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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 January 1, 2020 to March 31, 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.

The Dam Safety Program has been executed in a manner that is consistent with its stated objectives throughout the reporting period. The overall Dam Safety risk profile is shown in Figure 1. There has been a slight overall increase in assessed vulnerability of our dams this quarter, with new issues arising from the recent incidents at Spillimacheen, Aberfeldie and Hugh Keenleyside—and the resulting interim operational measures put in place—offsetting the first of the issues being closed at Ruskin with the completion of that project.

This report also describes the measures that have been implemented to date within the Dam Safety Program in order to manage impacts from the COVID-19 pandemic.

Risk Profile of BC Hydro's Dam

Dam Safety Contribution to Enterprise Risk

Dam Safety is assigned a high "risk priority" within BC Hydro's Enterprise Risk report, as depicted below. This high rating is arrived at by recognizing that: (1) there can be extremely severe consequences from the failure of a dam; (2) a dam failure can progress quickly without leaving adequate time to take effective actions to reverse the failure; and (3) our ability to mitigate this risk is considered to be "moderate" given that upgrades to existing dams are typically expensive, time and resource intensive and frequently technically challenging. The nature of dam safety risk is that it can only be realistically managed by minimizing to the extent practicable the probability of occurrence through a well-constructed and well-executed Dam Safety Program.

Risk	Severity	Likelihood	Speed of Onset	Ability to Mitigate	F20 Q3 Risk Priority	Change from Last Quarter
Dam Safety *Risk of a dam safety incident*	H	L	Fast	M	H	• For F20 Q4 the overall Dam Safety risk is stable. • Adjustments to dam safety surveillance and incident response due to conditions posed by COVID-19

Given the nature described above, this Dam Safety component of the Enterprise Risk is not expected to change from quarter to quarter. Neither is it expected to diminish over time in response to dam upgrade projects delivered within the Capital Plan, such projects being intended to adequately manage this aspect of BC Hydro's risk rather than eliminate it.

Board briefing – DAM SAFETY QUARTERLY REPORT

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, the higher the likelihood of that deficiency leading to poor performance. The aggregated Vulnerability Index for all deficiencies at a particular dam characterizes the extent of concern for the dam's poor future performance from all causes.

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. Notable changes in Vulnerability Index in F2020 Q4 are described below and identified in Figure 1.

1. A Vulnerability Index ***addition*** of 2.71 (AN deficiency) at **Hugh Keenleyside Dam**.
   As a result of the sinking of two pontoons of the navigation lock's floating guidewall (see "New Issues"), the debris boom's right anchor has been compromised.

2. A Vulnerability Index ***addition*** of 3.61 (AN deficiency) at **Peace Canyon Dam**.
   Stability analysis of the dam's spillway blocks, performed within the Peace Canyon Dam Instrumentation and Drains Upgrade Project and using interpreted distributions of uplift from current piezometer data, has calculated a sliding factor of 1.43 for Block S6 which is less than the value of 1.5 in the CDA guidelines. The results of this analysis are being used to inform the project on requirements for remediation of and upgrades to the dam's drainage system.

3. A Vulnerability Index ***addition*** of 3.68 (AN deficiency) at **Aberfeldie Dam**.
   Following the discovery of several leaks in the high density polyethylene penstock and their subsequent repair (Dam Safety Quarterly Reports from F2020 Q1 through Q3), the integrity of the penstock is considered to be compromised. Risks are presently being managed via increased surveillance and monitoring of leak detection instrumentation, as detailed in an Interim Dam Safety Risk Management Plan.

4. A Vulnerability Index ***addition*** of 3.42 (AN deficiency) at **Spillimacheen Dam**.
   Following the rupture of a penstock isolation valve (PIV) last year (Dam Safety Quarterly Reports from F2019 Q4 through F2020 Q3), the remaining penstock isolation equipment in the surge tower is considered to be susceptible to ice damage during winter operations. Measures to heat vulnerable spaces and monitor temperatures in those spaces have been implemented and detailed in an Interim Dam Safety Risk Management Plan.

5. Vulnerability Index ***reductions*** of 6.87 at **Ruskin Dam**.
   Sealed Engineering Design Conformance Records for newly in-service assets and upgrades were received in Q4 and Dam Safety is now reviewing them to update the Issues Database. Issues regarding seepage and piping in the right abutment, seismic stability of the right abutment, and the seismic stability of the dam crest have been closed. Issues relating to the spillway gates remain open pending correction of outstanding project deficiencies. Issues relating to the dam's left abutment and spillway gates remain open pending resolution of the sinkholes that were discovered in January (see "New Issues").

