2008 Long Term Acquisition Plan

BC hydro

APPENDIX F8

Potential Large Hydro Project Report

1.1 Potential Large Hydro Projects

In addition to examining Peace River Site C, Waneta Expansion Project and the potential for a pumped storage project on the Jordan River described in section 3.3.12, BC Hydro updated information with respect to nine potential large hydroelectric projects investigated by BC Hydro in the past. The nine projects are Elaho, McGregor, Murphy Creek, Border, Homathko, Liard River, Iskut, High Site E and Low Site E. Three previously studied projects (Cutoff Mountain, Stikine and McGregor Diversion) were removed from consideration due to legislative constraints.

BC Hydro updated the information concerning the earliest possible In-Service Date (**ISD**) of the nine potential large hydro projects and provided high level cost estimates for each of these nine large hydro projects (see Table 1 below). As explained in Table 1, these cost estimates are for the pre-feasibility level of design and are therefore subject to a high degree of uncertainty. None of these potential large hydro projects are currently undergoing further evaluation by BC Hydro.

1.1.1 Potential Large Hydro Projects Removed from Consideration

The following large hydro projects were not updated as part of the Resource Options Update due to legislation prohibiting their future development:

- The Cutoff Mountain site on the Skeena River (1330 MW, 6990 GWh/year of average annual energy) and several sites on the Stikine River (2900 MW, 15,500 GWh of average annual energy). Both of these potential large hydro developments are now legislatively barred pursuant to section 4 of the B.C. *Fish Protection Act*,[2] which designates the Skeena and Stikine Rivers as "protected rivers" and prohibits the construction of bank-to-bank dams on these protected rivers.

[2] S.B.C. 1997, c.21. The other "protected rivers" are: the Adams River, the Alsek River, the Babine River, the Bell-Irving River, the West Road River (commonly known as the Blackwater River), the Clearwater River, the Fraser River, the Nass River, the Skagit River, the Stuart River, the Taku River, the Tatshenshini River, the North Thompson River, the South Thompson River and the Thompson River.

- McGregor River Diversion project (3380 GWh/year of average annual energy) is also legislatively barred. This project would entail diverting most of the McGregor River flows across the divide between the Pacific and Arctic watersheds into the Peace River basin. Section 6 of the *Water Protection Act*[3] prohibits the construction of "large scale projects" capable of transferring a peak instantaneous flow of 10 cubic metres of water a second between major watersheds.

1.1.2 Review of Nine Potential Large Hydro Projects

BC Hydro updated the ISD information and inflated earlier cost estimates for the following nine potential large hydro projects:

- Elaho, a proposed 200 MW (945 GWh/year of average annual energy) earthfill dam project to be sited on the Elaho River 6 kilometres (**km**) upstream of the Squamish River. Engineering and cost estimates were developed in 1983 for a non-diversion option;

- McGregor Lower Canyon, a proposed 360 MW (1673 GWh/year of average annual energy) earthfill dam, two unit powerhouse project to be located at Lower Canyon on the McGregor River approximately 30 km upstream of the confluence with the Fraser River. The project would not divert the McGregor river flow into the Peace system, but would create a reservoir of approximately 23,000 hectares, that would potentially encroach on the boundaries of the Arctic Pacific Lakes Provincial Park. A prefeasibility study was conducted in 1980;

- Murphy Creek, a proposed 275 MW (1794 GWh/year of average annual energy) earthfill dam and five 55 MW unit powerhouse project to be situated on the Columbia River 3 km upstream of the City of Trail. Households adjacent to the proposed reservoir and sections of railway, highway and municipal infrastructure would need to be relocated. In addition, there would likely be impacts to White Sturgeon, a species listed under the *Species at Risk Act*.[4] Engineering preliminary designs and other associated studies were conducted in the early 1980s;

[3] R.S.B.C. 1996, c.484.

[4] S.C. 2002, c.29.

