Coquitlam-Buntzen Project Water Use Plan

Revised for Acceptance by the Comptroller of Water Rights

7 April 2005

BC hydro

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Graeme Matthews
per

C.D. Matheson
Manager, Operations

Preface

The water use planning process for BC Hydro's Coquitlam-Buntzen facilities was initiated in September 1999 and concluded in April 2002. Further information became available before the draft Water Use Plan could be completed and further consultations were held, concluding in March 2003.

The operating conditions proposed in this Water Use Plan reflect the recommendations of the Coquitlam-Buntzen Water Use Plan Consultative Committee. BC Hydro thanks all those who participated in the process that led to the production of this Water Use Plan, for their effort and dedication.

Reservoir storage volume is currently restricted because of dam safety considerations. The Water Use Plan and the consultation for the development of the plan make the assumption that the licenced storage volume will be available.

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1.0 INTRODUCTION

The operating conditions proposed in this plan reflect the recommendations provided by the Coquitlam-Buntzen Water Use Plan Consultative Committee. The basis for the proposed terms and conditions to be authorized under the *Water Act* for the beneficial use of water at the Coquitlam-Buntzen generating stations are set out in this document. Future reference to this facility includes all the works including: Coquitlam Dam, Buntzen Dam, associated reservoirs, diversion tunnel, LB1 and LB2 powerhouses.

Through the Water Use Plan interest based process, a recommendation was reached whereby fisheries, domestic water, and recreation interests were all improved over current operations. These improvements will be at a cost of lower revenues from power generation.

The process was complicated by uncertainties related to anticipated fisheries benefits. To address these uncertainties the recommendation proposes testing two flow regimes. At the completion of the test flows, an operational regime would be based on the results of the tests.

2.0 DESCRIPTION OF WORKS

2.1 Location

The Coquitlam Lake and Buntzen Lake reservoirs lie within the Greater Vancouver Regional District GVRD watershed about 10 km north of the Lougheed Highway in Coquitlam. Water for the Coquitlam-Buntzen system originates in the headwaters of the Coquitlam River, which flows from Lower Mainland coastal mountains south to the Fraser River via the Coquitlam Lake Reservoir.

The Coquitlam-Buntzen system is in the asserted traditional use area of five First Nations, including Kwikwetlem First Nation, Tsleil-Waututh First Nation, Katzie First Nation, Squamish First Nation and Musqueam First Nation. It is also within the asserted traditional territory of Sto:lo Nation.

2.2 The Coquitlam-Buntzen System

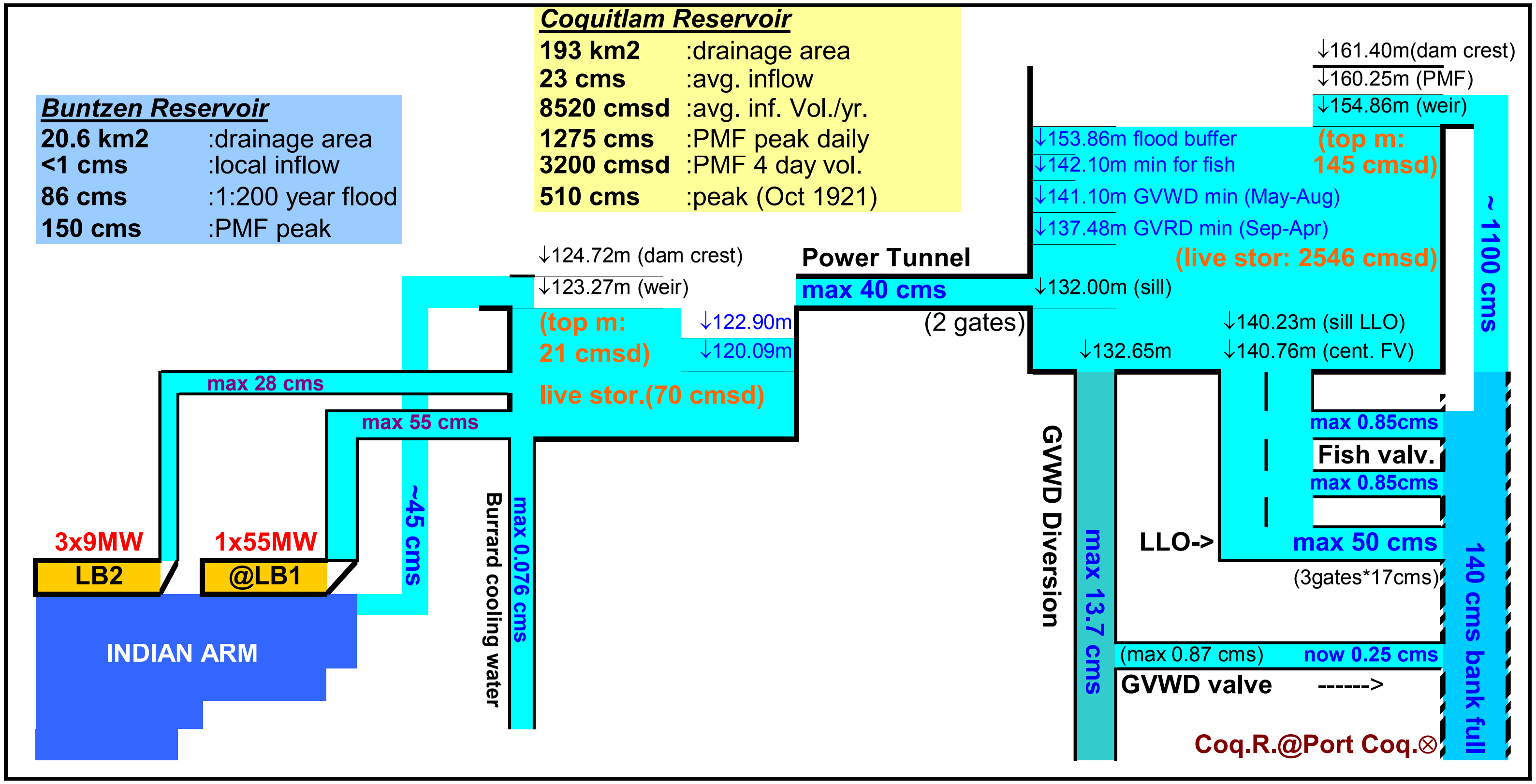

Figure 2-1 Coquitlam-Buntzen System

2.3 Existing Works

Coquitlam Lake Reservoir

The Coquitlam Lake Reservoir is part of the GVRD Watershed and is closed to the public. The reservoir supports a resident fish population, but there is no fish access from the Coquitlam River, downstream of the dam. The reservoir contains archaeological sites.[1]

Diversion Tunnel

A tunnel from Coquitlam Lake Reservoir to Buntzen Lake Reservoir diverts a maximum of 40 m^3/s.

Buntzen Lake Reservoir

Buntzen Lake Reservoir and its surrounding area are heavily used for recreation (swimming, boating, fishing, walking) and support resident fish and wildlife. Normal operating range for the reservoir is between 120.09 m and 122.90 m with daily levels fluctuating within this range to give BC Hydro flexibility (load factoring capability) in operating its powerhouses (LB1 and LB2). However, the minimum operating level during daylight hours in the summer season (15 May to 30 September), to improve recreational values for swimmers, is 122.2 m.

Buntzen Powerhouse and Outflow to Indian Arm

From Buntzen Lake Reservoir water flows via two release facilities, one at the Buntzen Dam, another on the west shore, towards two powerhouses situated on the shore of Indian Arm. Water is released from the powerhouses directly into Indian Arm.

The facilities have been in operation since 1903, making them the oldest in the Lower Mainland. The Buntzen generating stations (LB1 and LB2) are able to produce about 200 gigawatt hours of electricity each year, enough to provide electricity for 18 000 homes.

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[1] Heritage/Archaeological Resources Overview, BC Hydro and Power Authority Water Use Planning Project Coquitlam and Buntzen Reservoirs; I.R. Wilson Consultants Ltd., Prepared by Ian Wilson and Terry Clark, May 2001.

GVRD Diversion

Since 1987, there has been an agreement between BC Hydro and the Greater Vancouver Regional District (GVRD), approved by the Comptroller of Water Rights, for supply of water for municipal use beyond that allocated by license to GVWD. Discussions between BC Hydro and the GVRD on an expansion to this agreement began in 1995 and continued until the Water Use Plan process began. At the request of the Consultative Committee members, finalization of the agreement between BC Hydro and GVRD was deferred until completion of the water use planning process.

The existing BC Hydro/GVRD agreement identifies the maximum amount of water that may be directed from the Coquitlam Lake Reservoir to municipal water supply. The GVRD presently uses less than its maximum nomination. With full use of the current agreement with BC Hydro, the GVRD allocation of Coquitlam Lake Reservoir water is a maximum of 7.88 m^3/s. This represents about 34% of the average annual reservoir inflow.

Coquitlam Dam and Coquitlam River (downstream of dam)

Land along the river downstream of the dam is located in a variety of holdings, including GVRD, private property (including gravel operations), and provincial, regional and municipal parks. There is extensive urban development in the area, gravel operations adjacent to the river, and two Kwikwetlem First Nation reserves (IR#1 and IR#2) located on the banks of the Coquitlam River.

Release facilities at the Coquitlam Dam at the southern end of the Coquitlam Lake Reservoir provide significant downstream flood control benefits and facilitate regulation of inflows such that the river‘s water can be allocated for power generation, domestic water supply, fish and wildlife habitat, and recreation.

There are seven formal recreation areas (GVRD and City of Coquitlam) in the region of the Coquitlam River. As well, there are many informal open spaces and trails along most of the Coquitlam River corridor and these are in use year round for hiking and cycling. There are numerous plans and recommendations for enhancing recreation potential in this area and water releases from the Coquitlam Dam are therefore of increasing consequence to recreation interests.

The Coquitlam River is also the location of fish and wildlife interests. Serious concern about the decline of salmonid populations in the Coquitlam River has been expressed since the early 1980s. In response, several enhancement and conservation initiatives were introduced, including minimum flow agreements, hatchery production, and off-channel habitat creation. Fish flow agreements in 1993 and 1999 resulted in the construction of two water release valves. In 1999, minimum flow release to the river from the Coquitlam Lake Reservoir was approximately 0.65 m^3/s of which 0.57 m^3/s was released from the dam through the two fish valves and 0.08 m^3/s was released via the GVRD pipeline (Grant's Tomb/Swoboda Channel). Today, a maximum of 0.25 m^3/s (9 ft^3/s) can be released via the GVRD pipeline and 1.7 m^3/s (60 ft^3/s) from the two fish valves when the reservoir is full.

