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Clayton Falls Project Water Use Plan

Monitoring and Physical Works Program Synthesis Report

- **CLAMON-1 Aquatic Productivity Monitoring**
- **CLAWORKS-1 Water Release and Measurement Device**

Draft Report

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Executive Summary

The Clayton Falls Project Water Use Plan (WUP) was initiated in 2002 and finalized in 2003. On December 9, 2004, the Comptroller of Water Rights (CWR) issued an Order ("the WUP Order") under the *Water Act*[1] in response to the Clayton Falls Project WUP that included implementing one monitoring project and one physical works project.

This document was prepared as a part of the WUP Order Review process. It summarizes the outcomes from the monitoring and physical works projects, and outlines whether the management questions have been addressed and the anticipated results of the physical works have been achieved (Table E-1). The draft MPSR will be shared with government agencies, First Nations and key stakeholders for review and comments.

Both the physical works and monitoring project centered around the ordered 0.05m^3/s minimum flow release from the Clayton Falls dam. This was intended to ensure a minimum of 0.10 cms year round continuous discharge[2] in the lower reaches of Clayton Falls Creek.

The monitoring and physical works projects in the Clayton Falls WUP were:

CLAMON-1 Aquatic Productivity Monitoring: A four-year program to evaluate fish and invertebrate response to minimum flows prescribed in the Clayton Falls WUP.

CLAWORKS-1 Water Release and Measurement Device: A project to undertake the design and construction of a water release and measurement device to be installed in Clayton Falls Dam to ensure a minimum flow of 0.05m^3/s from the dam.

The key finding from the Clayton Falls Water Use Plan was that flows below the dam were consistently much greater than the minimum flow levels prescribed.

Table E-1 summarizes the outcome of CLAMON-1 and Table E-2 summarizes the outcome of CLAWORKS-1.

[1] The *Water Act* was replaced by the *Water Sustainability Act* in February 2016; however Orders and Water Licences continue to be valid and are governed by the new *Water Sustainability Act*.

[2] The 0.05 cms minimum flow through a discharge pipe is added to dam leakage of 0.05 cms to ensure a continuous discharge of 0.1 cms (Bekker 2010).

Table E1. Summary of objectives, management questions and outcomes for CLAMON-1.

Project	Objective	Management Question	Response
CLAMON-01	To assess the ecological benefits of the minimum flow release and to collect the information needed to help inform future decisions.	How does the minimum flow alter the physical conditions of habitats in Reach 2 and, in turn, influence the community composition and productivity of invertebrates and fish?	Physical and biological responses to Clayton Falls Dam minimum flows could not be measured, as flows below the dam were consistently much greater than the minimum flow levels prescribed.

Table E2. Summary of objectives, source requirements and completion timeline for CLAWORKS-1.

Project	Objectives	Source Requirements	Completion
CLAWORKS-1	1. Submit plans for a measuring device that is suitable for measuring the minimum flow of 0.05 cubic metres per second (cms) which is to be released from the dam on Clayton Falls Creek at PD40178.	Clause 3 – Clayton Falls Project Water Licence and Order (Comptroller of Water Rights 2004).	Considered met with the TOR submission, October 2005.
	2. Alter the Dam on Clayton Falls Creek to include the measuring device as approved.	Clause 4 – Clayton Falls Project Water Licence and Order (Comptroller of Water Rights 2004).	Considered met with the installation of flow pipe, March 2006.

Acknowledgements

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BC Hydro would like to acknowledge that its Clayton Falls facility resides on the traditional territory of the Nuxalk Nation. BC Hydro also acknowledges this water as a clean energy source for the region and its headwaters spanning into the traditional territory of the Gitga'at First Nation.

BC Hydro would like to thank the personnel of Kynoch Resources and Ron Ptolemy of BC Ministry of Environment for their respective contributions to the CLAMON-1 monitoring program, and Kathleen Groves of BC Hydro for her management of the CLAWORKS-1 project.

Alf Leake, Guy Martel and Randy Zemlak (BC Hydro) contributed to the original writing. Toby Michaud, Jeffrey Walker and Katherine Miltimore (BC Hydro) reviewed and approved the final version.