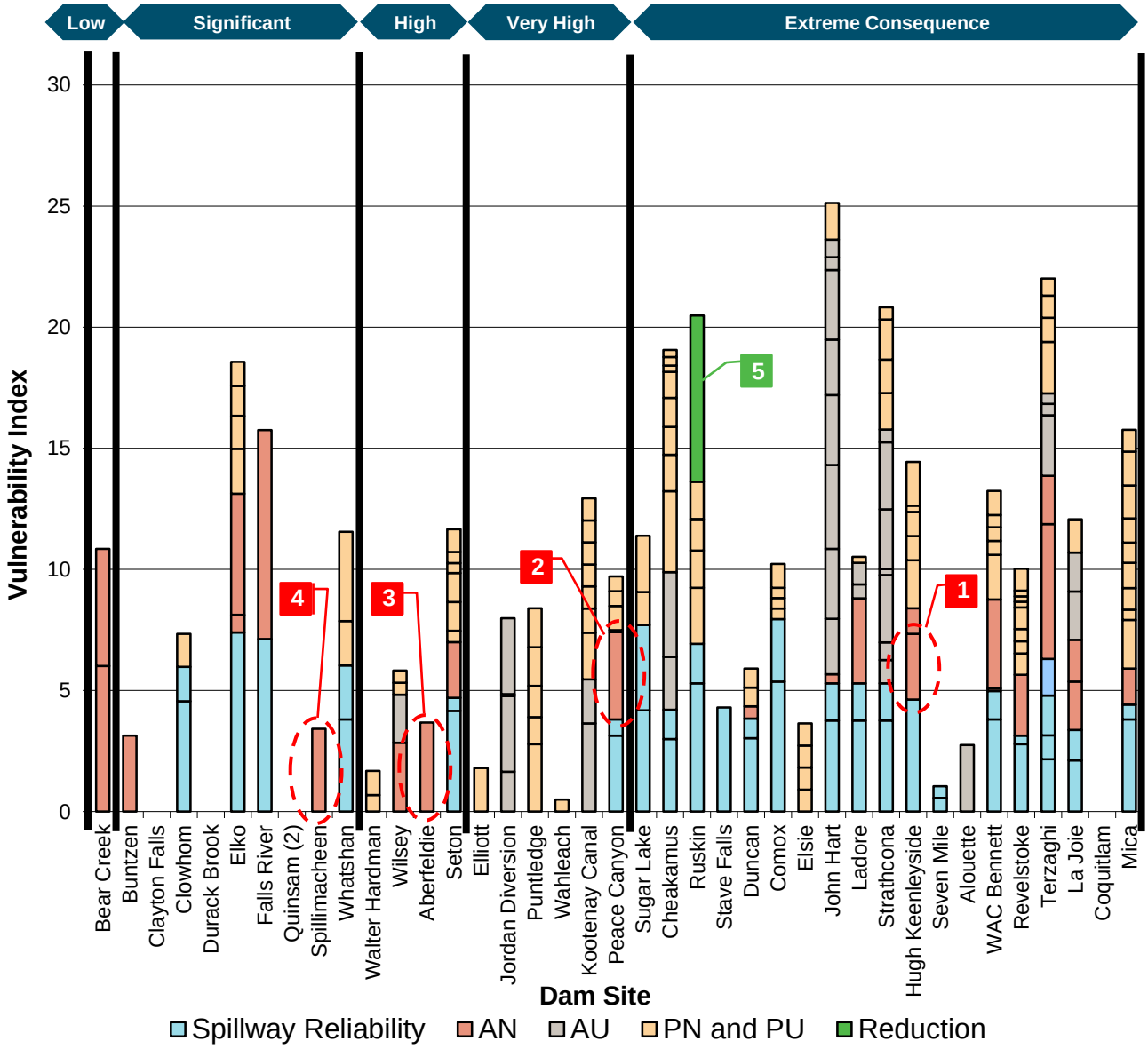

Figure 1 Dam Safety overall risk profile at the end of F2020 Q4, as represented by the Vulnerability Index. There were changes this quarter as indicated by the numbered boxes.

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

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. This is an indication of the changes in the understanding of BC Hydro's dam safety risk profile over time. Additions are due to the development or recognition of new issues. Reductions are due to risk remediation projects delivered through the Capital Plan, completed repairs and corrective maintenance, and resolution of issues via Dam Safety Investigations. Existing issues are re-examined on a regular basis and re-rated as required. As indicated by the uniformity of the height of the stacked blue and sand-coloured bars, BC Hydro's intent to not allow an overall increase in the dam safety risk profile continues to be realized.

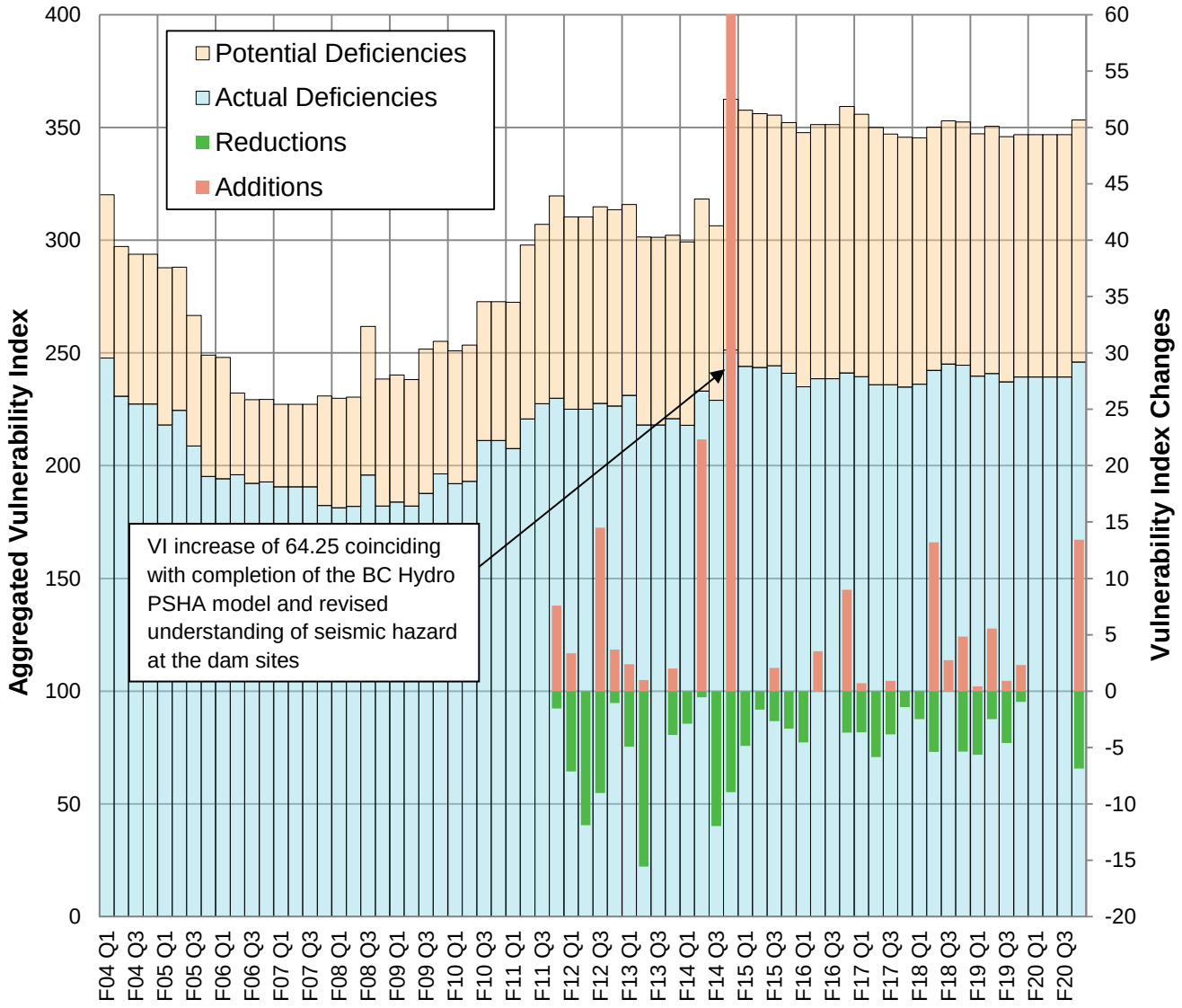

Figure 2 Changes and trends in the Vulnerability Index aggregated across the BC Hydro system. Note: the bars are "stacked" such that total aggregated Vulnerability Index is given by the top of the Potential Deficiencies bar.