3.0 HYDROLOGY OF THE COQUITLAM-BUNTZEN BASIN

The Coquitlam–Buntzen River basins are situated in the North Shore Coastal Mountains of the Lower Mainland. Figure 2.1 shows the location of both the Coquitlam Lake Reservoir and Buntzen Lake Reservoir watersheds. Due to the steepness of the valley slopes, Coquitlam Lake Reservoir has a long and narrow shape with a length of 13 km and a width which varies between 0.5 and 1.5 km. It has a surface area of 12.5 km^2 with a total storage of 222 million m^3. The drainage area of Coquitlam Lake Reservoir is 193 km^2. Approximately 75% of the average annual precipitation within the Coquitlam River Basin falls between October and March, and for elevations above 161.5 m (530 ft), about 50% of that precipitation falls as snow. In general, mild winters limit snowpack accumulation, however, snow melt combined with heavy precipitation sometimes produces high winter flows in the Coquitlam River. In addition, snowmelt during May through to July also causes high inflows. Compared to other months throughout the year, August and September, are generally quite dry. Average annual inflow into Coquitlam Lake Reservoir is about 23 m^3/s, mainly from heavy winter rains and high level snowmelt.

Downstream of Coquitlam Dam, Orr Creek and other tributaries add significantly to the volume of water in the Coquitlam River.

Buntzen Lake Reservoir receives the majority of its water from Coquitlam Lake Reservoir via the diversion tunnel. Local inflow has a similar pattern to that described for Coquitlam Lake Reservoir but due to its small size is not a significant factor in operations. A more detailed description of the hydrology is provided in Appendix 1.

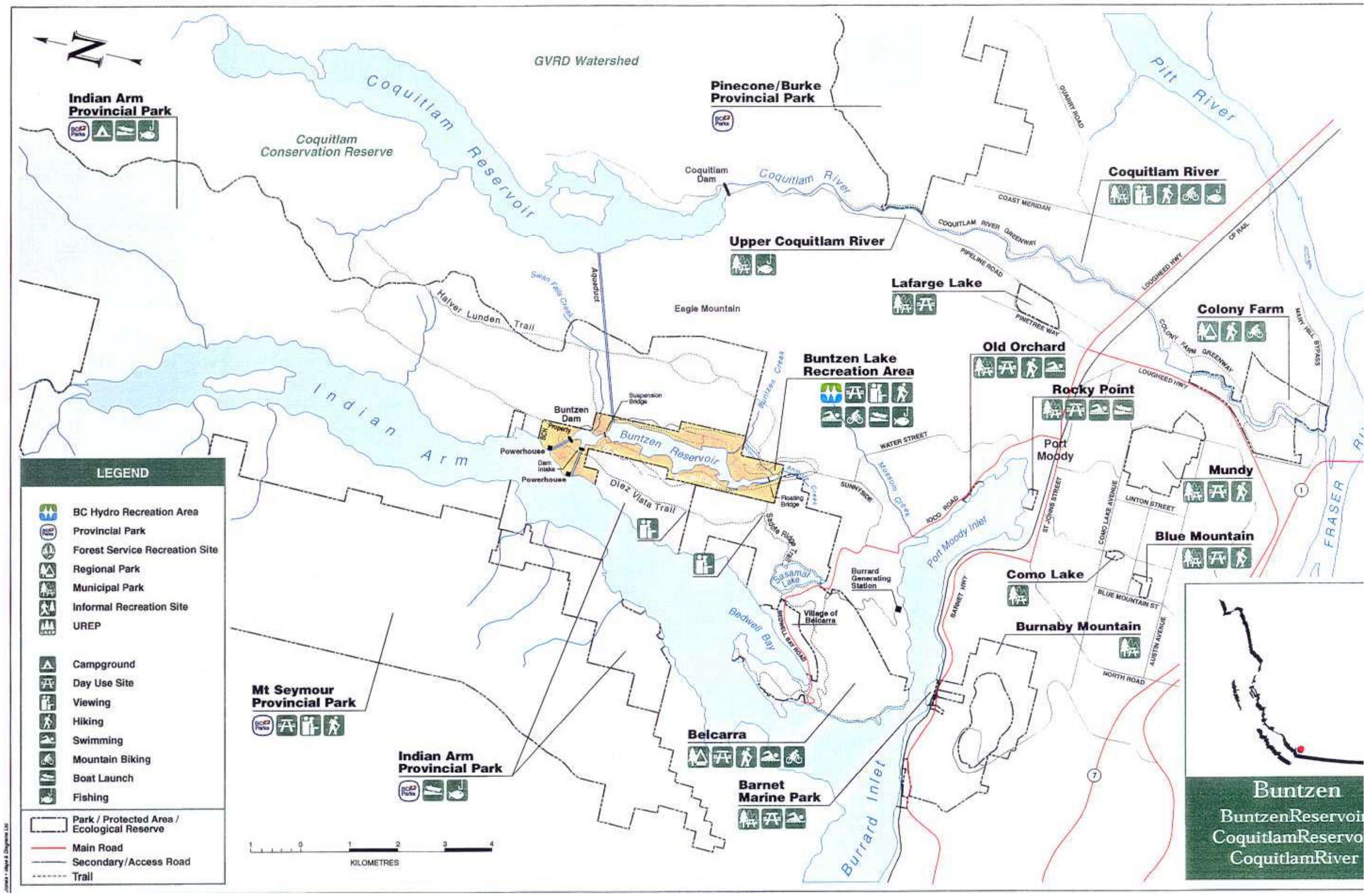


Figure 3-1 Map of Coquitlam-Buntzen

4.0 OPERATING CONDITIONS FOR FACILITY

4.1 Role of Facility in Provincial System

The Buntzen generating facilities are part of BC Hydro's integrated generation system, which is described in *Making the Connection* published by BC Hydro in April 2000.

Power Generation for the Coquitlam-Buntzen Project occurs at the two Buntzen Generating Stations, Lake Buntzen 1 (LB1) and Lake Buntzen 2 (LB2). Buntzen Generation represents approximately 7.1% of regional hydro generating capacity for the Lower Mainland/Coastal/Fraser Region. LB1 and LB2 represent about 0.4% of BC Hydro's power generating capacity and provide BC Hydro with emergency capabilities for its system.

4.2 Water Use at Coquitlam–Buntzen Facilities

The Coquitlam–Buntzen facilities are classified as a "coastal" system with the majority of its water resulting from rainfall and seasonal snow melt. LB1 and LB2 operate as auxiliary and peaking plants. The local inflow to Buntzen Lake reservoir is considered negligible. The small storage capacity in Buntzen Lake Reservoir and the small capacity of the diversion tunnel from Coquitlam Lake Reservoir mean there is not enough available water to continuously operate LB1 at full capacity. As a result, this unit is generally run at maximum capacity only during heavy load hours. Compared to LB1, LB2 runs far less efficiently and therefore is only operated when peaking capacity is required or LB1 is out of service.

4.3 Emergencies and Dam Safety

Emergencies and dam safety requirements shall take precedence over the constraints outlined in this Water Use Plan. Emergencies include actual and potential loss of power to customers. Dam safety requirements for operations are outlined in "Coquitlam-Buntzen: Operation, Maintenance and Surveillance Requirements (OMS) for Dam Safety" issued by BC Hydro's Director of Dam Safety.

4.4 Conditions for the Operation of Works for Diversion and Use of Water

As a result of the WUP consultation process, BC Hydro proposes to operate its facilities in accordance with the conditions described in the following sections. These conditions will limit the operation of the works and require a capital investment to undertake structural modifications to the discharge facilities at Coquitlam Dam. BC Hydro may not be able to operate to these conditions during extreme hydrological events.

4.4.1 Buntzen Lake Reservoir Levels

Between 15 May and 30 September during daylight hours, the minimum operating level of Buntzen Lake Reservoir is 122.2 m. At all other times the normal minimum operating level is 120.09 m.

4.4.2 Flood Routing Provisions

Between 1 October and 31 March, the maximum normal operating level of Coquitlam Lake Reservoir is 153.86 m in order to provide 1 m of storage space for flood routing. Between 1 April and 30 September, the maximum normal operating level of Coquitlam Lake Reservoir is 154.86 m. When the reservoir level exceeds the normal maximum operating level, flow will be discharged through the tunnel to Buntzen Lake Reservoir and through the low level outlets in order to control the reservoir to the normal maximum operating level. However, in order to reduce the frequency of flooding, releases through the low level outlets will be reduced, to zero if necessary, if flow in the Coquitlam River at Water Survey of Canada Gauge #08MH002 exceeds 140 m^3/s. The two fish flow release valves may remain open at all times during the routing of flood events.

4.4.3 GVRD Withdrawals

In addition to its own licenced withdrawals, GVRD removes water, for consumptive use, from storage in the reservoir under contract with BC Hydro. BC Hydro will include in its contract with GVRD limitations on GVRD withdrawals and a requirement for monthly nominations in advance of withdrawals in order to meet the conditions specified in Section 4.4.5.

BC Hydro will provide water to GVRD and DFO for release through their facilities at Grant's Tomb. The maximum amount of water passing through the facilities will vary with reservoir level but will be no greater than 0.25 m^3/s. This release will be included in the computation of the instream flow release from the Coquitlam Lake Reservoir specified in Section 4.4.5.

4.4.4 Flow Release to the Coquitlam River - Flow Trial #1

Flow Trial #1 maintains the existing flow regime, as ordered by the Comptroller on 16 December 1998, until 31 December 2006.

4.4.5 Flow Release to the Coquitlam River - Flow Trial #2

Flow Trial #2 will commence on 1 January 2007 for a period of nine years following Flow Trial #1. On completion of Flow Trial #2, BC Hydro will initiate a Water Use Plan review

Prior to the commencement of Flow Trial #2, structural modifications to the release facilities at Coquitlam Dam are required to safely provide the specified instream flow releases.

An Instream Flow Release Target and a Reduced Instream Flow Release Target have been chosen for each month of the year for Flow Trial # 2, as shown in the table below. BC Hydro will plan operations to provide the Instream Flow Release targets. In order to avoid a sudden and drastic reduction in instream flow releases and GVRD withdrawals in dry years, water allocations will be reduced in accordance with the following rules in order of priority:

1. BC Hydro will calculate each week the probability of achieving the Instream Flow Release targets. Generation withdrawals from the reservoir will be reduced in order to maintain an 85% or greater probability[1] of achieving the Instream Flow Release targets and the monthly GVRD nominations.[2] The monthly nomination may not exceed the maximum GVRD Nomination listed below.

2. When generation has been reduced to zero and further curtailment of reservoir withdrawals is required to maintain an 85% probability of meeting the Instream Flow Release targets, GVRD nominations will be reduced as required to a Maximum % GVRD Nomination Reductions specified in the table below.

3. If further curtailment of reservoir withdrawals is required to achieve an 85% probability of providing instream flow releases, the Instream Flow Release targets themselves will be reduced such that there is an 85% probability of meeting the Reduced Instream Flow Release Targets. The reduced targets will be no less than the Reduced Instream Flow Release Targets specified in the table below.

4. If further curtailment of reservoir withdrawals is required, instream flow releases and GVRD withdrawals will be reduced by equal percentages to achieve an 85% probability of providing the reduced instream flow releases.

[1] Analysis of historical records of reservoir inflows shows that the probability of providing the Reduced Instream Flow Release Targets and 90% of the Maximum GVRD Nomination Withdrawals is high except for the months of September and October, in which the probability is 85%.