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CC Consultative Committee

cms cubic meter per second

CWR Comptroller of Water Rights

MPSR Monitoring Program Synthesis Report

TOR Terms of Reference

WLR Water Licence Requirements

WUP Water Use Plan

Glossary of Terms

Anchor ice	Ice forming (anchored) at the bottom; it can significantly disrupt flows
Flashboard	Metal or wood structure projecting above the top of a dam to increase the depth of the water. At Clayton Falls Dam, flashboards are used to maintain the headpond level at the top of the spillway.
Frazil ice	Loose ice, usually formed over open water bodies (rivers, lakes, reservoirs, ocean) where water is turbulent
penstock	Intake structure (pipe in this case) that brings water from the headpond to hydroelectric turbines.
condition factor	A condition factor is a measure which compares the fish's weight to their expected weight given a relationship between weight and length for a given species or population.
sluice gate	Barrier to hold water or let water flow. In this case the headpond is drafted by discharging water over the spillway and through the sluice. On completion of the works, the sluice gate is closed to refill the headpond.

Clayton Falls Project Water Use Plan
Environmental Synthesis Report

1.0 CONTEXT

The Clayton Falls Project Water Use Plan (WUP) was initiated in 2002 and finalized in 2003 with the approval of the Comptroller of Water Rights (CWR). On December 9, 2004, the CWR issued an Order ("the WUP Order") under the *Water Act*[3] in response to the Clayton Falls Project WUP that included implementation of one monitoring project and one physical works project.

This document was prepared as a part of the WUP Order Review process. It summarizes the outcomes from the monitoring and physical works projects, and outlines whether the management questions were addressed (Table E-1).

The purpose of the WUP Order Review is to determine whether the ordered facility operational constraints and the physical works in lieu of operation changes are achieving the specific environmental and social objectives identified in the WUP.

The draft MPSR will be shared with government agencies, First Nations and key stakeholders for review and comment.

The specific objectives of the Monitoring and Physical Works Program Synthesis Report are to:

1. Provide a summary of the objectives, activities, and results for the monitoring and physical works projects;
2. Relate monitoring project findings to the objectives of the Clayton Falls WUP and provide any updates to this project findings from other work conducted after the project was completed; and
3. Where management questions were not addressed, identify the data gaps that persist.

2.0 PROJECT BACKGROUND

2.1 Hydroelectric Facility

Clayton Falls is the only dam not on BC Hydro's integrated system. The Clayton Falls hydroelectric project is located approximately 4 km west of Bella Coola (Figure 1) and consists of the Clayton Falls Dam and its generating station. The project is a run-of-river facility which diverts water from a 93 km^2 drainage area above the Clayton Falls Dam through a ~580 m long woodstave /steel penstock, to and through the Clayton Falls Powerhouse (Chan 2010). The flow from the tailrace channel, which is approximately 60 m and serves as spawning channel for Pink (*Oncorhynchus gorbuscha*) and Chum (*O. keta*) salmon, rejoins the

[3] The *Water Act* was replaced by the *Water Sustainability Act* in February 2016; however Orders and Water Licences continue to be valid and are governed by the new *Water Sustainability Act*.

lower Clayton Falls Creek. Lower Clayton Falls Creek flows into North Bentinck Arm. The Clayton Falls generating station has a capacity of 2 MW (Table 1).

Table 1. Clayton Falls general information. Source https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/environment/pdf/wup_clayton_falls_water_use_plan_pdf.pdf

Dam Name:	Clayton Falls
Dam Type:	Concrete Gravity
Year of Completion:	1961
Reservoir Name:	Clayton Falls Headpond
Water Course:	Clayton Falls Creek
Nearest City:	Bella Coola
Height Above Lowest Foundation:	7 m
Length of Crest:	41 m
Volume:	0 m3
Gross Capacity of Reservoir:	2,500 m3
Maximum Discharge Capacity of Spillways	180 m3/s
Spillway Type:	Free overflow with flashboards
Generating Station:	Clayton Falls
Nameplate Capacity:	2 MW