Non-Conformances in the Dam Safety Program

The risk profile of BC Hydro's dams—and our understanding of it—is very much dependent upon the effectiveness of the operational, maintenance and surveillance procedures in place and being utilized within the Dam Safety Program. Program non-conformances are identified and tracked in the Dam Safety Issues Database and rated as being of high, medium and low importance. The overall numbers of non-conformance issues by calendar year are plotted in Figure 3.

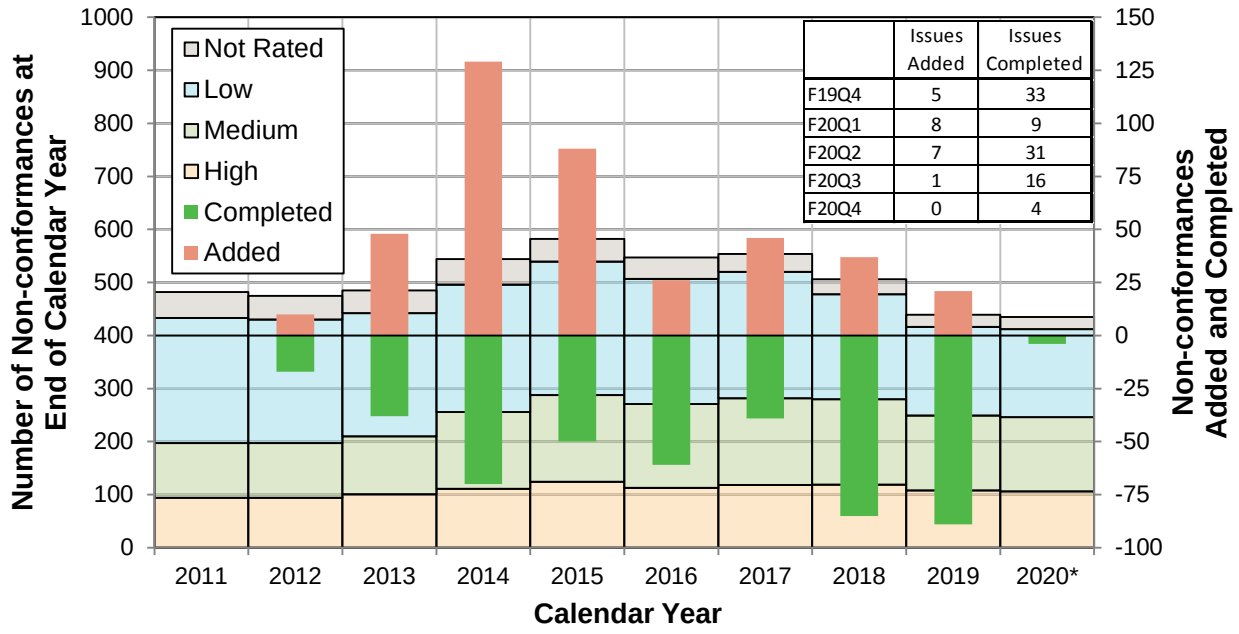

Figure 3 Changes and trends in the total number of non-conformances within the Dam Safety Program. Note: this data is plotted by *calendar* year. Calendar year 2020 represents the fourth quarter of F20 only.

Initiatives to improve the management and resolution of Program non-conformances are continuing. A strategy to reduce the number of non-conformances within the Dam Safety Program is nearing readiness. Originally planned to be completed in F2020, documentation of the strategy is now forecast for Q1 of F2021 as resources were diverted to higher priority regulatory activities. (See "Regulatory Communications".)

New Issues

Hugh Keenleyside Dam – Floating Guide Wall

The floating guidewall at Hugh Keenleyside Dam directs marine traffic safely into the facility's navigation lock that allows marine traffic to pass through the dam. The floating guide wall also forms part of the debris management system at the dam, preventing debris from accumulating and potentially blocking the discharge facilities. The guidewall provides protection from debris as well as anchorage for the right end of the debris boom. Please refer to the description of Hugh Keenleyside

Dam in the Dam Safety "book" on Diligent for an aerial photo showing the location and orientation of the floating guidewall and navigation lock.

The floating guide wall is composed of six pontoons that are shackled together. At about 09:30 on January 13, 2020, in high winds and below-freezing temperatures, the outermost pontoon (No. 6) was observed to be riding low in the water. It quickly became obvious that this pontoon was sinking and dragging Pontoon No. 5 down with it. At approximately 10:45, the connection between Pontoon No. 5 and No. 6 failed and No. 6 sank. No. 5 continued to take on water. Fortunately, the connection between Pontoon No. 4 and No. 5 also severed before No. 5 sank at 12:15 (Figure 4). Later inspection determined that Pontoon No. 4 was not appreciably damaged.

