

Board briefing – DAM SAFETY QUARTERLY REPORT**Executive Summary**

The purpose of this report is to update the Capital Projects Committee of the Board of Directors on key dam risk management activities during the period from July 1, 2020 to September 30, 2020 and to provide reasonable assurance that the safety of dams operated by BC Hydro continues to be managed to the established guidelines and criteria of the Dam Safety Program. To keep the Committee as fully abreast of the Dam Safety Program as possible, some notable developments that took place after September 30 but before the completion of this report have also been included. The key highlights from F2021 Q2 documented in this report are:

- There was a net decrease of 10.63 in the aggregated Vulnerability Index with completion of issues on the left abutment at Ruskin Dam, reconstruction of the right anchor of the debris boom at Hugh Keenleyside Dam, and completion of an issue related to the seismic deficiency of the dewatered and out-of-service penstock at Elko Dam.
- To mitigate risks of excessive river flows to spawning salmon runs on the Seton and Bridge Rivers, a temporary surcharge of Downton Lake reservoir above the Dam Safety restricted elevation of 734.0 m has been authorized and is ongoing under an Interim Dam Safety Risk Management Plan. To date, this has not resulted in any material increase of risk.
- Completion and issue of OMS Manual updates and Dam Safety Reviews have remained on track, with two OMS Manual updates and five Dam Safety Reviews completed year to date.
- Some progress has been made this quarter on spillway gate maintenance. The total number of outstanding issues has decreased from 174 at the end of Q1 to 146 at the end of Q2.
- A new Dam Safety Inspection App has been rolled out that will allow site inspections and manual readings to be recorded on corporate iPhones and automatically uploaded. The app is expected to improve productivity and reduce transcription errors.
- Dam Safety took part in the corporate-wide Great BC ShakeOut drill and extended it to perform a light simulation of an earthquake in the Lower Mainland and proof-of-concept testing for a new “Event Response Dashboard” to assist in coordinating Dam Safety’s activities in an emergency.
- Risk reductions through project work have resulted from completion of grouting of the vertical movement gauge casings in the cores of the Mica and Revelstoke earthfill dams and installation of a concrete plug in the intake structure at Spillimacheen Dam.

Impacts of COVID-19 on Dam Safety:

- Critical dam safety activities, such as surveillance, inspection and spillway gate testing, continued with minimal interruption under safe work protocols.
- Delays experienced by Dam Safety capital projects in Implementation Phase in Q1 have resulted in some project in-service deferrals, most recently for the Revelstoke 731 Block Stabilization project.

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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 Vulnerability Index for each currently identified issue at each dam site is shown in Figure 1. 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 F2021 Q2 are described below and identified in Figure 1. There were no Vulnerability Index additions and three Vulnerability Index reductions.

- 1** A Vulnerability Index **reduction** of 1.23 (PU deficiency) at **Elko Dam**.
A deficiency had been attributed to the likelihood that the station’s penstock footings are seismically deficient. With the generating station out of service and the penstock dewatered and out of service, there is no remaining vulnerability.
- 2** Vulnerability Index **reductions** of 6.69 (PN and PU deficiency) at **Ruskin Dam**.
Sealed Engineering Design Conformance Records for newly in-service assets and upgrades have been reviewed and all issues relating to the dam’s left abutment and intake structure have been completed. Issues relating to the spillway gates remain open pending review of final commissioning test results for corrected project deficiencies.
- 3** A Vulnerability Index **reduction** of 2.71 (AN deficiency) at **Hugh Keenleyside Dam**.
With the sinking of two pontoons of the navigation lock’s floating guidewall (see “New Issues” in the F2020 Q4 Dam Safety report), the debris boom’s right anchor had been compromised and an issue with this Vulnerability Index was added. In F2021 Q2, Engineering documented completion of the replacement of the right anchor to the original design intent and the issue was closed.

There were two other notable changes to our characterization of the risk profile. In updating the Operation, Maintenance and Surveillance Manuals for Seton Dam and Wahleach Dam, reviews of the populations at risk in the event of breach led to changes in those dams’ consequence classifications. A breach of the power canal at Seton could inundate up to 30 homes on the Cayoosh Indian Reserve and corresponds to a “Very High” consequence, raised from “High”. A breach of Wahleach Dam and resultant inundation of the community of Laidlaw corresponds to an “Extreme” consequence, raised from “Very High”. Those dams have been relocated accordingly in Figure 1. While there is no resulting change to the aggregated Vulnerability Index, the relative importance assigned to the issues connected to those sites is increased correspondingly. There are corresponding changes to the Program in accordance with the Dam Safety Regulation. At Wahleach Dam, formal inspections will be increased from annually to semi-annually and Dam Safety Reviews will occur every seven years instead of ten, and the Seton Dam OMS Manual will now be updated every seven years instead of ten.