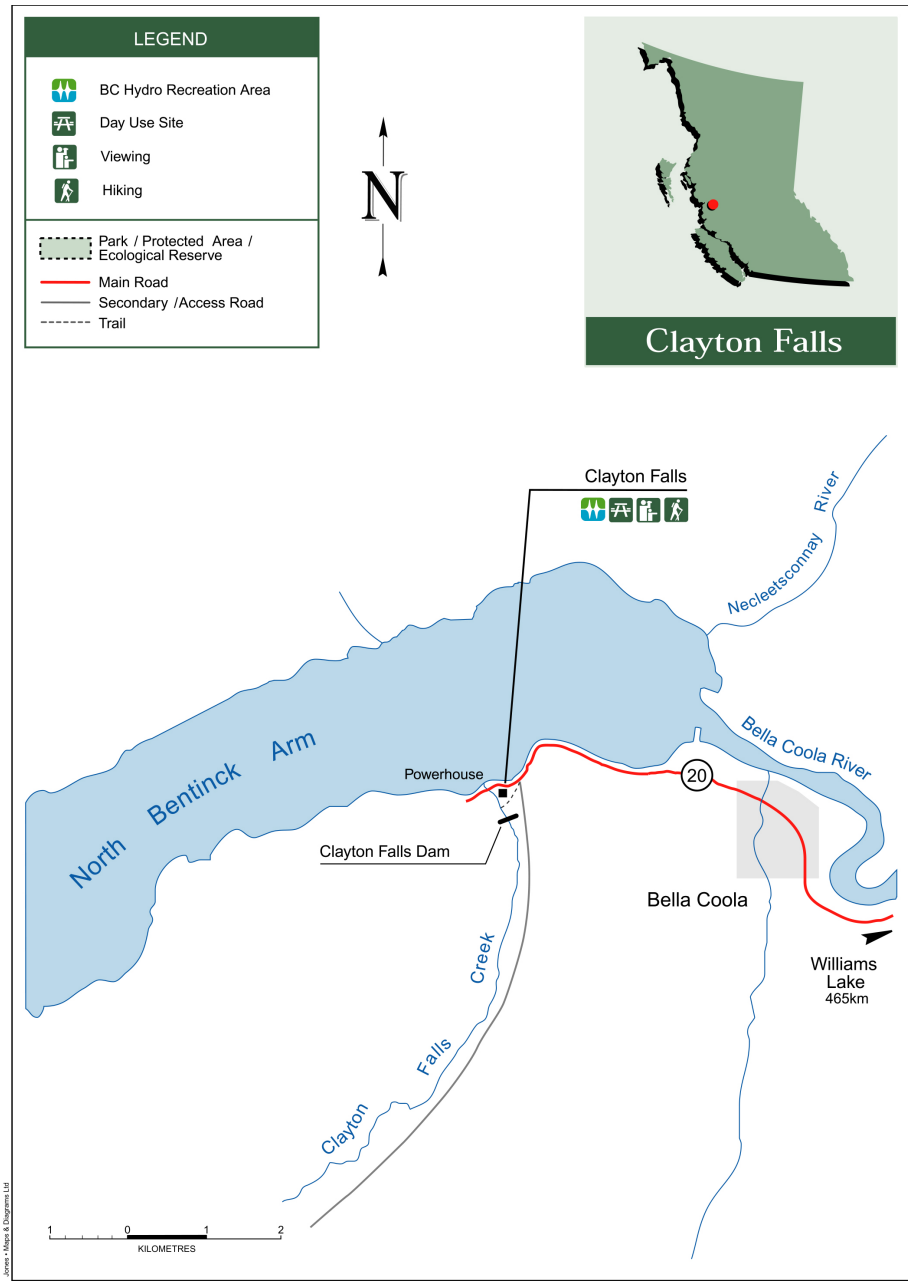

Figure 1. Site map of the Clayton Falls Project.

3.0 Clayton Falls WUP Process

The Clayton Falls WUP process was implemented over one year in 2002 following the Water Use Guidelines developed by the province (Province of British Columbia 1998). The process created the following outputs (in chronological order):

- Clayton Falls Project WUP Consultative Committee report: report of the WUP CC (BC Hydro 2003) – documentation of the structured decision making

process which evaluated operating alternatives against objectives represented by the WUP CC, and documented uncertainties that would define the study project for implementation following WUP approval.

- Clayton Falls Project WUP report (BC Hydro 2004) – submitted by BC Hydro to the CWR as the summary of operating constraints and implementation commitments (monitoring programs) to be appended to its Water Licences.
- Clayton Falls Project Water Licence and Order (Comptroller of Water Rights 2004) – the issuance of final water licences (120776 and 120177) and *Water Act* Orders issued by the CWR to implement the WUP as a condition of the final licences associated with the Clayton Falls WUP projects.
- Water Licence Requirements (WLR) Terms of Reference (TOR; BC Hydro 2005a) – for monitoring projects and physical works ordered by the CWR; management questions and methodologies were prepared to address uncertainties defined in the WUP consultative process and submitted to the CWR for Leave to Commence.
- Annual watershed reports – reports submitted to the CWR summarizing annual data collection results for ordered projects.

