Data Technology team is working with the Project's instrumentation team to ensure the current dam safety systems can accommodate the volume of information generated and required by the Project through reservoir filling and Project completion.
- Dam Safety Regulatory and Asset Planning has initiated work in Engineering to perform inundation modelling and mapping for dam breach scenarios involving the Peace River dams, including the WAC Bennett Dam, the Peace Canyon Dam and the to-be-completed Site C Dam.

Updates on these and newly commenced dam safety activities associated with the Site C Clean Energy project will be provided in future Dam Safety Quarterly Reports through the remaining duration of the Project.

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Capital Projects

Summaries of Dam Safety Capital projects are available for reference in the Dam Safety “book” in Diligent. This section of the report describes newly launched projects and provides updates for projects where significant developments occurred or milestones were achieved.

Bridge River 1 – Mitigate Surge Spill Hazard

Bridge River 1 Generating Station is located on the shores of Seton Lake. Water is conveyed to Bridge River 1 from Carpenter Lake reservoir through Mission Mountain by a rock tunnel that branches into two near its downstream end and feeds into four surface steel penstocks that run down a steep slope to Bridge River 1. Surge shafts extend approximately 100 metres upward from each of the tunnel branches to the surface of Mission Mountain to mitigate transient pressure rises in the penstocks.

The preceding Bridge River 1 Penstock Leak Detection Project installed a penstock leak detection system and a penstock inlet valve auto-closure system to automatically shut off flows to a penstock upon detection of a leak or rupture. The auto-closure system was commissioned but not put into service, due to concerns that a rapid closure of a penstock inlet valve could lead to a surge in the upstream tunnel and overtopping of the surge shafts, which could in turn lead to damage to the downslope BC Hydro facilities and potential loss of life.

This project was initiated in 2017 following the Bridge River 1 Penstock Leak Detection Project to mitigate the hazards caused by overtopping of the surge shafts due to rapid closure of the penstock inlet valves. Construction of concrete basins at the top of each surge shaft to contain overtopping flows was completed in Q1. This will now enable the auto-closure system to be commissioned and facilitate a future project to upgrade the penstock inlet valves to be capable of closure under flow from a ruptured penstock.



Figure 8 Construction of the containment basins at the top of the east (left) and west (right) surge shafts at the Bridge River 1 Generating Station.

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Bridge River 2 – Strip and Recoat Penstock 2 Interior

One of two penstocks for the Bridge River 2 Generating Station, Penstock 2 conveys water to Generating Units 7 and 8. The exteriors of the Bridge River 2 penstocks were recoated in 2008 through 2011 and the interior of Penstock 1 was recoated in 2019. This scope of this project is to recoat the interior of Penstock 2, the adjacent tunnel liner, and the Units 7 and 8 scroll cases. The project completed the recoating of Bridge River 2 Penstock 2 on June 20th, 2022 – ten days ahead of schedule. The contractor has demobilized from site.



Figure 9 Recoating of the Bridge River 2 Penstock 2. Top left: coating robot inside the penstock. Bottom left: New access hatch installed by the project. Right: penstock before (foreground) and after (background) recoating.

Hugh Keenleyside Dam – 90 Ton Gantry Crane Upgrade

The 90 ton gantry crane located on the crest of the Hugh Keenleyside Dam is required for operation and maintenance of the dam's low level outlet gates and the spillway operating gate stop logs. A recent inspection identified that the weight of the low level outlet gates exceeds the stated nameplate capacity of the gantry crane. As a result, the full scope of inspection and maintenance activities on the low level outlet gates cannot be safely and reliably performed. Moreover, the crane's controls are outdated and in poor condition, creating an increased risk of an unstable lift and failure even for lifting loads within the crane's capacity. This project was initiated in Q1 to replace the existing undersized crane with a new one with increased capacity and modern controls. The project will follow a scaled delivery model to expedite the replacement.

John Hart Dam – Seismic Upgrades

The objective of this project is to upgrade the John Hart Dam to address the identified deficiencies in seismic resistance and spillway gate reliability as well as the risk of dam overtopping due to potential flow imbalances between John Hart Dam and Ladore Dam upstream. Construction is

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currently targeted between 2023 and 2028. In F2023 Q1 the project team and supporting groups completed two rounds of information requests as part of the BCUC regulatory process and pursuant to Section 44.2 of the Utilities Commission Act. Additionally, the request for proposals for the civil works was issued and closed in F2023 Q1.

La Joie – Dam Improvements

The key dam safety issues at the La Joie Dam are the ongoing deterioration of the dam’s shotcrete facing and seismic deficiencies in both the dam and its intake tower, which were described in the F2022 Q2 Dam Safety Quarterly Report. As an interim risk reduction measure, Downton Reservoir has been operated at a reduced level since about 2015 until the dam is upgraded and the dam safety risks are fully addressed. The objective of this project is to upgrade the La Joie Dam, its intake tower and its other appurtenant structures to fully restore the integrity of the water barrier and to improve the seismic resistance to a level commensurate with an extreme consequence dam. The project also includes consideration of post-earthquake reservoir control and will address a number of specific issues related to the dam’s discharge gates.