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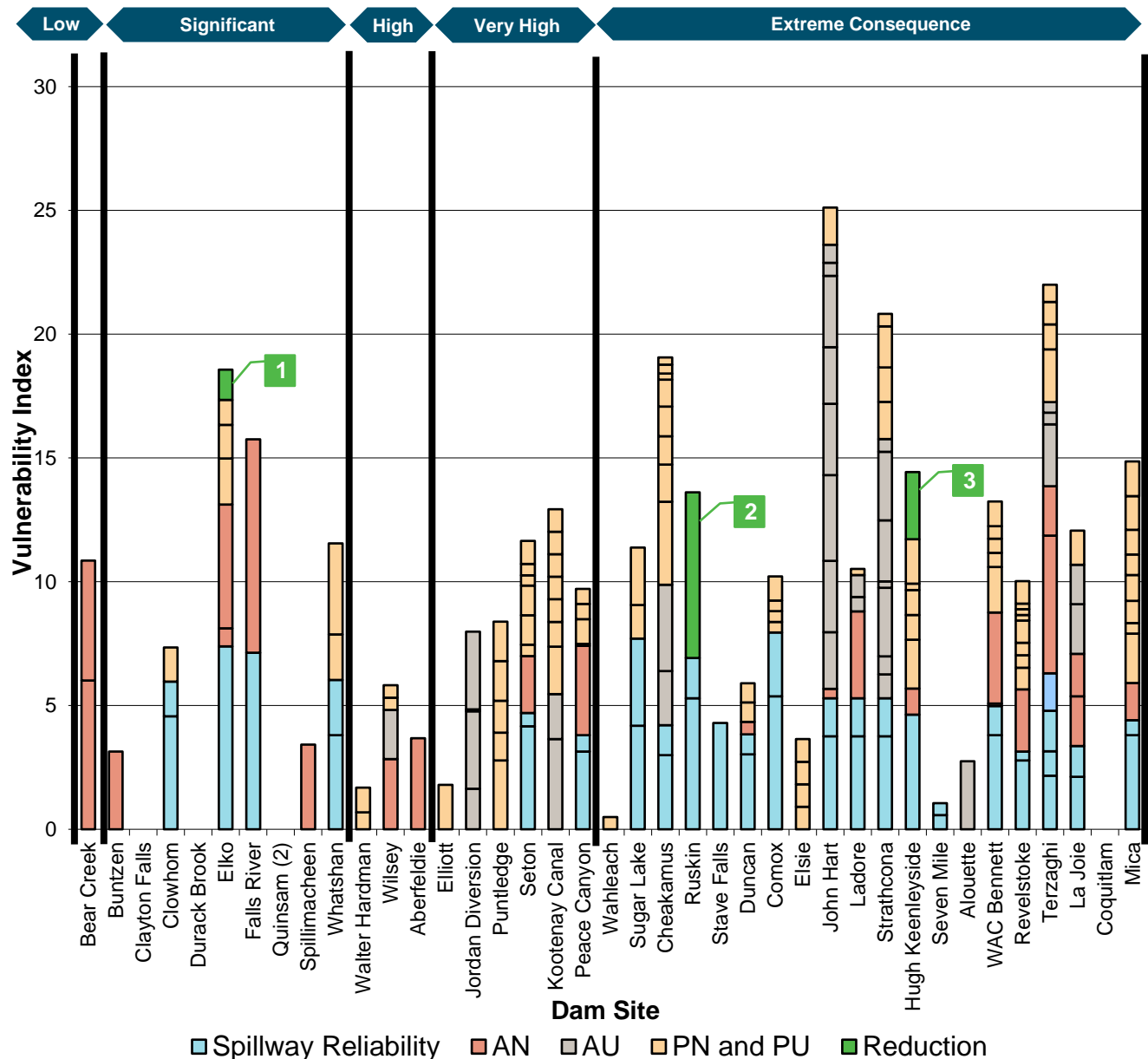


Figure 1 Dam Safety overall risk profile at the end of F2021 Q2, as represented by the Vulnerability Index. There were changes this quarter as indicated by the numbered boxes.

- AN** *Actual* deficiency (demonstrated to exist) under *normal* load conditions (associated with daily or short-term operations)
- AU** *Actual* deficiency (demonstrated to exist) under *unusual* load conditions (associated with flood and earthquake loading)
- 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 reliability of the dam’s spillway and/or other flood discharge systems

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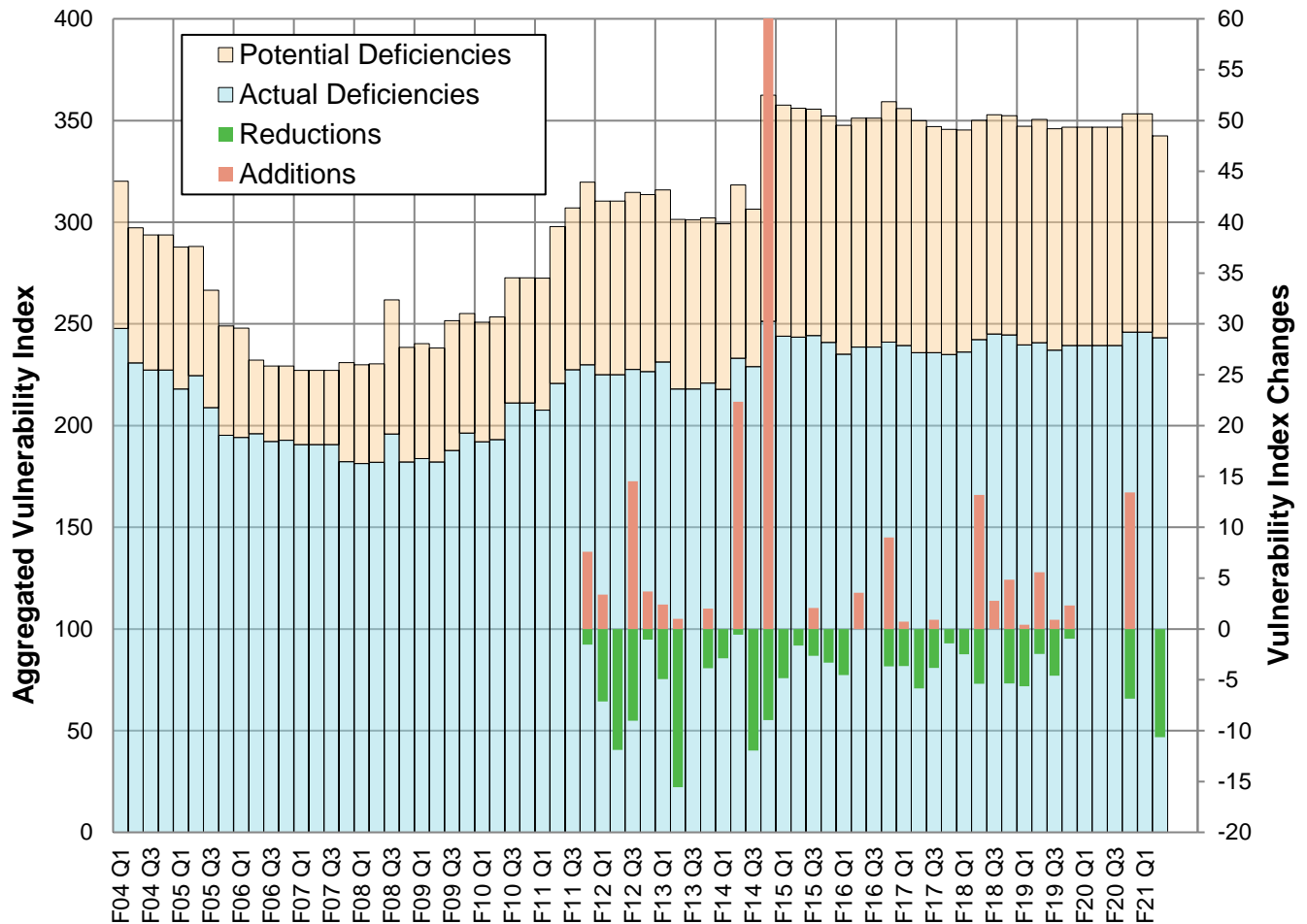


Figure 2 Changes and trends in the Vulnerability Index aggregated across the BC Hydro system. Note: the bars are “stacked” such that total aggregated Vulnerability Index is given by the top of the Potential Deficiencies bar.