- Border, a proposed 275 MW (1418 GWh/year of average annual energy) low head concrete dam and powerhouse project to develop the remaining head on the Columbia River in BC, located on the Columbia River near its confluence with the Pend d'Oreille River. Some residences in the City of Trail could be displaced and would have to be relocated. Municipal infrastructure, roads and parts of Highway 22A would be flooded. Pre-feasibility studies were completed in the 1970s, and further overview studies were conducted in 1990;

- Homathko River, a proposed 895 MW (4,558 GWh/year of average annual energy) development consisting of four dams and three power plants in an undeveloped river basin in the Coastal Mountains. The proposed facility development would include: a dam and 290 MW power plant on Mosley Creek; a dam and 420 MW power plant on Waddington Canyon on the Homathko River; a storage dam on Tatlayoko Lake, a dam and 185 MW power plant on the Homathko River at Nude Canyon. The facilities would be situated within the boundaries of the Homathko River – Tatlayoko Protected Area Provincial Park. An overview and feasibility studies were completed in the early 1980s. Project activities were suspended in 1984 due to changes in load growth forecasts;

- Liard River, a proposed 4318 MW (24,825 GWh/year of average annual energy) development consisting of 3 dams and power plants on the Liard River in Northern British Columbia. One hundred and sixty km of the Alaskan Highway and five settlements would have to be relocated to accommodate the project. In addition, the Fort Nelson Regional Land Management Plan designates areas of the Liard watershed as protected. Considerable project investigations were undertaken by BC Hydro in the late 1970's and early 1980's, but activity was suspended in 1982 due to changes in load growth projections;

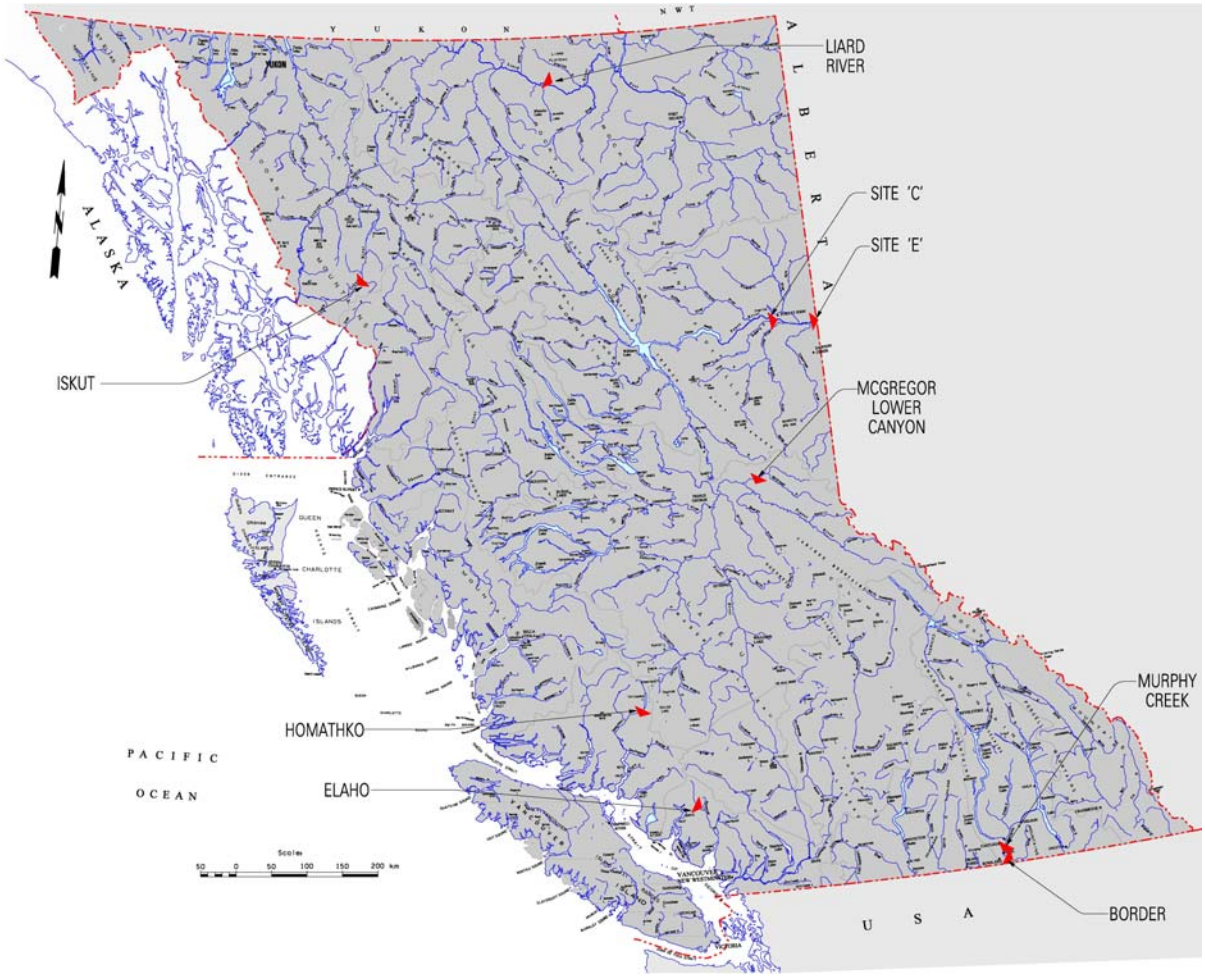
- Iskut River, a proposed 980 MW (4293 GWh/year of average annual energy) project. BC Hydro no longer has the rights to the land on which this project would be located. Feasibility and preliminary design work, including engineering and environmental studies, were conducted in the late 1970's and early 1980's. Project activity was suspended in 1983;