[2] GVRD nominations are defined as the amount of water requested by the GVRD from BC Hydro on a monthly basis at the start of each month subject to terms of rights extensions.

Month	**Jan 1-15**	**Jan 16-31**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Instream Flow Release Target (m^3/s)	5.90	2.92	2.92	4.25	3.50	2.91	1.10	1.20	2.70	2.22	6.07	3.96	5.00
Reduced Instream Flow Release Target (m^3/s)	3.60	2.92	2.92	1.77	1.10	1.10	1.10	1.10	1.10	1.10	3.59	1.49	2.51
Maximum GVRD Withdrawal Nomination (m^3/s)	11.9	11.9	11.9	11.9	12.0	12.0	12.0	18.0	23.0	23.0	12.0	12.0	11.9
Maximum % GVRD Nomination Reduction	10%	10%	10%	10%	10%	8%	9%	12%	12%	9%	10%	10%	10%

Releases from the GVRD facility at Grant's Tomb are included in the computation of the instream flow release from the Coquitlam Lake Reservoir.

When the instream flow release varies more than ±10% from the monthly target or reduced target, an adjustment to restore the releases within ±10% of target or reduced target will be made within 7 days if storage is available. For the months of June, July, August and September, instream flow releases will not be allowed to vary below the target, or reduced target at any time, by more than 10%.

4.4.6 Ramping Rates

1. When releases from the low level outlets and fish flow release valves are greater or equal to 7.1 m^3/s, the maximum rate of reduction of discharge is 9.5 m^3/s per hour.

2. When releases from the low level outlets and fish flow release valves are less than 7.1 m^3/s but above 2.8 m^3/s, the maximum rate of reduction of discharge is 0.71 m^3/s per half hour.

3. When releases from the low level outlets and fish flow release valves are 2.8 m^3/s or less, the maximum rate of reduction of discharge is 0.42 m^3/s per half hour.

4. The maximum rate of increase of discharge from the low level outlets and fish flow release valves is 9.5 m^3/s per hour.

5.0 PROGRAMS FOR ADDITIONAL INFORMATION

Development of the operating recommendations for the Coquitlam River was complicated by some uncertainties which, it is proposed, should be addressed by monitoring the test flows. The monitoring plan is expected to provide improved information on which to select an operational regime after the testing period is over.

Accordingly, it is recommended that the Comptroller of Water rights direct BC Hydro to undertake a monitoring program that will:

- assess expected outcomes of the operational changes being recommended;
- provide improved information on which to base future operating decisions.

The main elements of the monitoring program are described in Table 5-1. Estimated annual costs for these studies are summarized in the Coquitlam-Buntzen Water Use Plan Consultative Committee Report.

Table 5-1 Recommended Monitoring Program for the Coquitlam Water Use Plan

Study	**Hypothesis**	**Uncertainty/ Data Gap**	**Operational Implications**	**Duration**	**Certainty**[1]
Fish - Reservoir					
Access to Tributaries	Tributary access by discrete populations of salmonids is affected by operations in the drawdown zones.	Determine the habitat loss and potential life history use of streams with access issues in the drawdown zone.	No operational change proposed.	2 years.	High
Fish - Coquitlam River					
Ramping rates	Fish mortality and stranding are affected by flow rate changes at the dam.	Opportunistically, through field tests, determine the ramp-rates applicable to the Coquitlam River which reduce the impacts of operations through stranding of juvenile fish.	Move to an approved ramping regime after completion of field tests.	2 years	High

[1] Certainty measures: (High) Monitoring study will definitely lead to fine, quantitative discrimination among all of the competing hypotheses including measure of effect size. (Medium) Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses and may quantify effect size. (Baseline) Likely to allow only qualitative comparisons among a few competing hypotheses with little or no sensitivity to effect size.

Study	Hypothesis	Uncertainty/ Data Gap	Operational Implications	Duration	Certainty[1]
Habitat Suitability Criteria	Habitat use changes with availability of habitats provided at different flow releases from the dam and at different times of the year.	How do HSI standards change under different flow conditions, with an emphasis on high flows.	Move to an approved operational regime after the full review period of 12 years.	2 years	High
Pink Salmon Access	Pink salmon mainstem access is not affected by the proposed flow changes from the dam.	Determine flows at which pink salmon access is unhindered.	Change in flow allocation during August and September	10 years[1]	High
Invertebrate Productivity Index	Flow releases from the dam affect invertebrate productivity and is related to habitat availability	Determine invertebrate productivity response to flow treatments.	Move to an approved operational regime after the full review period of 12 years.	12 years	Medium[2]
Reservoir Release Temperature Regime	Reservoir operations do not affect dam release temperatures nor affect downstream fish habitat quality.	Determine the effects of Low Level Outlet releases on temperature regimes in the river. To explain impact of flows on productivity.	Outlet elevation will not change but duration of release may change to mitigate temperatures.	3-4 years	High
Fish Productivity Index	Coquitlam River flow treatments (dam releases) affect Fish productivity (as described by the habitat-flow curves produced in the IFN assessment results).	Determine the effects of flow treatments on fish productivity; namely smolts out vs. adults in for steelhead and coho. Determine the effects of increased habitats on productivity.	Move to an approved operational regime after the full review period of 12 years.	12 years	Low[3]
Flushing Flow effectiveness	Flushing flows from the dam may significantly improve habitat quality and fish productivity in the Coquitlam River.	Determine the physical changes in substrate quality and relate to fish production by measuring natural/opportunistic events meeting pre-set conditions.	Could confirm the benefits of the opportunistic flushing flow.	6 years[4]	High

[1] Will only occur in odd years when pink returns are prominent; study will end when flow requirements for passage are known.
[2] Although a control stream may improve the "Certainty" of some results, at this time BC Hydro does not support development of a control stream with this Water Use Plan. Certainty varies and would move to High if a control stream were used.
[3] Certainty varies and would move to High if a control stream were used and to Medium with 2 years control stream data.
[4] Will be assessed as natural high flow events occur during Flow Trials 1 and 2 (one in each, plus an initial assessment in year "0"). Flows between 70-110 m^3/s are expected 1 out of every 4 years.

6.0 IMPLEMENTATION OF RECOMMENDATIONS

The operating conditions and the monitoring program proposed in this Water Use Plan will be implemented after BC Hydro receives direction from the Comptroller of Water Rights.

7.0 EXPECTED WATER MANAGEMENT IMPLICATIONS

Implications for the provincial interests considered during the preparation of this Water Use Plan are expected outcomes based on the best available information. After BC Hydro has been directed to implement the operational changes, BC Hydro will be responsible for meeting the operational parameters but not for achieving the expected outcomes.

7.1 Other Licensed Uses of Water

BC Hydro has an existing license to withdraw water from Buntzen Lake Reservoir to be used for boiler water at Burrard Generating Station. This water withdrawal will not be affected by the recommended change in operations.

The operating parameters outlined in this water use plan will allow the GVRD to achieve its long term goals for water supply from Coquitlam Lake Reservoir.

7.2 Riparian Rights

The recommended change in operations will not affect riparian rights associated with the reservoirs or along the streams below the facilities.

7.3 Fisheries

Littoral habitat within Coquitlam Lake Reservoir varies relatively little with the recommended change in operation and no change is expected in Buntzen Lake Reservoir.

Within the Coquitlam River, spawning and rearing habitat for Steelhead trout and Chinook salmon are improved. Flows for short term survival, spawning and rearing are increased. Invertebrate habitat is improved.

7.4 Wildlife Habitat

The Water Use Plan is expected to provide adequate flows to maintain floodplain ecosystem health in the Coquitlam River and have no impact in either reservoir area.

7.5 Flood Control

Flows above 140 m^3/s in the Coquitlam River are expected to flood the cemetery at IR2. The recommended change to reservoir discharge will reduce the probability of flows exceeding 140 m^3/s at the Kingsway WSC gauging site and consequently reduce the risk of flooding the cemetery.

The recommended changes in operations will not compromise the current level of flood protection.

7.6 Recreation

Minimal change is expected to occur on recreational activities, hiking and fishing, on the Coquitlam River.

Recreation opportunities on Buntzen Lake Reservoir are improved by limiting the reservoir drawdown during daylight hours in the summer.

7.7 Water Quality

No change is expected in the quality of water released from any of the water release facilities.

7.8 Industrial Use of Water

The gravel industry, downstream of Coquitlam Dam, can better meet regulations through sediment dilution with the addition of water in the Coquitlam River. No water was added to the river flow for the specific purpose of dilution. Rather, this is a secondary response to having more water in the river for the fishery.

7.9 Electrical Power Production

The recommended change in operations will, over a 39-year average, reduce electrical production from 125 GWh annually to 54 GWh during Flow Trial #2.

7.10 First Nations Considerations

The Coquitlam-Buntzen system is in the asserted traditional use area of five First Nations, including Kwikwetlem First Nation, Tsleil-Waututh First Nation, Katzie First Nation, Squamish First Nation and Musqueam First Nation. It is also within the asserted traditional territory of Sto:lo Nation. The proposed conditions are not expected to affect traditional use in the area. It is expected that the proposed conditions will benefit First Nations considerations as outlined in Section 7.5.

7.11 Archaeological Considerations

The proposed conditions are not expected to affect archaeological interests.

8.0 RECORDS AND REPORTS

8.1 Compliance Reporting

BC Hydro will submit data to the Comptroller of Water Rights as required to demonstrate compliance with the conditions conveyed in the Water Licenses. The submission will include records of:

- Coquitlam Lake Reservoir elevation
- Buntzen Lake Reservoir elevation
- Coquitlam Dam instream flow release
- Discharge through the tunnel to Buntzen Lake Reservoir

8.2 Non-compliance Reporting

Non-compliance with any operation ordered by the Comptroller of Water Rights will be reported to the Comptroller in a timely manner.

8.3 Monitoring Program Reporting

Reporting procedures will be determined as part of the terms of reference for each study or undertaking.

9.0 PLAN REVIEW

A review of this Water Use Plan is recommended within 15 years of its implementation and will be triggered upon completion of the two flow trials and all associated monitoring analysis. A review may be triggered sooner if significant new risks or opportunities are identified. In particular, provision of fish passage over Coquitlam Dam or the ability of the Coquitlam River to handle flushing flows higher than 200 m^3/s would trigger a WUP review. A solution to the current dam safety issue that does not restore the full storage capacity of Coquitlam Lake Reservoir would also trigger a WUP review.

10.0 NOTIFICATION PROCEDURES

Notification procedures for floods and other emergency events are outlined in the "Coquitlam Dam Emergency Planning Guide" and the "Fraser Valley Generation Power Supply Emergency Plan (PSEP)": Both these documents are filed with the Office of the Comptroller of Water Rights.