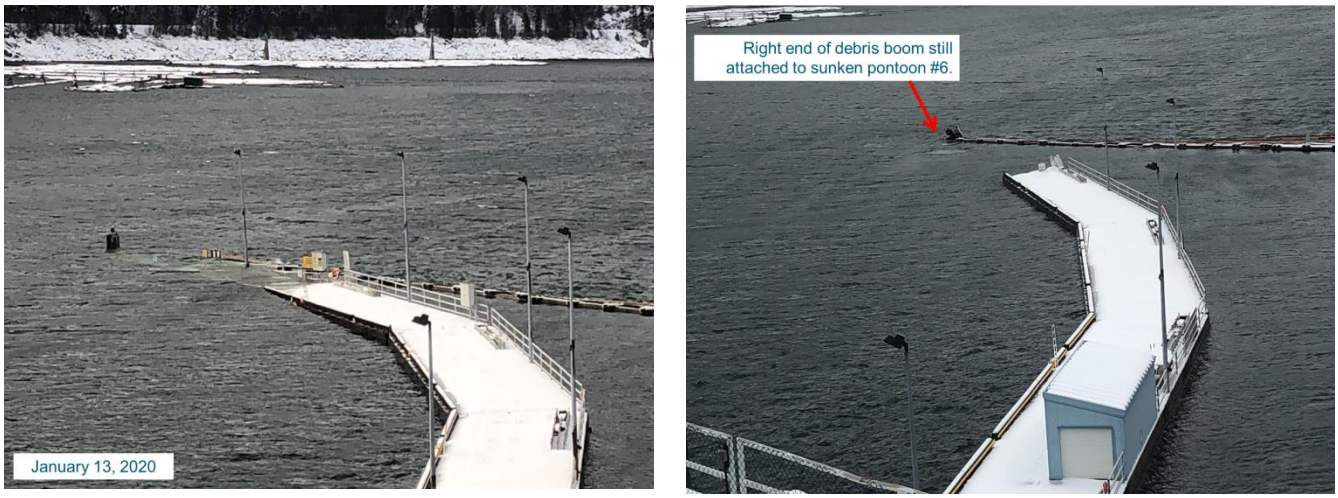

Figure 4 Photo on the left shows Pontoon 6 just below the water. Photo on the right shows the guide wall after Pontoons 5 and 6 had submerged.

An Emergency Operations Centre was immediately established. The lock was closed to all traffic and appropriate community and regulatory notifications were made, including to Arrow Lakes Generating Station, Nav Canada and the Coast Guard. A Dam Safety Incident was registered with the Comptroller of Water Rights, as the events had the potential to impact the dam's spillway and low level outlets.

The sinking of Pontoon No. 6 dragged the right (south) end of the debris boom down with it, potentially compromising the boom's anchorage. Had the connection failed, debris or the boom itself would have been free to enter one of the dam's discharge passages, potentially jamming the gates. Loads on the boom were reduced by significantly reducing discharge through the dam and organizing tug boats to remove debris from the boom as quickly as possible. The resulting gap between the submerged end of the debris boom and Pontoon No. 4 was closed by a temporary log boom as soon as the integrity of Pontoon No. 4 was confirmed. Subsequently, the submerged sections of the debris boom were removed and the remaining portion of boom was connected to Pontoon No. 4. This has permitted the navigation lock to be re-opened, but only to commercial traffic and with modified operations.

The cause of the sinking is still under investigation.

Ruskin Dam – Left Abutment

On January 6, 2020, after an extended period of heavy precipitation, a sub-contractor working at Ruskin Dam noticed a small depression in the filter blanket that was recently constructed on the left abutment behind the powerhouse. An investigation confirmed this to be a sinkhole. A second sinkhole has since developed in the same area and both have increased in size.

The cause of the sinkholes is currently being investigated, but non-invasive inspections to date have given no indication that they are the result of seepage from the reservoir or the adjacent G3 penstock. They are not considered to pose an immediate safety risk to the dam, public or workers. The area is inspected daily and the sinkholes are being monitored via the Automated Data Acquisition System. Plans have been developed to perform invasive field investigations under the Ruskin Dam and Powerhouse Upgrade Project's contract, which are pending approval under the Work Management During Pandemic protocols.

Dam Safety Response to COVID-19

On March 13, 2020, Dam Safety began developing business continuity plans for operations during the COVID-19 pandemic and on March 16, Dam Safety staff were directed to work from home. Due to Dam Safety's role in responding to emergencies, the group is well set up for working from home with most staff already having laptop computers and VPN connections to the network.

The functions performed by the Surveillance department were classified as essential work and plans were developed to continue to providing Dam Safety support in a way that minimized potential exposure of our personnel to the virus.

- The Surveillance department is divided into five regions, all capable of functioning independently. All inter-regional business travel was suspended to reduce the risk of spreading the virus between regions.

- The Dam Safety Engineers and Dam Safety Technologists were directed to work from home, minimizing trips into the office. Staff took important reference documents, monitoring equipment and BC Hydro vehicles home so that site work, such as monitoring and inspections, could be dispatched from home rather than from the office.

- Staff work independently, and in cases where more than one staff member is required for a job, they travel in separate vehicles and maintain safe distances between each other while completing the work.

Dam safety inspections and spillway gate testing have been defined as critical work and are continuing as scheduled. Dam Safety has representation on the committees that assess and approve other critical and high-priority work.

To date, the Dam Safety group has been able to function with only minor impacts to the Program.

Further planning is underway to better prepare ourselves for an unplanned incident, such as that at Hugh Keenleyside Dam, described previously. Under the present pandemic conditions and the work protocols that BC Hydro has adopted in response, it is expected that responding to such an incident could be slower than in more normal conditions.

- While we would certainly put aside these work protocols as necessary to respond to an emergent situation, coming to a determination that it is appropriate to do so might take a short period of time. To align with the protocols of Operations crews and mitigate delays due to concerns for exposure to the virus, the Surveillance team is being divided into small "pods" of two that will not physically interact with other pods and, in incident response, will be carefully scheduled so as to interact with no more than one Operations crew pod. Development of a rapid decision framework for responding under these conditions is also underway.

- Moreover, logistics may be somewhat more difficult to organize than in more normal circumstances, as various suppliers may also be operating differently in response to the pandemic. Lists of available providers for such logistical needs are being compiled.

Jordan Diversion Dam – Public Safety Near Miss

On the evening of April 20, 2020, two members of the public were in the river channel immediately downstream of Jordan Diversion Dam, apparently having made their way there from the main logging road on the river's west bank. Doing so would have required them to ignore extensive warning signs, circumvent BC Hydro's fencing, and make their way down a steep, dangerous slope. Please refer to the description of Jordan Diversion Dam in the Dam Safety "book" on Diligent for photos of the site showing the terrain and, notably, a hollow cone valve that controls flows through the dam's low level outlet. At 7:03 pm of that evening, the hollow cone valve was remotely opened, sending just over 40 cubic metres per second of water downstream. The members of the public were fortunately able to escape the river channel unharmed. The following morning, one of the persons contacted BC Hydro. He made note that warning signs in the area told persons to leave if a warning siren was heard, but that no siren had sounded prior to the release. A subsequent check of the siren found it to be inoperative, and the siren was promptly replaced.