Non-Conformances in the Dam Safety Program

Activities to review, resolve and close non-conformance issues continued in F2021 Q2. Regularly scheduled Issues Database review meetings – during which non-conformances are reviewed, updated, or closed as appropriate and actions for closure of non-conformances are developed – resumed late in Q2 after having been paused in Q1 as part of the response to COVID-19. A total of 29 non-conformance issues were completed and closed in Q2. Twenty-six new non-conformance issues were added to the database, however, for a net reduction of three issues.

The downward trend in outstanding non-conformance issues is continuing but beginning to slow. Efforts are now being extended to more critically assess new issues that are being raised, particularly from Dam Safety Reviews, to better distinguish true non-conformances from less urgent recommendations and suggestions for improvement. Existing non-conformance issues recorded in the Issues Database are also being reviewed and assessed for possible closure (and tracking by alternate means) in this context.

Board briefing – DAM SAFETY QUARTERLY REPORT**New Issues****Downton Reservoir (La Joie Dam) Surcharge**

To manage the risk of failure of La Joie Dam following a major earthquake and, particularly, the consequential cascading failure of Terzaghi Dam downstream, Downton Reservoir has been drawn down since 2015 with its Normal Maximum Reservoir Level reduced from its licensed elevation of 749.41 m down to 734.0 m. The resulting loss of storage in Downton Reservoir has created operational constraints in the Bridge River System that have made it difficult to prevent excessively large discharges into the Lower Bridge River during periods of salmon migration and spawning.

In mid-August, an extended forced outage of the generator at Seton required that outflows from Seton Lake be diverted from the canal and generating station and into the river which, without some form of mitigation upstream, would result in either excessive flows down that river that would imperil already depleted Sockeye and Coho runs or excessive flows down the Bridge River with similar concerns. The safe operation of BC Hydro's dams must protect the health of the natural environments upstream and downstream of the dams as well as the health and welfare of the public and so on September 24, 2020, with imminent threats to the survival of a number of salmon runs, the Director, Dam Safety authorized a temporary surcharge of Downton Reservoir to a maximum elevation of 740.0 m which will be in effect through December 31, 2020. To date, a 1.0 m surcharge of the reservoir has occurred and is being managed under an Interim Dam Safety Risk Management Plan that is based upon recommendations provided by Engineering, and excessive discharges down the Lower Bridge and Seton Rivers have been avoided. Total contained water volume in the two reservoirs has not reached levels that could lead to a cascading failure of Terzaghi Dam in the event of a major earthquake and the induced failure of La Joie Dam.

The Board will be provided with a complete account of the Downton Reservoir surcharge in the next quarterly report.

Update on Existing Issues**Dam Safety Response to COVID-19**

Dam Safety critical work such as dam inspections and spillway gate testing continued with very little impact. During Q2 there were no inspections or spillway gate tests missed due the pandemic or related work arrangements. There were some impacts to the program, however, most notably affecting maintenance programs and capital projects, and these impacts are described in later sections of this report as they pertain to specific facets of the program.

Kinbasket Reservoir Surcharge

The surcharge of Kinbasket Reservoir behind Mica Dam that was forecast in last quarter's report came to pass. With approval from the Comptroller of Water Rights, the reservoir intermittently exceeded the licensed Normal Maximum Reservoir Level by up to 0.15 m between August 22 and September 6. Under an Interim Dam Safety Risk Management Plan, enhanced surveillance of Mica Dam was undertaken by a combination of staff from Stations Field Operations based at Mica and five Dam Safety personnel who rotated to Mica from their headquarters at Revelstoke Dam and Kootenay Canal Generating Station, during which no abnormal instrument readings or observations of the dam's performance were recorded.

Board briefing – DAM SAFETY QUARTERLY REPORT**Ruskin Dam – Left Abutment**

As reported in the Fiscal 2020 Q4 report, two sinkholes developed on the downstream slope of Ruskin Dam's left abutment, just upstream of the powerhouse and proximate to buried ductwork. They are not considered to pose an immediate safety risk to the dam, public or workers. Invasive field investigations are now underway under a new project that has been initiated by Dam Safety.

Peace Canyon Dam – Canada Energy Partners Water Disposal Well

The oil and gas industry conducts hydraulic fracturing and water disposal activities – which are known to have induced seismic events – in proximity to BC Hydro's dams in the Peace River region. Water disposal well WA #22301, located just over 3 km from Peace Canyon Dam, operated from December 2008 to April 2010 and then from January to March 2017. Since March 2017, approval of these operations was subject to the operator, Canada Energy Partners, complying with several conditions that were imposed by the Oil and Gas Commission (“**OGC**”) in consideration of the well's proximity to Peace Canyon Dam. Those conditions were never met, and in September 2020 the operator abandoned the well and the OGC issued a letter to Canada Energy Partners cancelling the well's approval to operate. With this cancellation, and with the March 2014 imposition of the “Tenure Buffer Area” around BC Hydro dams by the Ministry of Natural Gas Development (now the Ministry of Energy, Mines, and Petroleum Resources), operation of this water disposal well cannot be reinstated.

Compliance with Processes and Regulations**Regulatory Communications – BCUC**

On September 25, 2020, the British Columbia Utilities Commission served BC Hydro with another – believed to be the final – round of Information Requests regarding the safety of BC Hydro dams on the Peace River. The six questions sought to understand whether the geotechnical conditions that are leading to designs for foundation enhancements at Site C have any impact on the safety of WAC Bennett Dam and Peace Canyon Dam or on BC Hydro's responses to previous Information Requests in this matter. Responses to those questions, explaining that there are no impacts from the conditions at Site C on the two upstream dams or previously supplied answers, were provided to the BCUC on October 13, 2020. BC Hydro further provided an addendum to one previous Information Request response to inform the BCUC of the abandonment of the CEP injection well near Peace Canyon Dam, described above.

Regulatory Communications – Comptroller of Water Rights

Regulatory Communications with the Provincial Dam Safety Office consisted of submissions required under the Dam Safety Regulation for decommissioning of Bugaboo Dam, plugging of the power tunnel at Spillimacheen Dam, and notification of consequence classification changes for Seton Dam (High to Very High) and Wahleach Dam (Very High to Extreme). In addition, OMS Manuals and Dam Safety Reviews were submitted as discussed in the following sections.