The project completed an extensive site investigation at the upstream toe of the dam in late April and early May. While the investigation occurred during annual low reservoir levels, it required an additional drawdown below the normal low reservoir level. The investigation significantly improved BC Hydro’s knowledge of the foundation and structure conditions and of the potential impacts and challenges of maintaining an extended construction drawdown, which will greatly benefit project planning and design decisions moving forward. One example is the large volume of debris that will have to be cleared from the dam’s toe prior to construction and the related scheduling requirements.



Figure 10 La Joie Dam during the spring 2022 drawdown. Note the significant volume of debris located on the toe of the dam.

Revelstoke Dam – St. Cyr Landslide Instrumentation

As described in the Dam Safety Quarterly Reports from F2021 Q4 through F2022 Q4, an assessment of recent satellite remote sensing, aerial imagery and ground inspections around Revelstoke Dam has identified a large active landslide between St. Cyr and Coursier Creeks, approximately five kilometres upstream of the dam. This project is the first step to providing continuous monitoring capability by installing instrumentation into holes drilled deep into the slide,

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and to developing more understanding of the geology of the landslide by recovering comprehensive samples from the drill holes for ensuing geotechnical investigations. Drilling activities commenced in Q1, with the first of two drill holes now complete. Preliminary results from the first drill hole indicate the slide base is at considerable depth (190-235 metres), confirming the expected large volume (about 900 million cubic metres) of this landslide. Drilling on the second hole is ongoing.

Terzaghi Dam – Spillway Chute Access Improvement

The objective of this project is to mitigate the rockfall hazard to allow detailed in-chute inspection of the Terzaghi Dam spillway structure, drain maintenance, concrete repairs, and, if required, facilitate subsequent capital projects to perform upgrades to the spillway structure. In Q1 the Project secured endorsement to proceed into the Feasibility Design Stage. The recommended Leading Alternative comprises select slope treatment of meshing, bolting, and shotcreting of identified rockfall sources on the steep rock slope above the spillway. It was confirmed that this Alternative would allow for the appropriate level of access to meet current requirements for inspections, investigations, and minor repairs.



Figure 11 Terzaghi Dam spillway chute rock wall inspection. Overview (top left), engineer controlling the drone's high resolution camera (top right), location of a loose, hazardous rock (bottom left), and close-up view of the hazardous rock which is approximately 0.6 metres or 2 feet wide (bottom right).

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Also in Q1, the project team conducted a detailed inspection of the rock slope. Initial plans to visually inspect the slope from the floor of the spillway chute raised concerns regarding risks to personnel safety, the costs and efforts required to mitigate those risks, and the effectiveness of an inspection from the chute floor. Instead, the Terzaghi Dam Safety Engineer – a licensed drone pilot – was tasked to fly Dam Safety’s advanced drone along the rock slope. The project team’s engineers were outfitted with virtual reality goggles and auxiliary controls for the drone’s high resolution camera to collect close-up imagery and three-dimensional scans of the rock slope to inform the project’s design efforts. In effect, the engineers were able to conduct close-up visual inspections of the entire rock slope without leaving their safe location along the dam crest. Moreover, use of the drone enabled the identification of potential rockfall hazards that would have been invisible to inspectors and safety watchers in a conventional inspection. See Figure 11. This new technology shows tremendous potential for improving the safety and effectiveness of work on this and similar projects.

Various Sites – Probabilistic Seismic Hazard Analysis Model Update

In 2012, BC Hydro completed work and put into service an industry leading probabilistic seismic hazard analysis model for its operational areas in British Columbia. The model was developed through a first-ever Senior Seismic Hazard Analysis Committee Level 3 study by a project team composed of more than twenty BC Hydro and consultant scientists and engineers with specialist experience in earthquake hazards, seismology, ground motion modeling, and seismic source characterization, augmented by consultation with a broader group of internationally recognized experts, whose varied technical opinions and interpretations were collected via workshops and then integrated into the probabilistic model. The current, existing model has an expected service life of 15 years, ending in 2027, at which time it is expected that an updated model that incorporates post-2012 developments in ground motion modelling and understanding of seismic sources in and around British Columbia will be available for use. The project to develop the updated probabilistic seismic hazard analysis model was initiated in Q1.

Dam Safety Investigations

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

Dam Safety currently has 14 active investigations underway to assess dam performance, investigate known issues, and collect additional information that is necessary to characterize the condition and performance of various dams in BC Hydro’s fleet. Additionally, there are six ongoing programs of work to update flood models, investigate seismic hazards, and improve capabilities in monitoring reservoir slopes across the system.