IMS #195340 "JOR: Member of the public reports water released downstream of Diversion Dam" has been entered as a Public Near Miss. An investigation has been launched, and that investigation is involving representatives from Stations Field Operations, Public Safety and Dam Safety.

Reorganization of the Dam Safety Key Business Unit

The previous Quarterly Report described a pending reorganization of the Dam Safety Key Business Unit and the creation of a new Regulatory and Asset Planning department. This department was created and structured, in part, to better deliver on BC Hydro's regulatory compliance obligations. Good progress has since been made in establishing this new department.

Janet Green, P.Eng. joined BC Hydro on March 23, 2020, to become Manager, Dam Safety Regulatory and Asset Planning. Janet comes to us from FortisBC, where she was most recently the Senior Manager, Renewable Energy Projects and before that the Manager, Gas System Assets. In that role, Janet led a team of 35 asset management personnel that carried out the maintenance and capital planning functions for FortisBC's gas assets. This experience will be of immeasurable value to Dam Safety as we expand our role beyond administering and implementing the Dam Safety Program to also acting as the formal asset manager of the dams and ancillary structures and systems. Before joining FortisBC, Janet worked for an engineering consulting company carrying out geotechnical investigations, installing and monitoring instrumentation, and modeling the stability of slopes and embankment dams.

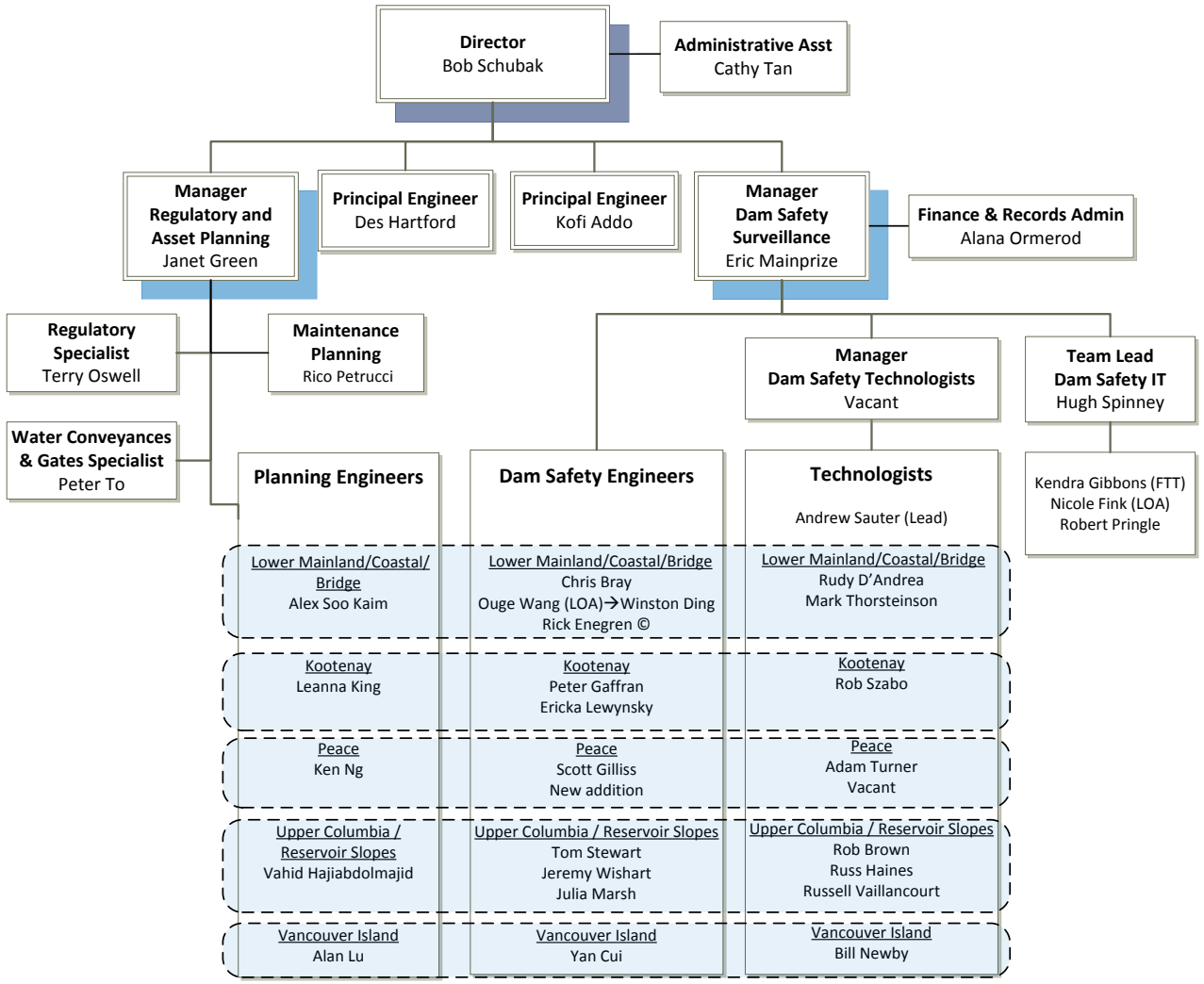

Figure 5 The new Dam Safety organizational structure.

Further, agreements were finalized with Stations Asset Planning to transfer three personnel from that unit into Dam Safety as of April 1, 2020 to fill out the new department's roster. The new structure of the Dam Safety Key Business Unit, effective April 1, 2020, is shown in Figure 5 on the following page.

The new Regulatory and Asset Planning department will look after the filing of required regulatory submissions and the planning and oversight of Dam Safety Reviews, investigations, maintenance activities and capital projects. The department has been designed to align with the Surveillance department, with Planning Engineers seeing to the regulatory and asset management activities relating to specific, assigned regions and working with the Dam Safety Engineers and Technologists for those regions within a matrix structure. This alignment also extends to the Generation Asset Management team to better coordinate the development of strategies and plans for entire facilities.