Operation, Maintenance and Surveillance Manuals

Each dam has an Operation, Maintenance and Surveillance Manual (“**OMS Manual**”) for Dam Safety that identifies responsibilities and expectations within BC Hydro for maintaining the safety of the dam. The OMS 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.

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The new Regulatory and Asset Planning department is now fully engaged in the delivery of OMS Manual updates. Overall, there are ten OMS Manuals scheduled for updating in F2021. The OMS Manuals for Seton and Wahleach Dams were completed and issued in Q2. Updates to the Bear Creek, Quinsam Diversion, Quinsam Storage, and Whatshan progressed in Q2 and are scheduled to be issued in Q3. Elko, Buntzen, Coquitlam and Ruskin updates are scheduled for completion in Q4 and work on these is underway.

The work and delivery plans for the OMS Manual updates are depicted in Figure 3(a), below. Work is currently active on all eight outstanding updates and is on track. As of the date of completion of this quarterly report, all three OMS Manuals scheduled for delivery in October (Q3) have been completed.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Forecast	Target
OMS Manual updates completed	2	2	✓	10	10
Completion of F21 work plan	53%	53%	✓	Measure only	

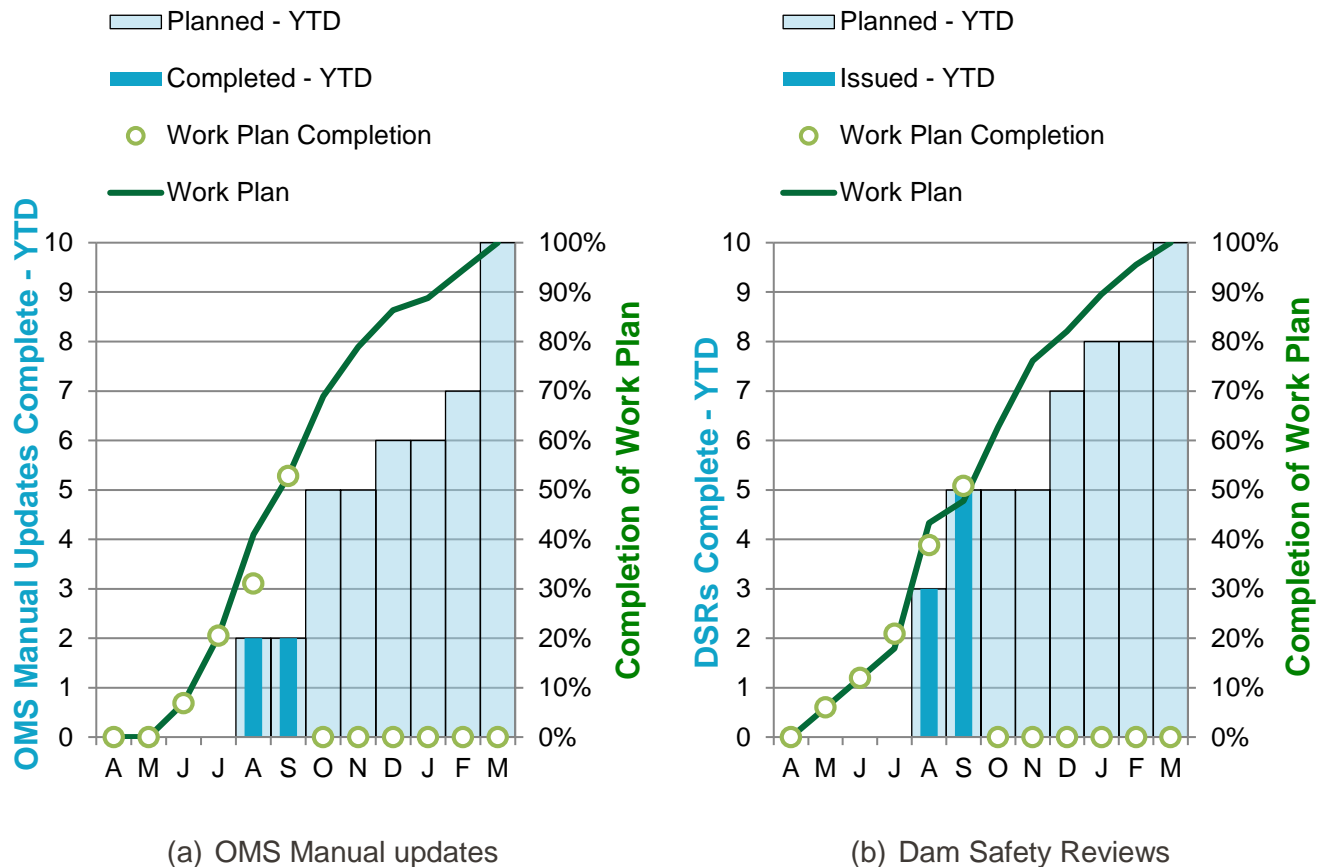


Figure 3 F2021 work and delivery plans for (a) OMS Manual updates and (b) Dam Safety Reviews.

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Dam Safety Reviews

Dam Safety Reviews are a regulatory requirement carried out at minimum intervals of every five to ten years for High, Very High and Extreme consequence dams.

Responsibility for managing the Dam Safety Reviews has now fully transitioned to the new Regional Planning Engineers. The work and delivery plans for the Dam Safety Reviews are depicted in Figure 3(b), above, and are summarized in that figure and the table below. In all, ten Dam Safety Reviews are slated for completion in F2021. Five of those ten Dam Safety Reviews were issued in Q2 and work is currently active on the reviews for the other five dams, namely: Aberfeldie, Coquitlam, Jordan, Strathcona, and Sugar Lake. Site visits for Aberfeldie, Jordan, Strathcona and Sugar Lake took place in Q2. The Coquitlam site visit was carried out in early Q3. The draft reports for all five reviews are in progress.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Forecast	Target
Dam Safety Reviews completed	5	5	✓	10	10
Completion of F21 work plan	51%	48%	✓	Measure only	

As described in last quarter's report, recommencement of the Ruskin Dam Safety Review has been postponed until F2021 Q4 to ensure that the information required for the review is available from the Seismic Upgrade Project

Surveillance
Inspections

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

410 of the 411 scheduled site inspections were completed in Q2. In early July the weekly site inspection of Coquitlam Dam was missed due to a miscommunication that resulted in Buntzen Dam being erroneously inspected instead of Coquitlam Dam.