Appendix 1
Coquitlam River Basin Hydrology

Inter-office memo

TO:	Eric Weiss	25 June 2002
FROM:	Kathy Groves	File: PSE 151.0 C-COQ-151.0
SUBJECT:	Coquitlam Hydrology Report for the Water Use Plan - **Revised**	

1 Introduction

This report highlights the hydrology of the Coquitlam River hydroelectric system. Physiography and climatology are reviewed for the combined areas of the Coquitlam and Buntzen watersheds.

Methods used to calculate reservoir inflows, such as BC Hydro's FLOCAL program, are discussed. Typical inflow hydrographs and summaries are provided. Flow records for the Coquitlam River system referred to in this report were used in power studies conducted for the Coquitlam River Water Use Plan.

Procedures used to provide daily and seasonal volume inflow forecasts are also described.

2 Physiography

The drainage basin for the Coquitlam system is shown in figure 1.

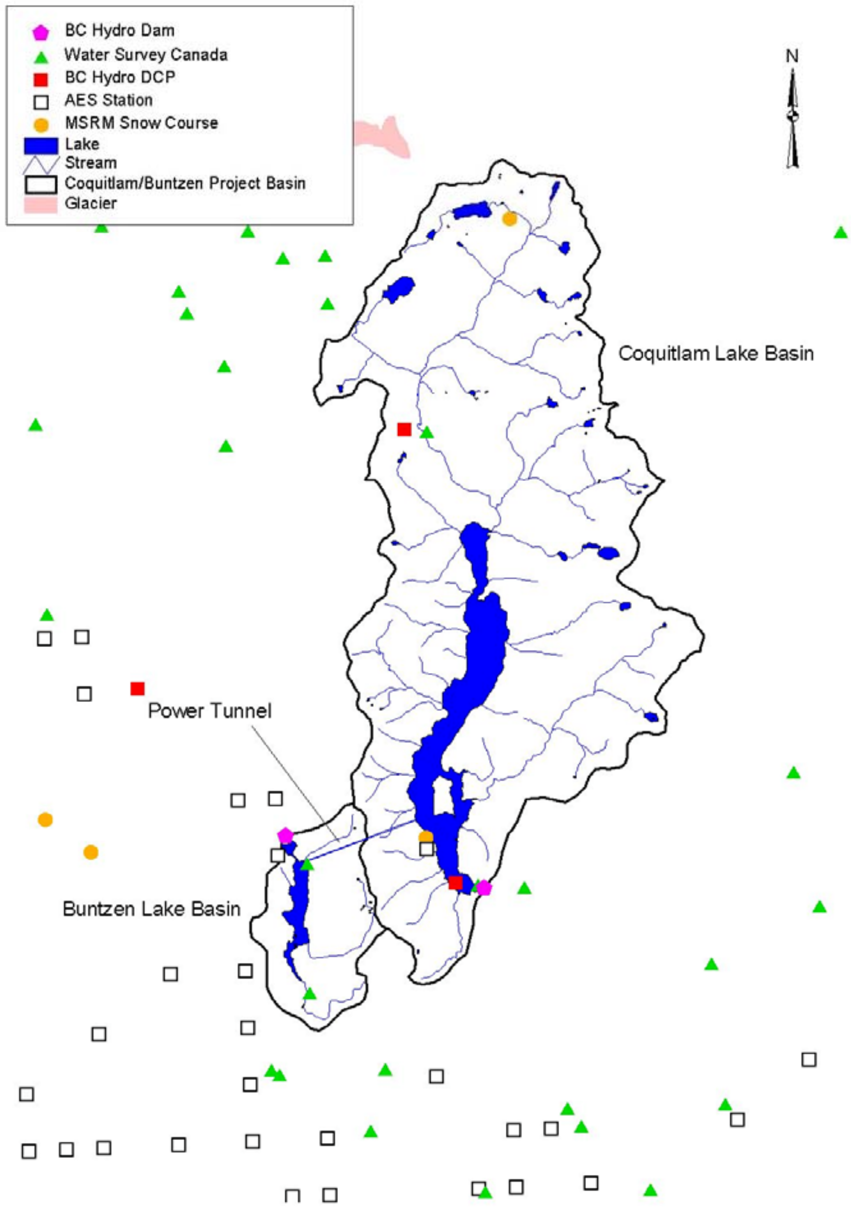


Figure 1 – Watershed Map and Hydrometeorological Stations

The Coquitlam/ Buntzen watersheds lie in the southernmost extension of the Pacific Ranges of the Coast Mountains of British Columbia immediately to the north of the Lower Fraser Valley and about 30 km north-east of downtown Vancouver. Coquitlam has a drainage area of 193 km^2 that ranges in elevation from 153 to over 2000 m. The median basin elevation is 830 m as indicated in the hypsometric curve shown in Figure 2[1]. The curve defines the percentage of the watershed above or below a given elevation. The Buntzen Lake watershed has a drainage area of 21 km^2 that ranges in elevation from 127 m to 1257 m.

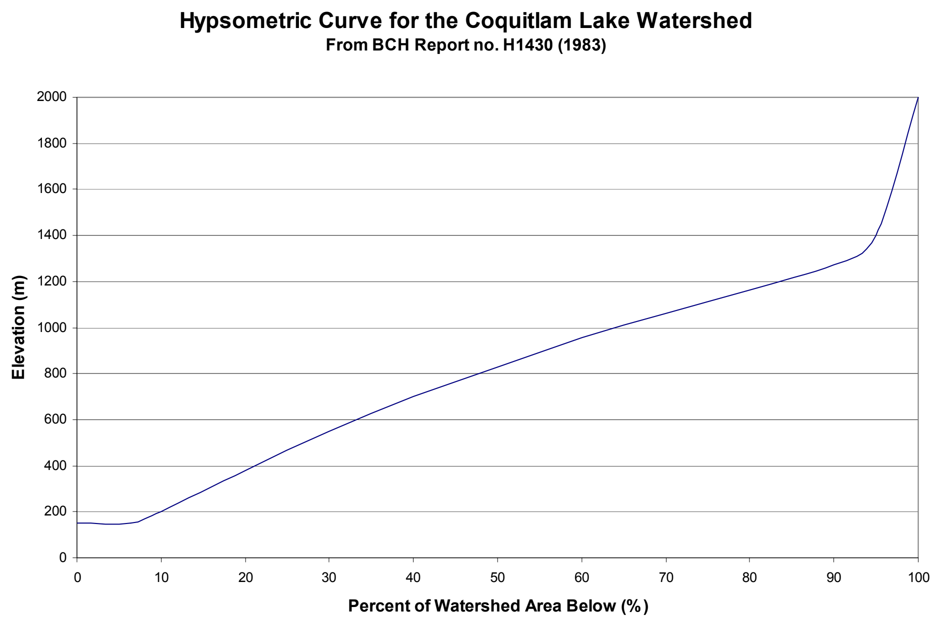


Figure 2: Hypsometric curve for Coquitlam Lake Watershed

Coquitlam Lake is approximately 13 km long. The stage-storage relationship shown in Figure 3a indicates the storage capacity of the reservoir at different reservoir elevations. Storage available between the normal operating range of El. 140.23 and 154.86 m. is estimated from the stage-storage curve at about 2050 cms-days (175 million cubic metres).

[1] BC Hydro. January 1983. "Coquitlam Reservoir Probable Maximum Flood Study". Hydroelectric

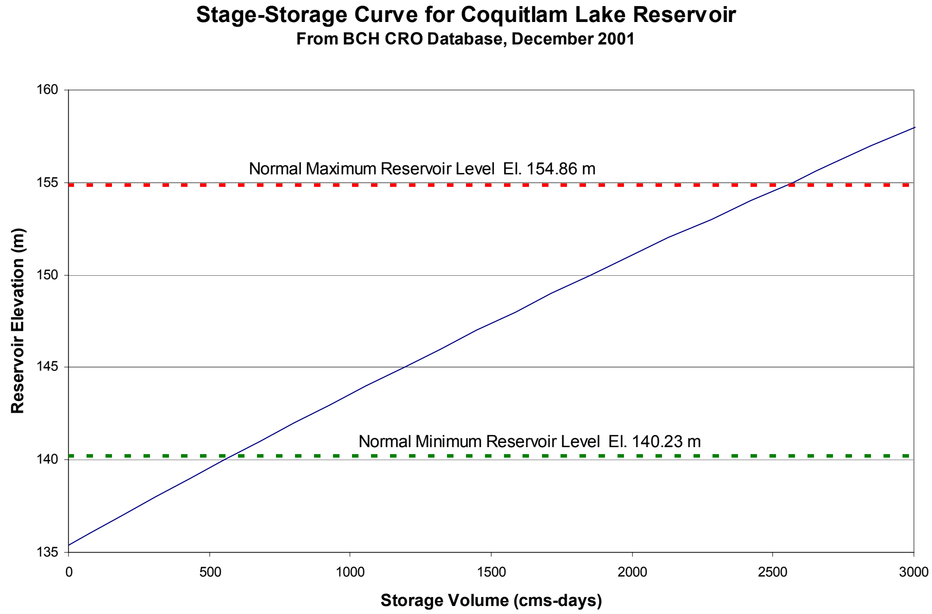


Figure 3a: Stage-Storage curve for Coquitlam Lake Reservoir

Buntzen Lake, which is impounded by Buntzen Dam, is approximately 4.5 km long. The stage-storage relationship shown in Figure 3b indicates the storage capacity of the reservoir at different reservoir elevations. Storage available between the normal operating range of 120.09 m and 122.90 m is estimated from the stage-storage curve at about 55 cms-days (5 million cubic metres).

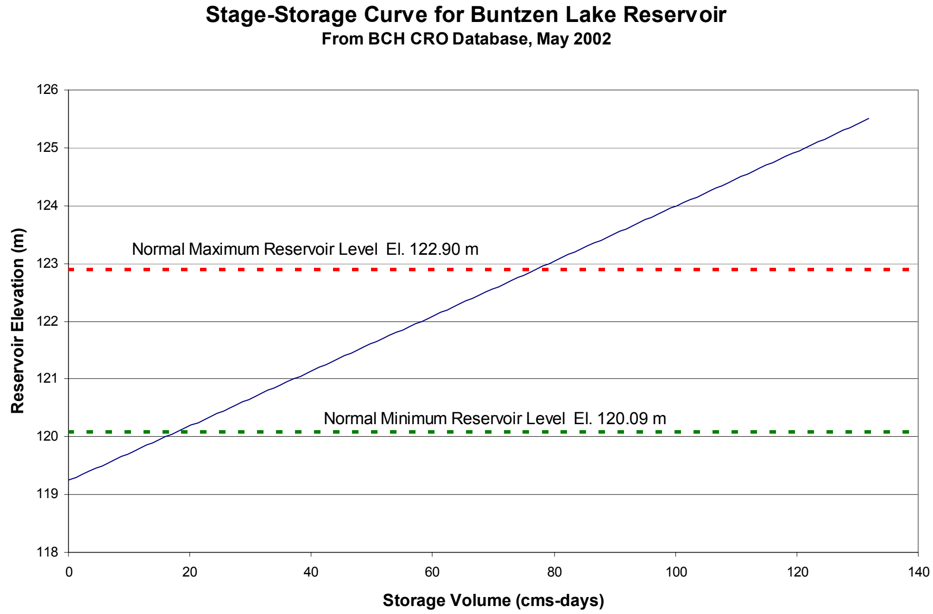


Figure 3b: Stage-Storage curve for Buntzen Lake Reservoir

3 Climatology

The Coquitlam basin is open to southwesterly flows of warm, moist air which are responsible for the heaviest rainfalls for durations greater than one or two hours. The abrupt rise of the Coast Mountains exerts a strong orographic influence on these airflows.