Elements of maintenance planning will also move into Dam Safety and be incorporated into the new department. A description of the new maintenance planning arrangements will be provided in next quarter's report.

There have also been some changes, albeit less dramatic ones, to Dam Safety Surveillance, where retirements and promotions opened up positions to be repurposed. The main thrust of repurposing these positions has been to improve coverage, mentoring and future succession of Dam Safety Engineers in the regions. Firstly, a new Dam Safety Engineer, Ms. Ericka Lewynsky, P.Eng., was recruited last fall to work in the Kootenay region with Peter Gaffran. Currently, a second repurposed position is being readied for recruitment in the Peace region, and will commence once recruiting activities are resumed at BC Hydro. A new Dam Safety Engineer will be added (see "New addition" in Figure 5) to work with Scott Gillis in the surveillance and monitoring of WAC Bennett, Peace Canyon and Site C Dams.

Another repurposing has occurred in the increasingly important technology group led by Hugh Spinney. With the retirement of a data processor, and with Dam Safety's data systems become almost fully automated, that position was changed to a more technical data analyst position, and was filled by Robert Pringle who was previously a Technologist in the Peace region. While Robert's previous position is listed in Figure 5 as being vacant, he remains stationed at GMS and is available to support the Peace region team as needed. Again, recruitment for that vacancy will commence when such activities are resumed at BC Hydro.

One final vacancy is that of the Manager, Dam Safety Technologists. This M1-level manager role has gone through recruitment and a candidate has been selected. The official offer is ready to be sent, pending the resumption of recruiting activities.

Compliance with Processes and Regulations

Regulatory Communications – BCUC

Arising from media reports alleging a risk of dam failure in the Peace River region due to induced seismicity from oil and gas industry operations, and a complaint filed by the author of those allegations, there was unprecedented interest in the Dam Safety Program from the British Columbia Utilities Commission in Q4 of F2020. The Commission issued a number of Information Requests to BC Hydro in this period regarding BC Hydro's understanding of the hazards and risks posed by these operations and the general condition and safety of BC Hydro's dams in the region. Responses were provided to the Commission on January 3, February 3, March 20, and April 17. Given the number of questions posed by the Commission and the level of detail requested, this activity occupied a large amount of the available time of several members of Dam Safety's staff, and displaced planned, regular work within the Program as well as initiatives underway to make improvements to the Program.

Regulatory Communications – Comptroller of Water Rights

The annual meeting between BC Hydro Dam Safety and the office of the Comptroller of Water Rights was held in Victoria on February 3 and 4, during which BC Hydro provided:

- A description of the reorganization of the Dam Safety business unit;
- Information on the hazards and risks posed to BC Hydro's dams by induced seismicity in the Peace River region;
- A review of the surveillance program;
- Updates to ongoing and planned capital projects and investigations;
- An update on the preparations for Site C diversion.

Operation, Maintenance and Surveillance Manuals

Each dam has an Operation, Maintenance and Surveillance (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.

Three updates of OMS Manuals were completed and submitted to the Comptroller of Water Rights in Q4: John Hart Dam, WAC Bennett Dam and Alouette Dam. Owing to the resourcing challenges described in last quarter's report, however, only four of eight planned OMS Manual updates were completed overall in F2020. Planned updates to the OMS Manuals for Ruskin, Strathcona, Seton and Wahleach Dams were not completed.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Actual	Target
OMS Manual updates completed	4	8	✘	4	8
Completion of F20 work plan	39%	100%	✘	39%	100%

The measures that are being taken to recover and bring the delivery of OMS Manual updates onto the regulatory schedule were described in last quarter's report. These measures include organizational changes, for which a description was provided previously in this report. Where in the past there had been two persons tasked to regulatory activities such as OMS Manual updates (only one through the latter half of F2020), this organizational change means that six persons—five Planning Engineers and one Regulatory Specialist—will share these responsibilities within their roles. It is expected that this arrangement will prevent any repeats of the resourcing difficulties that led to missing the delivery of OMS Manual updates in F2020. We have provided the Comptroller of Water Rights with a schedule for updates to the OMS Manuals that will bring us back into alignment with the regulatory schedule within F2021. The new department's first priority is to deliver on this schedule and the Planning Engineers' first assigned tasks are to familiarize with their assigned facilities and commence work on the scheduled updates. With the plan and resources in place, this issue will be fully resolved in F2021.

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.

	Year-To-Date			Year-End	
	Actual	Target	Indicator	Actual	Target
Dam Safety Reviews completed	3	8	✘	3	8
Completion of F20 work plan	65%	100%	✘	65%	100%

In Q4, the Dam Safety Review for Hugh Keenleyside Dam was completed. For the year in total, three of eight planned Dam Safety Reviews were completed and reports issued. Of the five scheduled Dam Safety Reviews that were not completed in F2020, two were delayed because short-staffed BC Hydro personnel were diverted to work on finalizing the more urgently required OMS Manual updates,

described above, and the other three were late due to missed delivery milestones by the external Dam Safety Review Engineers. Regarding the five outstanding Dam Safety Reviews:

- The Ladore Dam Safety Review report has been reviewed for clarity by BC Hydro and is being finalized by the external Review Engineer;
- The first draft of the Dam Safety Review report for Kootenay Canal has been reviewed and returned to the external Review Engineer to address BC Hydro's comments;
- The first draft of the Dam Safety Review report for Puntledge Dam has been reviewed and comments are being prepared for the external Review Engineer;
- The first draft of the Dam Safety Review report for Mica is with BC Hydro for review; and
- The draft report for Walter Hardman Dam is expected in early Q1 of F2021.

The first four of these five outstanding Dam Safety Reviews are sufficiently advanced to be confident that they will be completed in F2021 Q1. Pending the state of the first draft report, the Walter Hardman Dam Safety Review is also expected to be completed in F2021 Q1.

The F2021 program of Dam Safety Reviews is already underway with the external Review Engineers having been identified and the supporting packages of reference information being prepared. With a complete roster of Planning Engineers on staff (see "Reorganization of the Dam Safety Key Business Unit") to undertake and support this work, our expectation is that the completion of Dam Safety Reviews will return to the planned schedule in the first half of F2021.