Routine Inspections	F21 Year-to-date	F20	F19	F18	F17	F16
Completed	821	1642	1638	1595	1583	1594
Missed	1	6	2	16	29	24

Board briefing – DAM SAFETY QUARTERLY REPORT**New “Inspection App”**

Dam Safety Surveillance rolled out a new “Inspection App” in Q2 following completion of improvements identified during the initial field testing. The iOS-based app allows site inspections and manual readings to be recorded on corporate iPhones. Once the inspection or readings are complete, the inspector simply hits the submit button, the inspection and monitoring data is automatically uploaded to the appropriate database and notification is sent to the Dam Safety Engineer indicating the work has been completed. The app is expected to improve productivity and reduce transcription errors. The Inspection App was used by Dam Safety and Stations Field Operations staff for inspections at 10 of the 41 dam sites and to record over 10% of the 3600 manual instrumentation readings taken during the last quarter. By the end of this fiscal year it is expected that it will be in use at another 20 sites and will be used to record and upload about 80% of the manual data collected each month.

Instrumentation and Monitoring

Dam Safety Surveillance collects checks and assesses about 2 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 (ADAS). Even though a majority 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 ADAS system is functioning as expected, identify any unusual trends, and ensure continued accuracy of the data being for ongoing engineering assessment. They are tasked to perform three such checks per week. During Q2, 202 checks were completed, exceeding the target of 195.

Reservoir Slopes

Dam Safety’s Slope Surveillance Program completed four aerial inspections and six site landslide inspections and maintained continuous monitoring of the Reservoir Slopes Instrumentation System. Planned inspections of the Peace Area slopes (GMS and PCN) and Falls River reservoir slopes were deferred in consideration of the required cross-regional travel during COVID-19. Reservoir slopes specialists also provided ongoing oversight of the Downie Slide Instrumentation Project and the 731 Block Slope Stabilization Project, both associated with Revelstoke Dam.

Unusual Events or Observations

The Dam Safety On Call Person (DSOP) responded to 81 calls in Q2 of F2021, which included instrumentation alarms, operational inquiries, operations notifications during high inflows and earthquake notifications.

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As described in the F2021 Q1 Report, Dam Safety has taken on elements of maintenance planning and, jointly with Generating Stations Maintenance Planning (“**GSMP**”) within Stations Asset Planning, will prepare and administer the annual maintenance plans for the dams and generating stations. Details of the procedures and governance for this arrangement continue to be developed, with current focus on integrating Dam Safety into existing maintenance processes and business rules and establishing stronger oversight and clarified prioritization of spillway gates maintenance.

Civil Maintenance

As of the end of Q2, the Civil Maintenance Program had completed 18 projects against a plan of 22 with a total spend of \$1.495M against a plan of \$2.352M. In part, the underspend is attributable to several project shaving been completed under budget. Notable project completions include: Alouette spillway joint and concrete repairs, Kootenay Canal Rover Creek debris barrier repairs, and Whatshan Generating Station pressure relief valve inspection and cleaning.

BC Hydro's F2021 maintenance programs continue to be adjusted in year due to operational considerations. In Q2 there were 2 projects deferred and 5 projects added, bringing the total project count for F2021 to 39 and the revised total program budget to \$3.019M. The most notable change was the deferral of concrete repairs to the WAC Bennett Dam spillway to accommodate extended spilling to manage unusually high inflows in the leadup to Site C diversion.



Figure 4 Alouette spillway concrete joint repairs.

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Dam Safety is monitoring the delivery of the Civil Preventative Maintenance Program. In F2021 Q2, 265 preventative maintenance tasks were completed on a plan of 436. It is understood by Dam Safety that this low rate of delivery reflects, in part, impacts from the COVID-19 pandemic work protocols. More significantly, however, F2021 is the first full year of implementation for the Civil Preventive Maintenance program and it is expected that there are ongoing learnings within Program and Contracts Management in how to effectively execute this plan. Dam Safety will continue to monitor the progress of plan execution and work with our delivery partners to make improvements.

Dam Safety has established a process to review requests to defer preventative maintenance tasks that it considers to be of a high priority. The changes to the review process to incorporate Dam Safety have been implemented.

Spillway Gate Testing and Maintenance

During Q2 of F2021, 61 of the 62 scheduled gate tests at 23 sites were carried out. The missed test was at Revelstoke Dam in September, where gate testing was deferred – with acceptance from Dam Safety – to allow maintenance work on the gates to be carried out.

No gate system failed to operate on demand during testing. In seven cases, while gates did operate on demand, certain individual components of the gate system that are critical to one or more operational paths of a gate – “lines of defence” – malfunctioned. Three of those were corrected within the quarter.

Some progress has been made this quarter on spillway gate maintenance. The total number of outstanding issues has decreased from 174 at the end of Q1 to 146 at the end of Q2, and overall in 2020 the number of issues resolved exceeds the number of issues identified. This progress is shown in Figure 5 on the following page, which plots the numbers of issues identified (tan bars) and closed (blue bars) in each calendar year. A total of 14 condition-based or corrective maintenance issues were identified in Q2 of F2021 while a total of 39 new and previous issues were addressed. Ten of the issues addressed were “line of defence” issues, while the remainder were other deficiencies. Those 146 issues comprised 131 corrective and condition-based maintenance issues recorded in Passport, 3 other issues being tracked by Dam Safety but not in Passport, and 12 issues that are to be resolved through small capital projects and are being tracked through the capital planning process.

As discussed in last quarter’s report and further demonstrated by the red trace in Figure 5, line of defence issues have generally been resolved on a timely basis and that remains the case. As of the end of Q2, there were 17 outstanding line of defence maintenance issues, which were originally identified in the calendar years shown in the table below:

	2020	2019	2017-18	2010-16
Year of origin of outstanding spillway gate “line of defence” maintenance issues	12	1	3	1

Twelve of the 17 outstanding issues were identified within this current year, and three of those were in the most recent quarter. All are being actioned. The two oldest outstanding line of defence issues are at Mica Dam and Sugar Lake Dam, and are described as follows:

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- In December 2017, the diesel generator that provided backup power to the spillway and outlet works gates was back energized and failed. A new generator was purchased in 2018 but not immediately installed, requiring some reconfiguration to fit in its required location. In the interim, a rental mobile unit has served as the temporary backup power supply and is currently operating under an Interim Dam Safety Risk Management Plan. Work to complete the installation is now underway and is expected to be completed in Q3 of F2021.
- In November 2010, a low level outlet gate at Sugar Lake Dam was observed to bind at small gate openings of approximately 10 cm. Since that time, the gate has not been closed and operation has been limited to openings larger than that value. The gate is tested each month and satisfactory operation within these limitations has been verified. The gate is required to pass large floods, but its limited operation is not considered to impact that function and so, unlike the other line of defence issues, has been given a low priority for resolution.