Figure 4 shows a bar chart of normal monthly precipitation as recorded at the Coquitlam above the lake DCP (El. 55m). Minimum and maximum monthly precipitation is indicated to illustrate the variability in the data. As can be seen from the plot, about 50 percent of the annual precipitation normally falls between October and January. A probable maximum precipitation event of 458 mm over 24 hours[2] has been estimated for the basin.

[2] BC Hydro. July 1994. "Probability of PMF for Coquitlam Lake", Hydroelectric Engineering Department, Report No. H2826

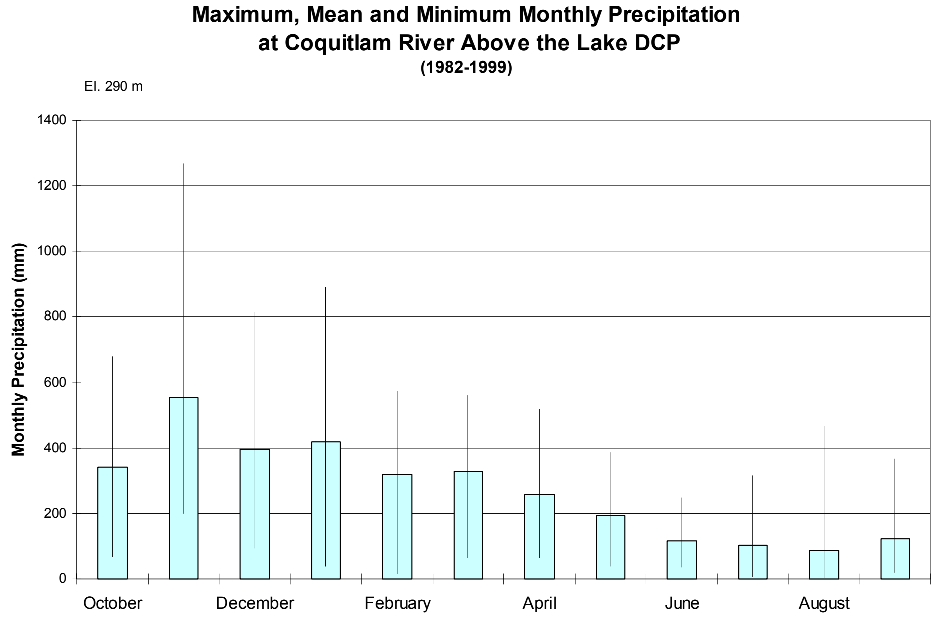


Figure 4: Maximum, mean and minimum monthly precipitation at Coquitlam River DCP

Figure 5 (below) shows maximum, mean, and minimum temperatures at the Coquitlam above the Lake DCP.

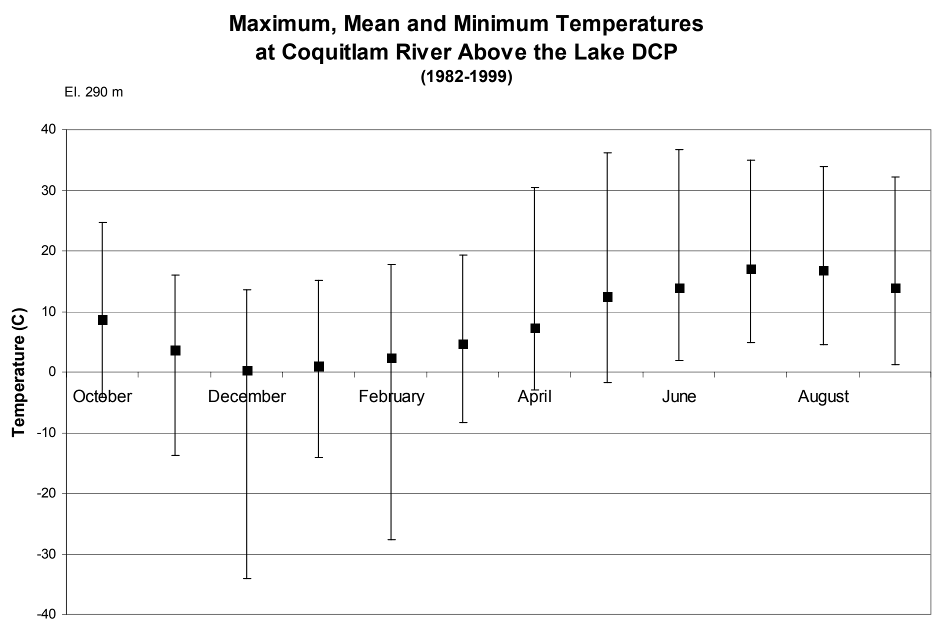


Figure 5: Maximum, mean and minimum temperatures at Coquitlam River DCP

Although there isn't a snow course located within the Coquitlam basin, correlations to several different stations have been developed to represent the snow pack in the Coquitlam watershed. The Stave Lake snow course (1D08) is the closest to the Coquitlam basin. Data for the snow course are shown in Figure 6.

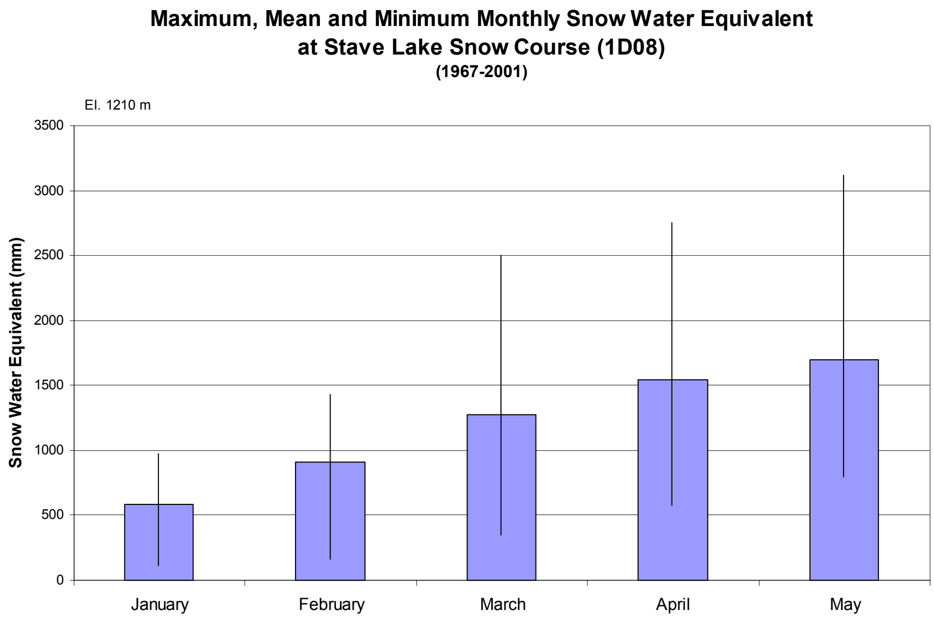


Figure 6: Maximum, mean and minimum snow water equivalent for Stave Lake (1D08) snow course

4 Inflow calculations

Reservoir inflow calculations: Inflow is the volume of water entering a reservoir within a given period of time. Reservoir inflows are calculated rather than measured directly. Daily inflows may be derived from mean daily discharge from the reservoir and change in reservoir storage over a period of 24 hours. The generic formula is:

$$\text{INFLOW} = \text{OUTFLOW} + \Delta\ \text{STORAGE} \quad \text{.........................(1)}$$

where INFLOW = average inflow over a one - day period

OUTFLOW = average outflow over a one - day period

Δ STORAGE = S2 - S1, where

S2 = reservoir storage at the end of the day

S1 = reservoir storage at the end of the previous day

Reservoir storage for a specific reservoir elevation is derived from a stage – storage curve unique to each reservoir.

The nature of the calculation of inflows can result in “noisier” hydrographs than observed at unregulated, natural river channels. Noisy inflows can arise due to various sources of error, such as wind set up on the reservoir, resolution of elevation measurements, errors in reservoir elevation readings, errors in outflow measurements through turbines, spillways or valves, errors in stage-storage curves and errors in the rating curves for various outlet facilities. The impact of noise tends to reduce as the time interval over which inflow is computed increases.

Storage relationships: Storage relationships used to determine the volume of water in Coquitlam and Buntzen Reservoirs are shown in figures 3a and 3b.

Outflow relationships: Turbine flow at the Buntzen powerhouses is computed based on megawatt output and hydraulic head. “Hydraulic head” is a measure of the vertical distance between the water level in the reservoir and the water level immediately below the turbine outlet. Power output is proportional to head and discharge through the turbine. A generic relationship between these variables is shown in figure 7.

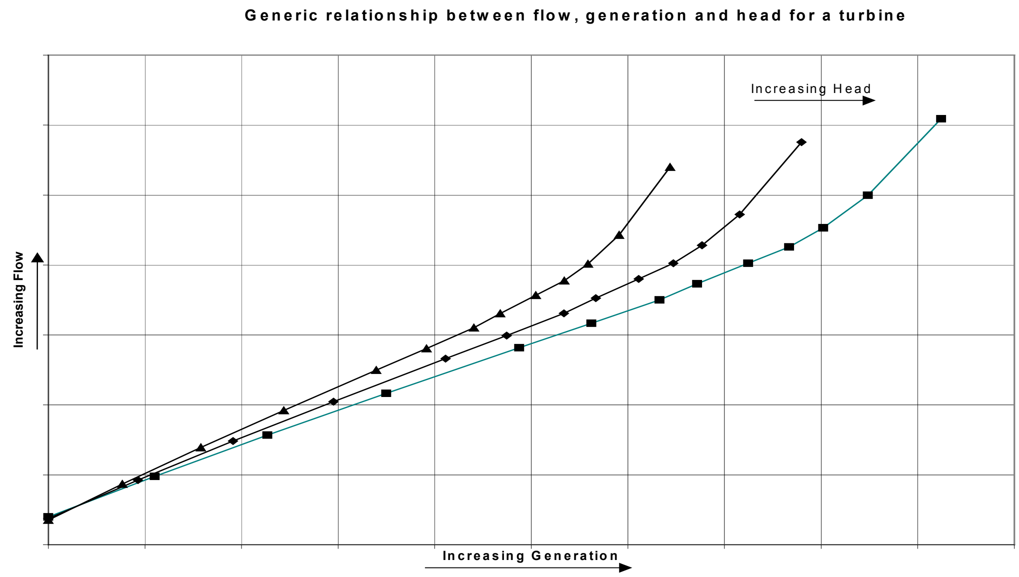
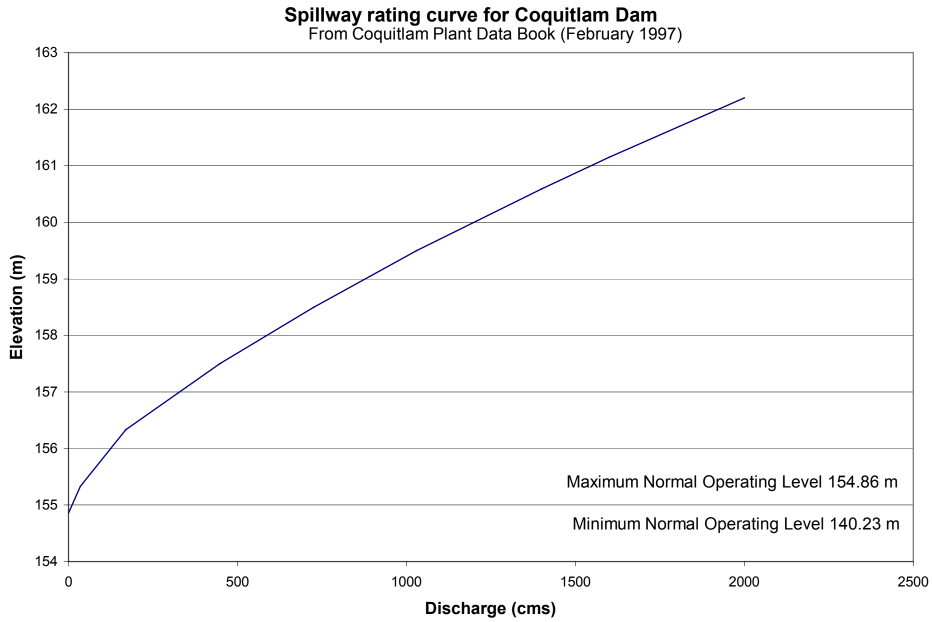