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.

During Q4 of F2020, 378 of 382 inspections (99.5%) were completed. The four missed inspections are detailed below.

- Two weekly inspections were missed by Stations Field Operations in mid-January at Wahleach and Elliott Dams due to temporarily unsafe road access conditions following large snow storms. These misses were discussed with and agreed to by the Dam Safety Engineers.

- In early February, a weekly inspection was missed by Stations Field Operations at Kootenay Canal. The inspection was missed due to a miscommunication. The assigned employee was completing his last day of work at Kootenay Canal and did not get the task completed. This miss was not communicated to Dam Safety. The Dam Safety Engineer followed up with the inspectors and re-iterated the importance of the inspections.

- The final inspection was missed the last week of March at Clayton Falls Dam. Although crews are on site most days, the inspection checklist form was not completed and submitted. The Dam Safety Engineer followed up with the Field Manager and inspectors to re-iterate the importance of the inspections.

Routine Inspections	F20	F19	F18	F17	F16	F15
Completed	1642	1638	1595	1583	1594	1603
Missed	6	2	16	29	24	8

In total through F2020, 1642 of 1648 inspections were completed. Of the six missed inspections through the year, three were agreed to in advance in consideration of temporarily unsafe road conditions due to poor weather.

Instrumentation and Monitoring

The Regional Dam Safety Technologists continue to build on last fiscal's initiative to drive consistent, regular checking of instrumentation data plots at all dams to identify any unusual trends and to ensure continued accuracy of the data being collected. They are each tasked to perform three such checks per week. During Q4 of F2020, 204 checks were completed, exceeding the target of 180.

Reservoir Slopes

Dam Safety's Slope Surveillance Program continued through Q4 via ongoing monitoring the Reservoir Slopes Instrumentation System and oversight of the Downie Slide Instrumentation Project.

Unusual Events or Observations

The Dam Safety On Call Person (DSOP) responded to 151 calls in Q4 of F2020. The calls included instrumentation alarms, operational inquiries, operations notifications during floods and earthquake notifications. Issues of note were the sinking of the Hugh Keenleyside Guidewall and the discovery of the Ruskin sinkholes. Both events are discussed in more detail above (see "New Issues").

Maintenance

Civil Maintenance

As of the end of Q4, the Civil Maintenance program had completed all 30 projects in its updated plan with a total spend of $3.91 million against an updated plan of $3.87 million.

The Civil Maintenance program went through a significant reorganization in Q4 of F2020 to align with BC Hydro's Plan-Build-Operate-Support Model. Starting in F2021, the delivery of civil maintenance projects—including planning, scheduling, tracking and reporting—moves into the Project and Contract management (PCM) business unit within Operations. Responsibility for identifying, prioritizing and budgeting civil maintenance projects moves into Dam Safety, with the three members of the disbanded Civil Maintenance team in Stations Asset Planning joining Dam Safety's newly formed Regulatory and Asset Planning department.

Spillway Gate Maintenance and Testing

During Q4, all 60 scheduled gate tests at 23 sites were carried out. Five gate systems failed to operate on demand during testing. In seven other cases, while gates did operate on demand, certain individual components of the gate system malfunctioned.

Operational restrictions were put in place on two spillway gates at Hugh Keenleyside Dam on the discovery of kinked hoist ropes that are prioritized for replacement. As of the end of March 2020, operational restrictions were in place on four out of 109 flood discharge gates across the system.

A total of 32 corrective maintenance issues were identified through ongoing testing and maintenance in Q4 and a total of 18 new and previous issues were addressed in the same period, for an increase of 14 overall in this reporting period. There were 154 corrective maintenance issues outstanding at the end of March 2020.

The Quarterly Report for F2020 Q1 noted that all outstanding issues at that time had been scheduled within the maintenance plan to be corrected in F2020 and F2021. The Q2 report further noted that, with the continuing rise in numbers of maintenance issues, additional funds had been allocated to address a substantial portion of the backlog more immediately in F2020. The number of outstanding maintenance issues on our spillway gates has nevertheless continued to increase through the year. With elements of maintenance planning moving into the Dam Safety group (see “Update on the Reorganization of the Dam Safety Business Unit”), an area of immediate focus will be to determine why this is occurring and what will be required to reverse it.

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.

Please also refer to “Dam Safety Response to COVID-19” under “New Issues”, earlier in this report, for a discussion on Dam Safety’s efforts to prepare itself to respond to an incident during the pandemic.

Capital Projects

There were 37 Dam Safety initiated capital projects underway in Q4 of F2020. Summaries of these projects are available for reference in the Dam Safety “book” in Diligent. Updates regarding projects that were newly launched, where significant developments occurred or where milestones were achieved within the fiscal quarter are provided below.

Work has generally continued on these Dam Safety initiated projects through the early days of the COVID-19 pandemic. In particular, engineering design work in Identification and Definition Phases has continued without serious impediment. As noted in the following project updates, however, a number of projects that were in or just entering construction have experienced delays as BC Hydro has scaled back such work in order to manage the risks of exposure to our personnel.

Kootenay Canal – Install Intake Dam Foundation Uplift Instrumentation

The objective of this project is to install standpipe piezometers at the Kootenay Canal Power Intake to better monitor the dam and to inform future assessment of the stability of the intake structure.

In Q4, the project moved through gate into Implementation Phase, the planning for construction was completed and the drilling contract bids were received and evaluated. Implementation of the project, planned to be completed in the first two quarters of F2021, may be impacted by work restrictions arising from the COVID-19 pandemic.

Ladore Dam – Spillway Seismic Upgrade

This project is one of the trio of projects currently being undertaken on the Campbell River System on Vancouver Island and is a key component of the long-term strategy for risk mitigation in that system. When implemented, Ladore Spillway Gates Seismic Upgrade project will have designed and constructed upgrades to ensure that:

- The spillway gates have sufficient strength to resist the effects of earthquakes up to and including the Maximum Design Earthquake having ground motions with annual exceedance probability of 1/10,000 and will serve their function as a part of the dam's principal water barrier to retain the Lower Campbell Lake reservoir during and after any such earthquake;

- The spillway gates systems will retain their function to release water for discharge through the spillway in a controlled manner after any earthquake up to and including the Maximum Design Earthquake; and

- Operational reliability of the spillway gates' electromechanical systems has been improved in alignment with BC Hydro's Reliability Principles for Flood Discharge Gate Systems.