All reports are available on BC Hydro's WUP website

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/clayton-falls.html

3.1 Outcome of the WUP

The operating conditions under the Clayton Falls WUP Order issued by the CWR are shown in Table 3-1.

The 0.05m^3/s minimum flow release from the Clayton Falls dam in the WUP Order was intended to ensure a minimum of 0.10m^3/s year-round continuous discharge[4] in the lower reaches of Clayton Falls Creek. The WUP Order also required the installation of both an engineered release structure and gauge (CLAWORKS-1); the benefits of this minimum flow release were monitored over a four-year period (CLAMON-1).

Table 3.1. Operating conditions of the WUP Order for the Clayton Falls Hydroelectric system (Comptroller of Water Rights 2004).

System Component	Constraint	Time of Year	Purpose
Clayton Falls Dam and Generating Station (Clause 1)	A minimum flow of water of 0.05 cubic metres per second must be released from the dam at all times	All year – Commencing April 1, 2006 and thereafter.	Fisheries benefits
	The head pond shall be drafted gradually over a two hour period	During maintenance and civil inspections of the dam.	

[4] The 0.05 cms minimum flow through a discharge pipe is added to dam leakage of 0.05 cms to ensure a continuous discharge of 0.1 cms (Bekker 2010).

System Component	Constraint	Time of Year	Purpose
	Scheduled maintenance or shutdowns are not to proceed.	Winter – If frazil or anchor ice is present within the tailrace.	
	Flow to the tailrace shall be increased via the fish bypass valve or by bringing the generator online.	Winter – If frazil or anchor ice forms in the tailrace during unit shutdown.	
	The intake for the conservation works at PD63362 is to be shut off.	At all times – except during periods when flow from PD40178 to the tailraces is reduced due to annual maintenance and penstock dewatering, or when other conditions exist which would result in a tailrace flow of less than 0.08 cubic metres per second.	

The monitoring project was ordered to address the data gaps and uncertainties in the Clayton Falls Project WUP and to assess whether anticipated benefits from changes made under the WUP were actually achieved. Results from monitoring projects are reviewed upon completion as part of BC Hydro's WUP Order Review process, and the results are used and considered along with other values to support decisions about whether further changes may be considered during the WUP Order Review.

The following projects were implemented under BC Hydro's Water Licence Requirements program according to these terms of references:

- CLAMON-1 Aquatic Productivity Monitoring
- CLAWORKS-1 Water Release and Measurement Device

All WUP Terms of reference, including any revisions and addenda are reviewed by agencies and circulated to First Nations for review and comment prior to submission to the Comptroller of Water Rights.

4.0 ORDERED MONITORING PROJECT SUMMARY

4.1 CLAMON-1 Aquatic Productivity Monitoring

4.1.1 Project Summary

The primary objective of this project was to assess anticipated benefits to fish habitat from the implementation of a 0.05m^3/s minimum flow release from the Clayton Falls dam (Comptroller of Water Rights 2004).

Objective	Management Question[1]	Response
To assess the ecological benefits of the minimum flow release and to collect the information needed	How does the minimum flow alter the physical conditions of habitats in Reach 2 and, in turn, influence the community	Physical and biological responses to Clayton Falls Dam minimum flows could not be measured, as flows

Objective	Management Question[1]	Response
to help inform future decisions.	composition and productivity of invertebrates and fish?	below the dam were consistently much greater than the minimum flow levels prescribed.

[1]BC Hydro 2005a

4.1.2 Project Approach

The Aquatic Productivity monitoring program was conducted from September 2005 to October 2009. Reports were compiled each year following 2005. The final report summarized results for the study period. All reports are available on BC Hydro's WUP website:

https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/northern-interior/clayton-falls.html

The monitoring program had three components:

1. collection of information on salmonid abundance, invertebrate abundance, and diversity,
2. assessment of pre- and post-minimum flow release changes in these measures; and
3. comparison of salmonid abundance in Clayton Falls reaches with that from nearby unregulated streams.