Figure 7: Generic relationship between flow, generation, and head for a turbine

Rating curves are used to compute flow passed through or over a discharge facility. “Rating curves” show the relationship between flow, gate opening (where appropriate), and reservoir elevation for a given release device. Spillway rating curves for Coquitlam and Buntzen dams are shown in Figures 8a-b.



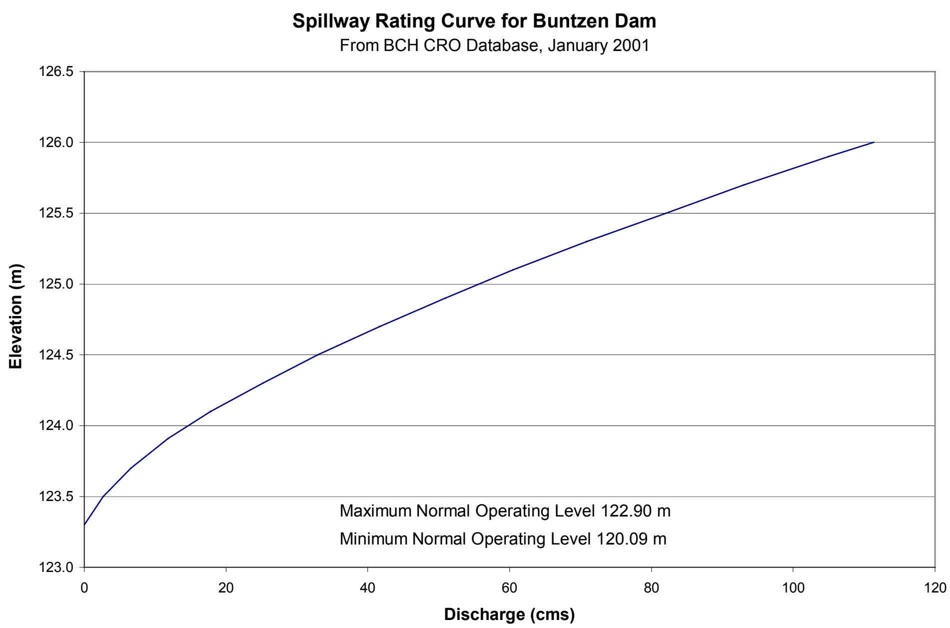


Figure 8a-b: Spillway Rating Curves for Coquitlam and Buntzen Dams

Coquitlam dam has three low-level outlets; the combined rating curve for all three outlets fully open is shown in Figure 9.

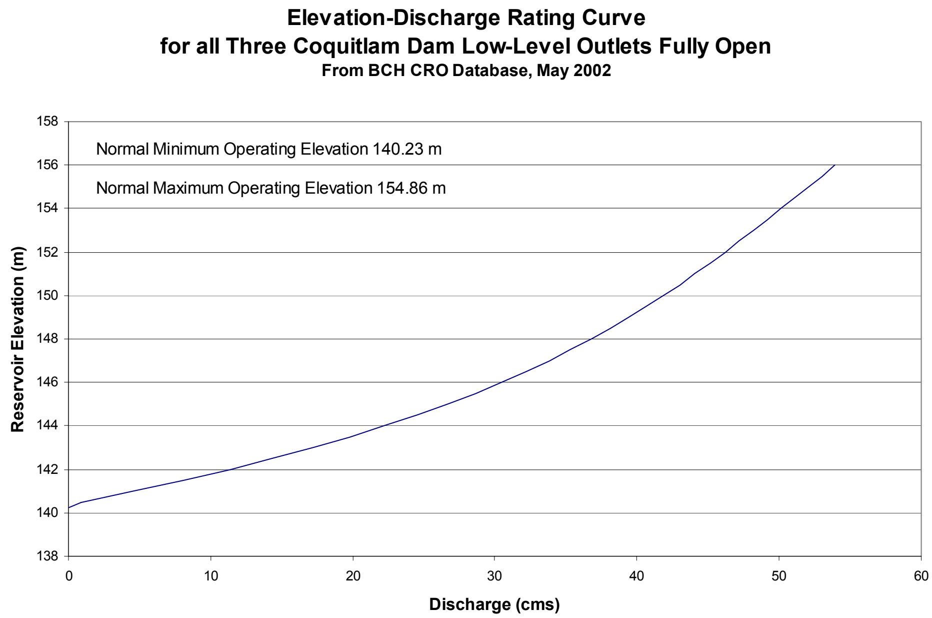


Figure 9: Low Level Outlet Rating Curve for Coquitlam Dam

Coquitlam Dam also has two fish valves; their combined rating curve is shown in Figure 10.

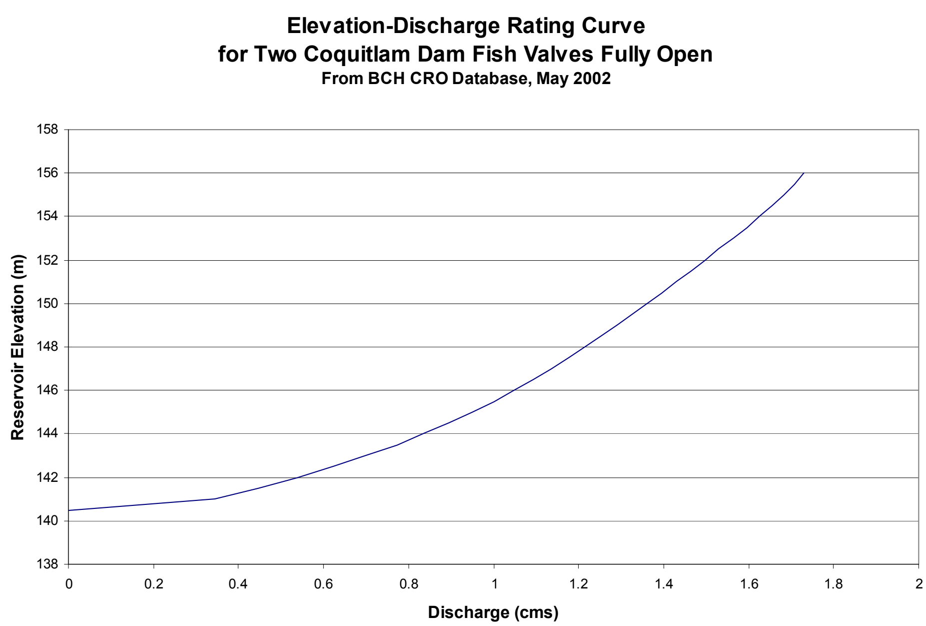


Figure 10: Fish Valves Rating Curve for Coquitlam Dam

Data records: BC Hydro computes inflow using a computer program called FLOCAL. Specifically;

> Natural inflows to Coquitlam Lake Reservoir are computed based on equation (1).
>
> Inflows to Buntzen Lake Reservoir are computed based on equation (1). Local inflow to Buntzen Lake is equal to inflow- regulated diversions from Coquitlam.

Various information, including gate openings, reservoir and tailwater elevations, energy, spill, turbine flows, and inflows are stored in FLOCAL. A FLOCAL configuration for Coquitlam and Buntzen is shown in Figure 11.

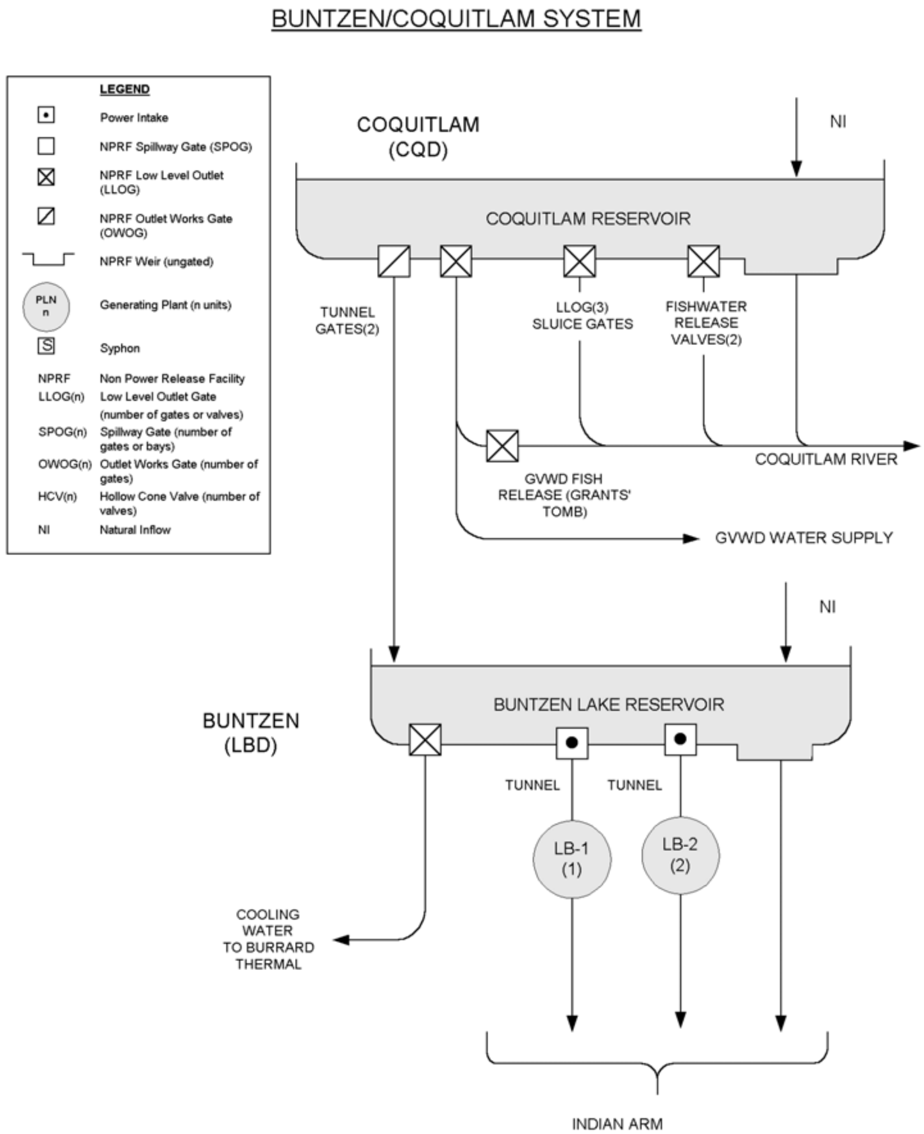


Figure 11: Schematic of the FLOCAL configuration for the Buntzen system

5 Reservoir inflow characteristics

Coquitlam Lake

Figure 12 shows a “spaghetti plot” of historical inflows to the Coquitlam Reservoir. The 10th, 50th and 90th percentile inflows are also shown.