In Q4, the project completed Feasibility Design and developed plans for Definition and Partial Implementation Phase work. The project team will be coming before the Committee in June to:

- Seek approval of the preferred alternative, which includes complete replacement of the spillway gates, hoists and hoist structure, reliability upgrades via new controls and power supplies, and reinforcement of the spillway piers; and

- Seek approval of the funding request for Definition and Partial Implementation work.

Mica/Revelstoke Dams – Vertical Movement Gauges

As part of the original construction of the Mica and Revelstoke earthfill dams, vertical movement gauges (MVs) were installed in the dam's cores. MVs are vertical and near-vertical inclinometer casings installed to monitor settlement and lateral displacement. Installation of the MVs during original construction resulted in less compaction in these areas than in the neighbouring fills in the core. The MVs are no longer used to measure settlement or deformation and have since been monitored as quasi-standpipe piezometers. Periodic sudden water level drops have been observed in both the Mica and Revelstoke MVs, as well as an accumulation of fine material at the bottom of the casings, suggesting a lack or degradation of sealing at some or all casing couplings and a hydraulic connection through the dam core within these MVs. This presents the potential for pressure distributions to

develop within the core that could induce hydraulic fracturing and/or internal erosion near these casings.

The objectives of the Project are to:

- Eliminate the potential to hydraulically fracture the core and/or exacerbate internal erosion risks by sealing the six core MVs at Mica Dam and the seven core MVs at Revelstoke Dam.
- Improve long-term monitoring capability by installing instrumentation in conjunction with sealing the MVs, if and where appropriate.

In Q4, the project reached the end of Definition Phase; construction planning was completed and the grouting contract and temperature monitoring equipment requests were issued, received and evaluated. The project is scheduled to progress into Implementation Phase in Q1 of F2021.

Peace Canyon Dam – Piezometers and Drains Upgrade

The objectives of this project are to install new, additional piezometers to monitor the uplift pressures of the spillway blocks, to upgrade the drains to improve sliding stability of the spillway blocks, and to improve seismic monitoring.

In Q4, the project funding for Feasibility/Early Implementation Phase was approved. The first stage of enhancement of the existing piezometers and drains—principally drain cleaning and testing—has been completed. The data collected during the first stage is being assessed and used to plan for the second stage. Work restrictions arising from COVID-19 may impact planned field investigations in early F2021.

Wahleach – Unit 1 Tailrace Tunnel Upgrade

The objective of this project is to refurbish the tailrace tunnel that runs under Highway 1 and the Canadian National Railway main line, specifically to correct deficiencies in the concrete-lined section of the tunnel and to recoat the steel section.

The steel coating work was completed in Q4, but three weeks later than scheduled due to found conditions in the pipe. Concrete repairs were not started and will now be deferred until next year due to work restrictions arising from the COVID-19 pandemic.

Dam Safety Investigations

There were thirteen Dam Safety Investigations and System-Wide Initiatives underway in Q4 of F2020. Summaries of these investigations and initiatives are being prepared for inclusion in the Dam Safety “book” in Diligent—similar to those for capital projects—but are not yet available for reference by the Committee. A summary of the findings and progress made so far for selected Dam Safety Investigations are provided in this section.

System-Wide Flood Information Compilation – Flood Dashboard

In 2019, Dam Safety initiated a system-wide data compilation project—the Flood Dashboard—to compile available information on flood characteristics and vulnerability for each dam in BC Hydro’s

portfolio into one platform. This comprised collecting flood information from a wide array of references and applying stress tests such as spillway gate outages and increases in flood magnitudes. The level of concern for flood passage capacity at any project is heightened when one of more of the following characteristics is present:

- The reservoir has risen to levels of dam safety concern in the past;
- Inability to pass the Inflow Design Flood;
- Inflow Design Flood estimate is outdated;
- Inability to pass the derived 1,000-year return period flood;
- Sensitivity to increases in design flood magnitudes due to climate change or for other reasons;
- Low passive spillway capacity and high reliance on active spillway controls;
- High dependency on reservoir storage and operating rules;
- Low ratios of design floods to historical events;
- Unacceptable likelihood of overtopping as derived from stochastic modelling (nominally 1/10,000 Annual Exceedance Probability);
- Low resilience of the dam or abutments to overtopping; or
- High downstream impacts of flood induced failure.

The Flood Dashboard project was completed in Q4 of F2020 and will be used to:

- Demonstrate the sensitivity of flood passage at each dam to changes in flood magnitude and outlet facility availability;
- Prioritize the next phase of Inflow Design Flood and probabilistic studies; and
- Provide more ready identification of dams that are comparatively more vulnerable.

Revelstoke Dam – Spillway Hydraulics Computational Fluid Dynamics Modelling

This study was initiated in 2018 to develop a three-dimensional computational fluid dynamics (CFD) model of the Revelstoke spillway to assess its performance in a range of operating scenarios. This Investigation was completed in Q4 of F2020. Principal findings were that the cavitation risk for the as-built geometry of the spillway is low, but that cavitation could become a concern if the Marble Shear rock mass that underlies the spillway displaces and induces offsets in the surface of the spillway. The study also recommended some additional work to better represent the effects of air entrainment so as to confirm preliminary findings regarding the spillway's capacity and rating curves. BC Hydro Engineering is working with the developers of the Flow-3D software to improve its capabilities in this regard.

Wilsey Dam – Static and Seismic Performance Assessments

The condition of Wilsey Dam has deteriorated with time. Seepage through the dam's lift joints and existing structural cracking has been noted. Further, the dam's ability to resist seismic loading is uncertain. Given these concerns, Dam Safety initiated an investigation in 2019 to assess the stability of the arch dam, to obtain a clear and complete understanding of the dam's deficiencies, and to determine the scope and high-level costs for any required repairs and upgrades. The results from this investigation will be fed into the facility's overall long-term strategy which will assess whether decommissioning could be a more viable option.

A draft report on "Phase I" stability analyses of the main arch dam and the plug dam was submitted near the end of Q4 and is currently being reviewed by BC Hydro.