Invertebrate abundance and diversity were to be assessed through colonization baskets, while salmonid abundance (standing crop) was to be calculated from multiple pass electrofishing verified from snorkel counts.

The monitoring study was contracted to Kynoch Resources in 2005. During the Year 1 assessment (2005) it was determined that benthic invertebrate monitoring was not practical in Clayton Creek owing to difficult sample recovery with fluctuating water levels and large substrate size (Kynoch Resources, 2009).

Subsequently, Kynoch Resources and BC Hydro agreed, in consultation with agency staff, to remove the benthic invertebrate portion of the ecological assessment from the project scope.

Physical data collected on habitats (hydraulic - riffle, rapids, cascade, run, pool - and substrate types) were stream cover, width, velocity, and depth. Fishes were sampled in established sites through electrofishing and snorkel. Please refer to Kynoch Resources (2009) for further details on all methods.

The project lasted four years, from 2005 to 2008, with some extra physical data collected in January – March 2009.

4.1.3 Interpretation of Data

Based on four years of data collection, there were no detectable effects on fish and benthic invertebrates, nor on their habitat, that could be directly associated with the minimum flow regime. The conclusion of the final year report was that "…there was sufficient water to exceed the minimum base-flow requirement of

0.01 m^3/s discharge from the headpond to reach 2 under all observed flow and operational circumstances." (Kynoch Resources 2009, p. 26[5])

Answer to Management Question

1. *How does the minimum flow alter the physical conditions of habitats in Reach 2 and, in turn, influence the community composition and productivity of invertebrates and fish?*

   Physical and biological responses specific to Clayton Falls Dam minimum flows could not be measured, as flows below the dam were consistently much greater than the prescribed minimum flow levels (likely in excess of 0.85 cms as compared to 0.05 cms for minimum flows).

4.1.4 Other Results

Answers to Management Hypotheses were (Kynoch Resources, 2009, pp. 19-20):

H_1: Pre-WUP flows in Reach 2 (dam leakage and local inflows) are sufficient to sustain over-wintering fish and invertebrates.

Results showed this to be true.

H_2: The provision of a year-round minimum base flow of 0.1 m^3/s to Reach 2 (0.05 m^3/s from the dam release and an anticipated 0.05 m^3/s from dam leakage and natural inflow) will partially restore the productive capacity of lower Clayton Falls Creek.

This hypothesis could not be tested as there was no effective change in discharge identified over the study period.

H_{3-5} (increases in invertebrate abundance and diversity, and in salmonid standing crop related to flow releases).

These hypotheses could not be tested as there was no effective change in discharge.

In addition to this information, the following relevant information was collected:

- Benthic aquatic invertebrate species collected and identified in Clayton Creek in 2005 formed a relatively diverse benthic community structure comparable to that of other streams of the region.
- Clayton Creek's summer base flow alkalinity was approximately 7.6 mg/L. Average and median summer water temperatures (2005-2008) were 8.5 and 8.3 ºC, while average and median conductivity were 23.3 and 22.0 µS/cm.
- There were no apparent fish habitat or rearing capacity limitations associated with restricted or reduced flows in Reach 2 during natural winter low-flow periods.
- Counts of large Coho fry (*Oncorhynchus kisutch*) in the lower Clayton Falls Creek were consistent with those in streams of similar, low productivity.

[5] While the 0.01 m^3/s quote is textual from Kynoch 2009, it is also acknowledged that this could be a typo in the original report. Refer to Section 3.1 and its footnote for more details.

- Condition factor of juvenile Coho Salmon and Dolly Varden char (*Salvelinus malma*) from Clayton Falls Creek was superior to that of the same species from other Bella Coola River watershed drainages (average of 1.26 for Clayton Coho vs. 1.01 in other watersheds; average of 1.18 for Clayton Dolly Varden vs. 0.96 in other watersheds[6]). Note that Individuals with a condition factor greater than 1.0 were heavier than expected and those with values less than 1.0 were lighter than would be expected given their length, respectively.
- Over the duration of the aquatic productivity monitoring period, flows in reach 1 of Clayton Falls Creek were consistently well above the required minimum of 0.05 m^3/s, and therefore limited direct observations of minimum flow suitability. Given the observed lack of effect of flow variation at the range of flows observed (well in excess of the 0.05 m^3/s minimum), it is likely that the study would not have detected a change in invertebrate response for samples within the water column at lower flows. We therefore recommend that this study be considered complete.