Outstanding line of defence maintenance issues are therefore seen to be generally current or, where not, under active risk management with interim plans in place.

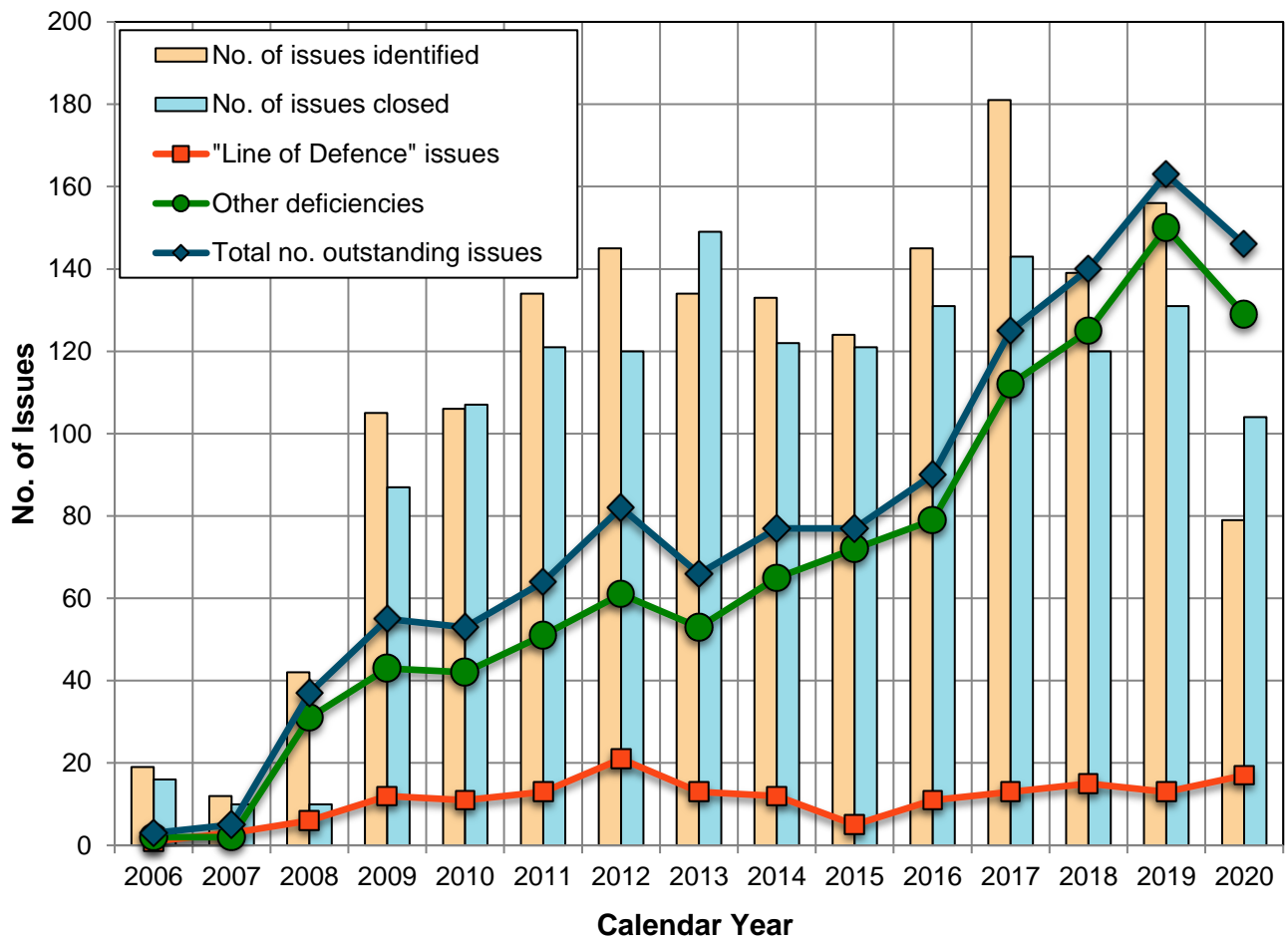


Figure 5 Number of cumulative identified and outstanding spillway gate corrective and condition-based maintenance and procedural issues at the end of each calendar year.

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The Q2 progress is encouraging, but current completion rates of planned F2021 work indicate that continued focus and additional improvements are required to continue the downward trend in outstanding issues. To wit, at the time of writing there were 68 work orders in Passport related to dam safety gate reliability that have been approved for completion in F2021 – 30 of those were planned for F2021 execution based on prioritization of the outstanding inventory and 38 have been approved in-year – yet only 23 of those work orders had been completed up to the end of Q2.

During Q2 Dam Safety began engagement with Stations Asset Planning and delivery partners in Program and Contract Management to better communicate the importance of the gate reliability issues and to explore opportunities for improvement in execution and reporting. One specific change that has been agreed to is that, going forward, all requests to defer spillway gate maintenance will be directed to Dam Safety for review and acceptance, which has not previously been the case. A second change that is pending is for all “line of defence” issues to be designated as “Priority 2” maintenance issues, which will require that those issues be rectified within a specified period and require early notification of risks that the work cannot be completed as planned. Thirdly, Dam Safety has adapted existing practices for prioritization of maintenance work orders to better reflect the operational and safety-critical nature of spillway gate systems and is now calibrating this adaptation to other risks and maintenance portfolios. Over the coming six months there will also be focussed collaborations with:

- Program and Contract Management to develop more detailed reporting of the status of the maintenance plan’s execution; and
- Collaboration between Dam Safety and Stations Asset Planning to ensure that the F2022 Plan includes an appropriate allocation to spillway gate maintenance.

Improvement of Dam Safety’s oversight of spillway gate maintenance – and all other dam-related maintenance – is a high priority for F2021 and progress will continue to be reported to the Board each quarter.

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 BC Dam Safety Regulation as part of annual compliance 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 other reports for quarterly updates on emergency preparedness and public safety around dams.

Metro Vancouver’s Cleveland Dam

Following the tragic accident at Metro Vancouver’s Cleveland Dam on October 1, 2020, members of BC Hydro’s Dam Safety KBU reached out to colleagues in Metro’s Water Service department to offer to assist in their investigation or to provide what information they might find beneficial. Subsequently, BC Hydro Dam Safety and Public Safety personnel provided Metro Vancouver staff with information on BC Hydro public safety warning systems and standards, and further put them in touch with other dam owners who have experienced similar events.