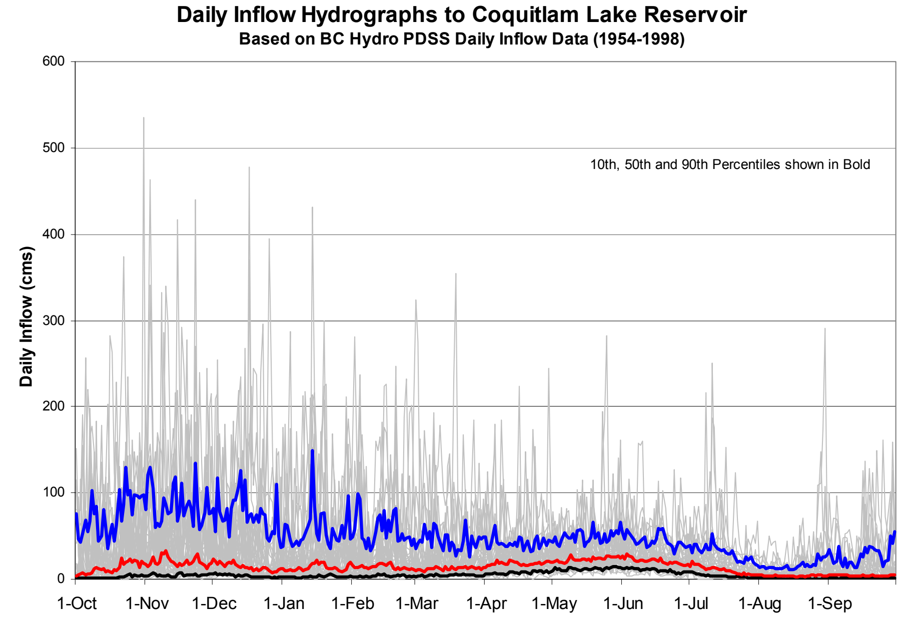


Figure 12: Historical Daily Inflows for Coquitlam Lake Reservoir

Figure 13 and Table 1 summarize the historical daily inflows by month and highlight the variability of inflows observed at the project.

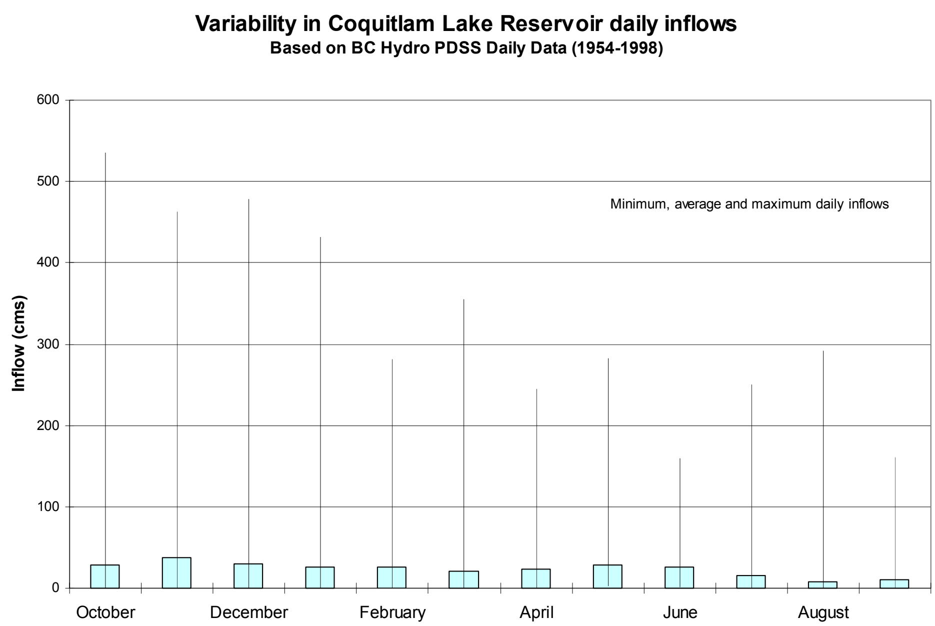


Figure 13: Variability in Coquitlam Lake Reservoir daily inflows

Table 1: Coquitlam Lake Reservoir daily inflows (1954-1998)

	Minimum Daily Inflow (cms)	Maximum Daily Inflow (cms)	Mean Daily Inflow (cms)
October	<1	536	28
November	<1	463	37
December	<1	478	30
January	<1	432	26
February	<1	281	25
March	<1	354	21
April	<1	245	23
May	3	282	28
June	1	160	26
July	<1	250	15
August	<1	291	7
September	<1	161	11

A "flow duration curve" indicates the percent of time that a flow is greater than a given discharge. Figure 14 shows a flow duration curve of daily inflows to Coquitlam Lake for the years 1954-1998. The figure again illustrates the large range and variability of inflows.

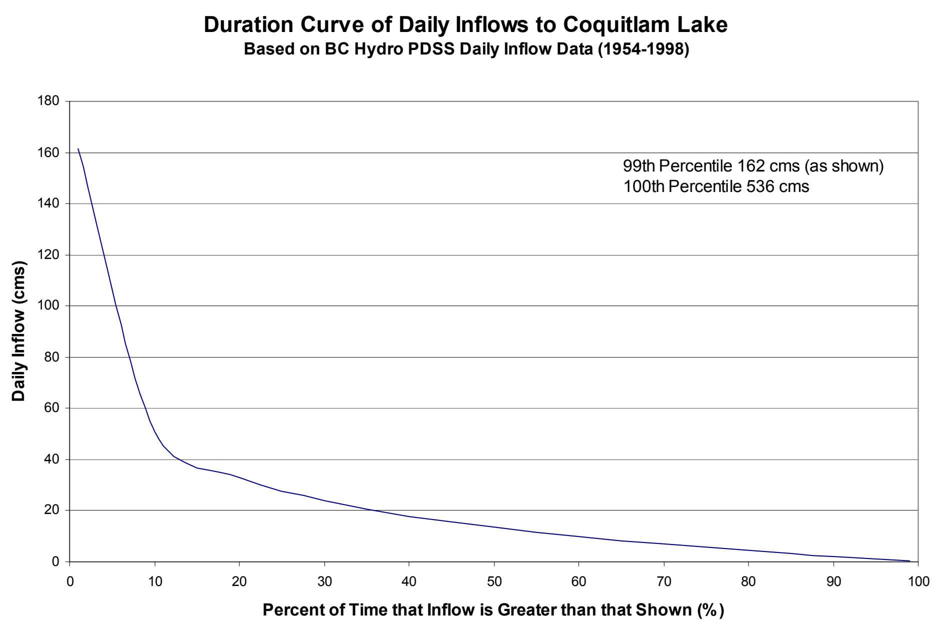


Figure 14: Duration curve of daily inflows to Coquitlam Reservoir

Figure 15 shows a duration curve for annual inflows to Coquitlam Lake.

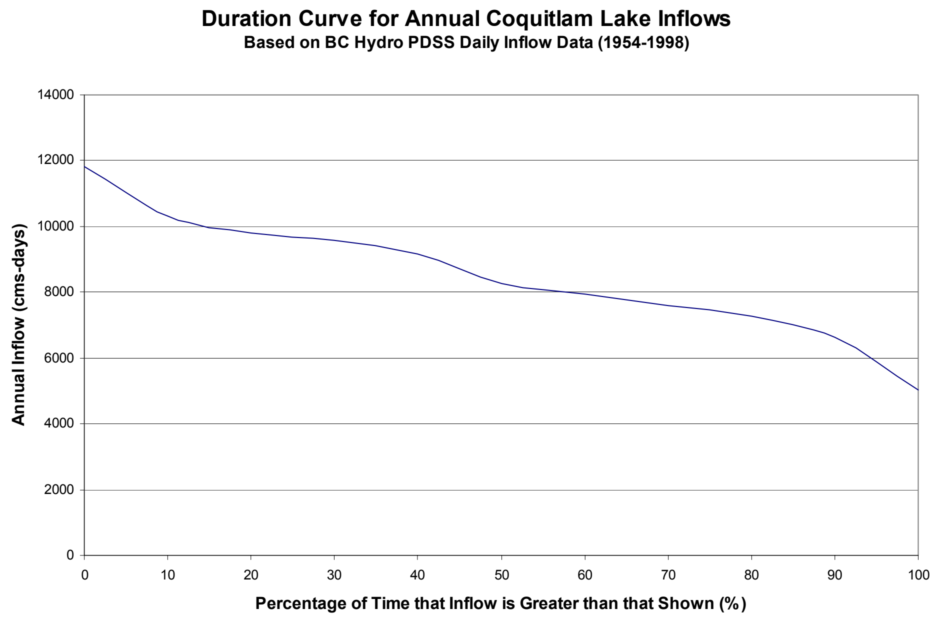


Figure 15: Duration curve of annual inflows to Coquitlam Reservoir

For reference, Figure 16 shows a comparison between the mean local inflow and total live storage available for selected BC Hydro and other hydroelectric projects. Coquitlam Lake Reservoir is highlighted and shows that the average annual inflow is about 2.5 times greater than the available storage.

The ratio of average annual inflow to available reservoir storage provides a qualitative indication of how the inflow regulation and spill management capability varies from project to project; the higher the ratio, the lower the regulation capability. Figure 16 also shows the relative contribution of Coquitlam Lake Reservoir to BC Hydro's total reservoir storage capability.