5.0 ORDERED PHYSICAL WORKS SUMMARY

5.1 CLAWORKS-1: Water Release Measurement Device

5.1.1 Project Summary

The Clayton Falls WUP CC expressed concern that the lack of a guaranteed base flow in the mainstem channel between Clayton Falls and the confluence of the tailrace channel might impact the overwintering survival of fish and their invertebrate prey. To address this concern, the CC recommended that the WUP include a 0.05 m^3/s minimum continuous flow release from the Clayton Falls Dam. The recommendation required that an engineered structure be designed to ensure passage of the minimum flow requirement.

The scope of this Physical Works included design, fabrication, and installation of a water release pipe (flow pipe) at Clayton Falls Dam. As outlined in the approved project Terms of Reference (BC Hydro 2005b), the water release pipe is considered an equivalent method to measuring the water flow of 0.05 m^3/s.

Project	Objectives	Source Requirements	Outcome
CLAWORKS-1	1. submit plans for a measuring device that is suitable for measuring the minimum flow of 0.05 cubic metres per second which is to be release from the dam on Clayton Falls Creek at PD40178	Clause 3 – Clayton Falls Project Water Licence and Order (Comptroller of Water Rights 2004)	Considered met with the TOR submission, October 2005
	2. alter the Dam on Clayton Falls Creek to include the measuring device as approved	Clause 4 – Clayton Falls Project Water Licence and Order (Comptroller of Water Rights 2004)	Considered met with the installation of flow pipe, March 2006

[6] From Kynoch Resources, 2009, Tables 14 and 15

5.1.2 Project Approach

To accomplish the objectives above, BC Hydro completed the following key phases and activities:

5.1.2.1 Identification / Feasibility Phase:

There were several options considered to meet the objectives (BC Hydro 2005b) and a pipe inserted through the lower flashboards along the spillway was the selected option for the water release.

5.1.2.2 Design Phase:

Detailed design of the flow pipe installation was included in the Engineering Design report (BC Hydro 2006a).

5.1.2.3 Implementation / Construction phases:

- A 0.15 m diameter pipe was installed through the lower flashboards along the overflow spillway to pass the 0.05 m^3/s minimum continuous flow into Reach 2.
- Centerline elevation of the pipe is at 78.6 m.
- Flow passage through the pipe is uncontrolled and is dependent on headpond levels. (Figure 5.1)

Figure 5.1 Location of Clayton Falls flow pipe, February 26, 2008.
Modified from Kynoch Resources 2008, photo A-3.

5.1.2.4 Completion Phase:

- Detailed design of the flow pipe installation was included in the Engineering Completion Report (BC Hydro 2006b).

5.1.3 Project Outcomes

An analysis of the discharge records from 2004-2009 showed that compared to the flows prior to the installation of the minimum flow release pipe, flows of at least 0.05 m^3/s are generally discharged into Reach 2 during the winter low flow period (December to March) through a combination of spill over the flashboards and flow through the flow pipe and sluiceway (Kynoch Resources 2009).

During annual maintenance, the headpond is drawn down and the flow pipe is dewatered. The sluice gate is thus opened to pass the required minimum flow into Reach 2 while the unit is out of service. At the end of the maintenance period, the sluice gate is closed to about 90% so that ample water is still flowing down Reach 2 through the sluice way while the headpond is being filled and adequate amount of spillage over the flashboards is achieved.

If the flow pipe requires substantial maintenance to meet dam safety requirements, BC Hydro will review the necessity of the flow pipe to meet minimum flows.

5.1.3.1 Sustainment: Structural and Ongoing Maintenance

Little to no maintenance will be required. Site staff confirmed that this location experiences the least frequency of flashboard breakage and is accessible for periodic removal of debris from the flow pipe inlet if required. Since its installation, only routine maintenance has been required to date.

5.1.4 Completion – Compliance Requirements

Deliverables of project completion included record drawings which are stored in BC Hydro's McLaren system and in the supplied operations and maintenance manual for the site works.

Project Reports/Records	Completion
Engineering Completion Report: CLA WUP WORKS Water Release and Measurement Device (File: CGR06MTC CLA01)	2006-07-13
BCH Inter-office Memo: Clayton Falls Minimum Flow Discharge Pipe Design Basis (File: CGR06MTC CLA01) (reference Engineering Completion Report)	2006-07-13

6.0 REFERENCES

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