BC Hydro Dam Safety has no information regarding the Cleveland Dam incident other than what has been published in the news media.

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ShakeOut 2020

Dam Safety participated in the emergency response exercise conducted on October 15 to coincide with the Great British Columbia ShakeOut. This year, the corporate-wide exercise was limited to individual practicing the basic “Drop, Cover and Hold On” followed by practicing of team check-in procedures for selected, key business units. Dam Safety then conducted a small table-top exercise of its own, responding to a hypothetical Magnitude 7.5 earthquake with an epicentre between Alouette and Coquitlam Dams.

A key driver for Dam Safety’s exercise was to perform proof-of-concept testing for a new “Event Response Dashboard” (ERD) that is under development by Dam Safety’s Information Technology team. A key learning from the 2019 ShakeOut exercise was the need for a simple information management system that can be scaled to the technology that’s available – ranging from manual tools to fully functioning network systems – after an earthquake. (Refer to the F2020 Q2 report.) The ERD pulls together GIS-based, real-time information from provincial and BC Hydro emergency management systems and from Dam Safety systems like the Earthquake Acceleration Estimator, Geoviewer, facility cameras, the instrumentation plotting and alarms, and the new Inspection App into a single dashboard that allows for a comprehensive viewing of all relevant, available information. The ERD also tracks employee check-ins and availability, assignment and status/completion of tasks, observation reports, and external emergency notifications such as Dam Alert and Dam Breach notifications. For scalability with available technology, tracking entries are made into simple Excel spreadsheets that can be maintained offline until network access is restored.

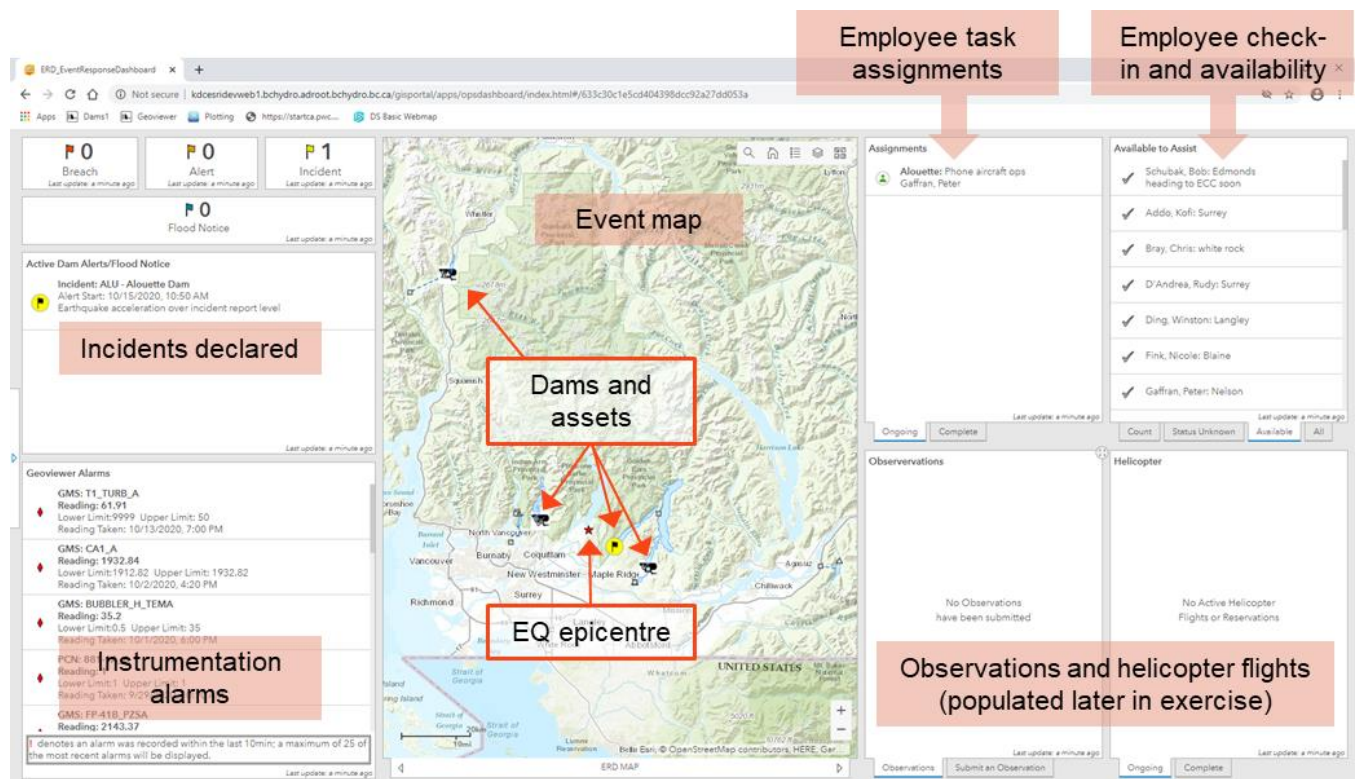


Figure 6 A screen shot of the Event Response Dashboard taken during the early moments of the exercise. The dashboard is readily reconfigured independently by multiple users wishing to reference different sources of information.

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Dam Safety staff participating in the exercise, regardless of location, were able to open the ERD on their web browser and practice manipulating views to obtain the required information to play their part in the exercise. Dummy inspection reports, including site photos, were created in the Inspection App and loaded to the dashboard. Following this very successful trial, suggestions from Dam Safety staff are being incorporated into the dashboard, after which Dam Safety will work with IT to move the ERD into a production environment for use in responding to a wide range of incidents; not just earthquakes.

Capital Projects

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

Work on Dam Safety capital projects proceeded with fewer restrictions in the field due to COVID-19. Delays incurred in Q1 due to working under the “Work Management during Pandemic” protocols were not generally reversed, however, and some projects’ in-service dates have been delayed as a result. Nevertheless, substantial and significant progress was made on several projects, tangibly reducing or eliminating dam safety risks.

Mica/Revelstoke Dams – Vertical Movement Gauges

The background of this project was discussed in last quarter’s report. In Q2, the project completed its main objective to seal the seven vertical movement gauges in the earthfill dam at Revelstoke and six vertical movement gauges in Mica Dam with grout and eliminate their potential to induce hydraulic fracturing or internal erosion in the cores of those dams. Instrumentation that has been placed in those casings to augment current piezometric readings will be connected and put into service in Q1 of 2022.