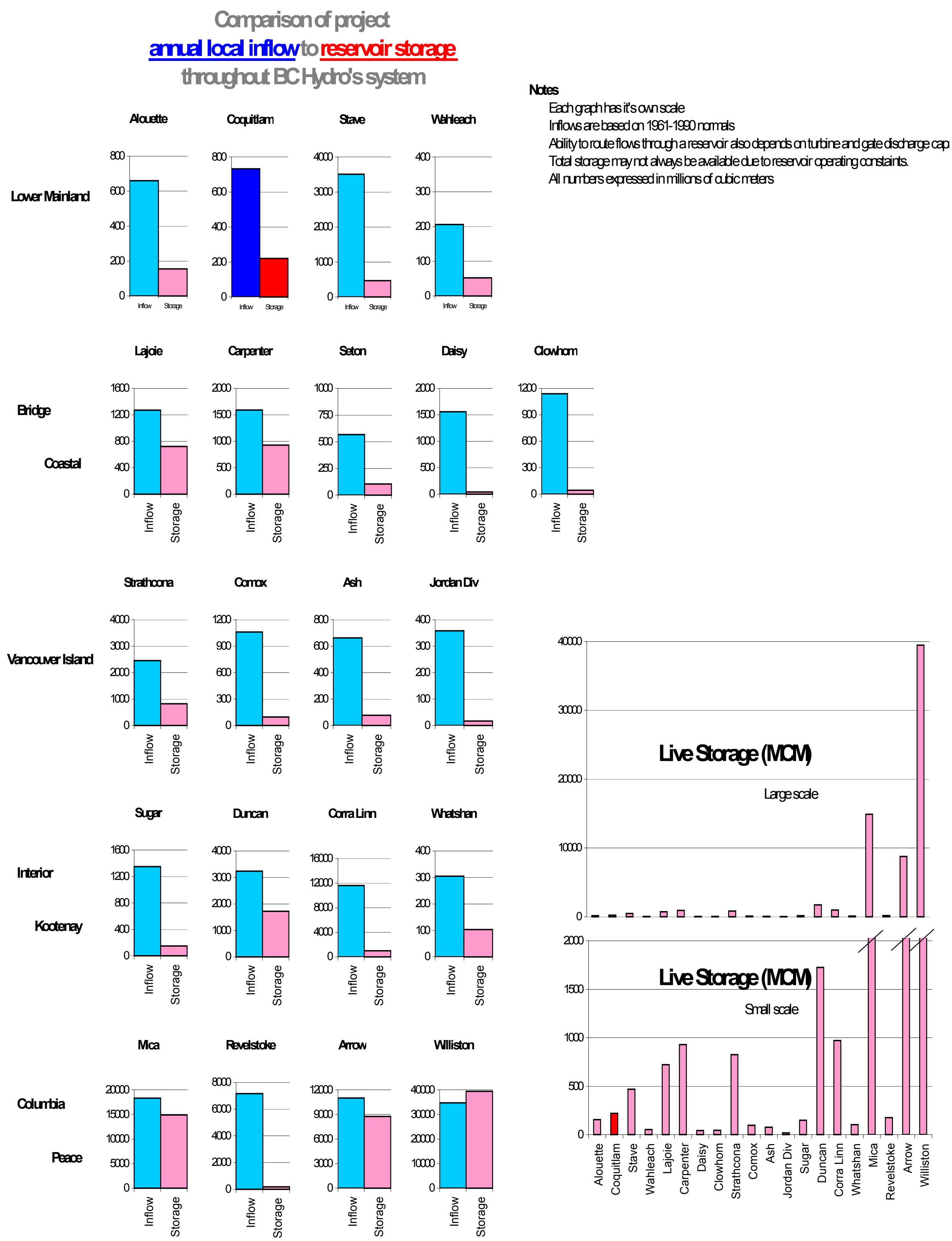


Figure 16: Comparison of project annual inflows to reservoir storage throughout BC Hydro's system

The GVWD uses Coquitlam Lake as a source of drinking water for Greater Vancouver. Figure 17 shows historical monthly average GVWD withdrawals from the reservoir.

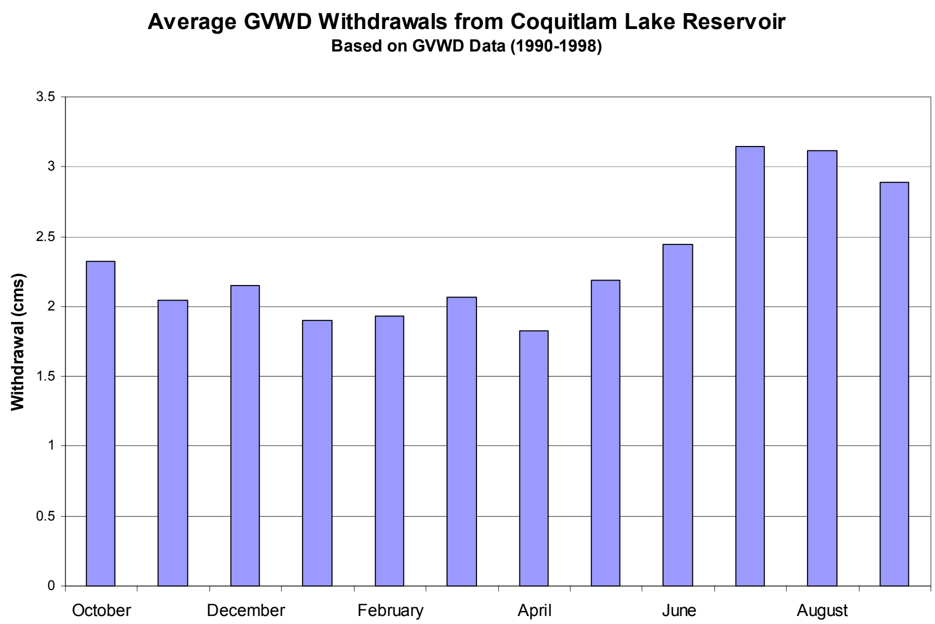


Figure 17: Historical monthly average GVWD withdrawls from Coquitlam Lake Reservoir

Buntzen Lake

For the purpose of the Coquitlam WUP, the relatively small amount of local inflow to Buntzen Lake has been ignored

Figure 18 shows historical monthly average diversion flows through the tunnel leading from Coquitlam Lake Reservoir to Buntzen Lake Reservoir.

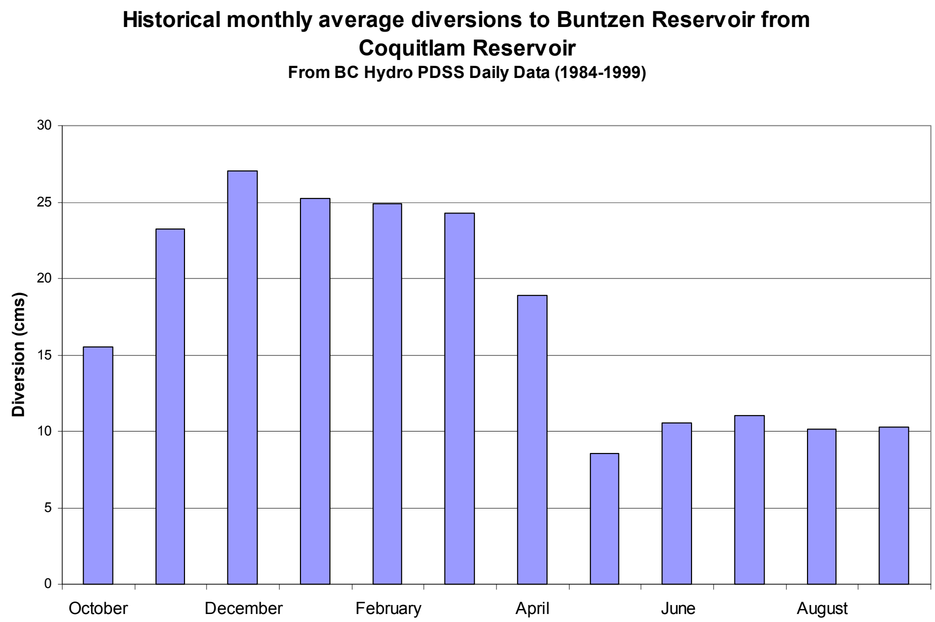


Figure 18: Historical monthly average diversions from Coquitlam Lake Reservoir to Buntzen Lake Reservoir

6 Operational inflow forecasting

BC Hydro's Resource Management produces two main types of hydrologic forecasts: daily inflow and seasonal volume inflow forecasts for Coquitlam Lake.

Daily inflow forecasts: Daily inflow forecasts are short-term forecasts that indicate the inflow expected over the next few days. An in-house conceptual watershed model, FLOCAST, is currently used to produce these forecasts. Each morning of each working day, Resource Management enters observed and forecast precipitation, temperature, and freezing level data into the model to forecast inflow over each of the next five days.

Volume inflow forecasts: Volume inflow forecasts estimate the volume of water that is expected to flow into Coquitlam Lake during a given period. BC Hydro typically produces forecasts for the period February through September. Volume inflow forecasts are issued beginning January 1 of each year. The forecasts are updated on the first of each month until August 1.The ability to forecast seasonal runoff for this period lies in the fact that much of the runoff during the forecast period is the product of snowmelt runoff. By measuring snow water equivalent in the mountain snowpack, as well as other parameters such as precipitation and streamflow up to the forecast date, a more accurate estimate of future runoff can be made than one based on historical inflow data alone.

7 Hydrometeorologic network

Hydrometeorological data is required to plan, monitor, and operate facilities in the Coquitlam and Buntzen Lake watersheds. Characteristics of the hydrometeorological data collection stations used for inflow forecasting are summarized in Table 2. Locations of hydrometeorological stations are shown in Figure 1.

Table 2: Active hydrometeorological stations used for Coquitlam Inflow forecasting

Station	Type	ID	Elev (m)	Latitude	Longitude	Start Year	Characteristics
Abbotsford Airport	AES	YXX	61	49 02	122 22	1944	Climate
Alouette	DCP	ALU	125	49 17 14	122 29 04	1983	Climate
Coquitlam	DCP	COQ	160	49 21 20	122 46 40	1984	Climate
Coquitlam R. above Lake	DCP	CQM	290	49 29 20	122 47 29	1982	Climate, Streamflow
Dog Mountain	MELP	3A10	1080	49 23	122 58	1945	Snow Course
Gold Creek	DCP	GOC	794	49 26 50	122 28 30	1983	Climate
Grouse Mountain	MELP	3A01	1100	49 23	123 05	1936	Snow Course
Nahatlatch	MELP	1D10	1520	49 50	122 03	1968	Snow Course
Palisade Lake	MELP	3A09	880	49 27	123 02	1946	Snow Course
Stave	MELP	1D08	1210	49 35	122 19	1967	Snow Course
Stave Falls	DCP	STA	330	49 32 22	122 19 19	1983	Climate

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Note: this memo replaces memo issued 6 March 2002, Lara Taylor to Eric Weiss, wr0109