Downie Slide Instrumentation Improvement

Downie Slide and this project to replace failing instrumentation to measure piezometric pressures and slide displacements were described in the F2019 Q2 Dam Safety report. In Q1, funding approval for Implementation Phase was received and site access improvements were completed. Drilling and installation of in-hole instrumentation (piezometers, inclinometers) commenced in Q2. The forecast in-service date of the instruments described above and of a new, continuous GPS surface displacement monitoring system is March 2022.

Revelstoke – 731 Block Stabilization

The 731 Block is a 55 m high prominent rock mass above Highway 23 on the left abutment of Revelstoke Dam. Two rows of high capacity anchors stabilize the block. Weathered and fractured rock above the upper row of anchors is prone to ravelling with potential to impact and damage the anchor heads. This project’s objectives are to mitigate the rockfall risk, address instabilities at the crest of the slope, and address the long-term performance of the existing anchors. Construction commenced in Q2, having been delayed in consideration of COVID-19 work protocols. The in-service date has moved from December 2020 to October 2021 as a result.

Board briefing – DAM SAFETY QUARTERLY REPORT**Bugaboo Diversion Dam Decommissioning**

The Bugaboo Creek Diversion was constructed to provide water to the Spillimacheen Generating Station but has been abandoned since the 1957 freshet washed out the spillway control structure. As BC Hydro derives no benefit from this facility and there is no financial justification to re-establish the diversion into the Spillimacheen River, this project was released in 2016 to decommission the Bugaboo Diversion Dam and diversion works. On completion of the Identification Phase, partial removal to meet the criteria of a “Minor Dam” in the Dam Safety Regulation – which allowed the retention of a beneficial wetland in the dam’s forebay with minimal ongoing requirements for monitoring and reporting – was confirmed as the Preferred Alternative. Partial removal commenced in Q2 and is expected to be completed at the end of October 2020. The work being performed by Nuqpu Development Corporation which is a business partner of the Ktunaxa Nation Council.

Kootenay Canal – Install Intake Dam Foundation Uplift Instrumentation

The objective of this project is to install instrumentation within and beneath the Kootenay Canal Power Intake to provide information on foundation pressures and rock/concrete contact to reliably assess the stability of the intake’s concrete blocks. In Q2 the project completed construction and the instrumentation was placed into service.

Spillimacheen Dam – Tunnel Plug Installation

The Spillimacheen Powerhouse has been out of service since March 2019, when one of two penstock inlet valves ruptured due to freezing and caused an uncontrolled release that flooded the powerhouse. Please see the F2019 Q4 Dam Safety quarterly report for details. Since then, the penstocks have been isolated from the dam’s forebay, but the temporary measures put in place left the water barrier vulnerable to a second failure in freezing conditions. This project was initiated in F2021 Q1 to install a concrete plug within the intake structure at the upstream end of the power tunnel leading to the generating station and so eliminate that vulnerability. The tunnel plug installation was completed and put in-service on October 16, 2020.

GMS – Durack Brook Dam Decommissioning (New Project)

Durack Brook Dam is a small earthfill structure, about 6 m high by 45 m long located on the hillside above WAC Bennett Dam. The dam was originally constructed in the 1960s to provide drinking water for the WAC Bennett Dam construction camp and was substantially rebuilt sometime between the late 1980’s and 1991. It presently provides non-potable water for the GT Shop and Visitor Centre but another project currently underway will establish a new water supply for those facilities in F2022. This project was released in Q2 to decommission and remove the Durack Brook Dam and an upstream diversion dam to eliminate the risks associated with those dams.

CMS – Concrete Dam Instrumentation Upgrade (New Project)

In 1985, 21 piezometers were installed in the foundation beneath the Main Concrete Dam at Cheakamus to monitor uplift pressures beneath the dam. Today only 11 of those piezometers remain functional. This project was released in Q2 to install new piezometers to complement the remaining 11 manually read piezometers and to provide real-time monitoring of uplift pressures under the concrete dam via the Automated Data Acquisition System.

Board briefing – DAM SAFETY QUARTERLY REPORT**Dam Safety Investigations**

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

Hugh Keenleyside Dam – Assessment of Right Abutment Berm Performance

Following a review of the berm design reports, instrumentation data, and elevations of the reservoir and tailwater, the investigation into the accumulation of fine sand and silt resembling the native soils at the toe of the right abutment berm has identified the most likely causes to be water flows within the channel at the base of the berm or wave action. The transition and riprap materials were found to be directly placed on the foundation soils at the location of the channel and are unable to protect the foundation materials from erosion. A site visit is planned for October 2020 to collect soil samples to confirm the source of eroded materials. A risk assessment will then be performed to determine the potential consequences of continued erosion.

Seven Mile – SPOG Testing and Operational Changes (New Investigation)

Seven Mile Dam currently has Local Operating Orders in place to restrict gate operations due to erosion of the left bank caused by the operation of the left-most spillway gates and vibration or deflection of the concrete training wall separating the spillway and the powerhouse deck during some combinations of operation of the right-most gates. The purpose of this DI, launched in Q2, is to perform analyses and conduct spillway gate tests at Seven Mile Dam to determine whether some of the current Local Operating Order restrictions on gate operations can be relaxed. The gate tests and the final DI report are planned for F2022.

Alouette Dam – Post Seismic Operability of Spillway Gates (New Investigation)

The concrete spillway located at the right abutment of the Alouette Dam can pass water via a free overflow weir and/or a gated sluiceway. The sluice gate is operated for routing of pre-flood flows and seasonally for Kokanee outmigration from the reservoir. A seismic performance investigation of the Alouette Dam carried out between 2006 and 2011 indicated that the spillway would sustain damage under the Maximum Design Earthquake (MDE). The post-earthquake operational priority is to minimize the risk of spilling by closing the sluiceway gate, if it is open, and by managing discharge through the bypass adit. If the sluiceway gate is inoperable and unable to be closed, flow of water over the spillway could lead to progressive failure of the dam. To meet Water Use Plan targets, Dam Safety deemed a gate opening of 200 mm was acceptable to provide the required flows while managing the post-seismic risks. If an earthquake damages the spillway and the gate is unable to be closed, sandbags will be placed upstream to prevent discharge of water into the chute.

Stakeholders and First Nations are desirous of testing higher pulse flows to determine whether those would increase Kokanee outmigration. Higher pulse flows would require gate openings greater than 200 mm. A DI was initiated in Q2 to determine methods to allow for increased flows through the sluiceway gate while maintaining the capability to terminate flows through the gate and over the spillway following an earthquake. The DI will examine options to implement remedial measures that would allow post-earthquake operability of the sluiceway gate, as well as measures that would stop the flows if the gate cannot be closed.