- Peace River - High Site E, a proposed 1800 MW (8500 GWh/year of average annual energy), 330 foot high dam project. Engineering feasibility studies were conducted in 1971-72 and indicated that it would be practical to develop most of the head between Peace River Canyon Dam and the B.C./Alberta border either by a single high dam at Site E near the border (referred to as "**High Site E**") or by two low dams, one at Site E (referred to as "**Low Site E**" and one at Site C. With respect to High Site E, studies carried out in 1974 to 1976 concluded that power development using both Low Site E and Site C would have less environmental impact than High Site E, including flooding of about 60 per cent less area. High Site E would affect the main highway and railway bridge crossings of the Peace River at Taylor. Major ground movements could occur between Site C and Site E with a High Site E dam. High Site E has received no further consideration since 1976;

- Low Site E, a 675 MW (3210 GWh/year of average annual energy) project comprising a combined dam and powerhouse on the Peace River 3 km upstream of the B.C./Alberta border. Low Site E was studied in conjunction with earlier studies of Site C; no separate studies were made for Low Site E. The 1970s studies referred to above with respect to High Site E concluded that Site C would be considerably more economic than Low Site E. In 1985 the Provincial Government removed the flood reserves for the Site E project. Low Site E would flood agricultural land and would require the relocation of a number of riverside residents.

The map below shows where each of the nine potential large hydro projects would be located. The location of Site C is also shown for reference.

Figure 1 Location of Potential Large Hydro Projects



Estimates of In-Service Dates: Large hydroelectric project generally require long periods for development, ranging from 12 to 25 years, from early evaluation to full commercial operation. Large hydroelectric project schedules are greatly influenced by the pre-construction time requirements to conduct environmental assessments, First Nations and public consultation and regulatory reviews. Additionally, continuously revised load forecasts and resource options updates that occur throughout the project schedule also affect ISDs. Proposed ISDs, consequentially, do not typically dictate the scheduling of pre-construction stages of large hydroelectric projects.

As part of its due diligence in assessing large hydro projects, BC Hydro analyzed and assessed the contemporary time requirements for engineering and regulatory processes as well as the construction/implementation schedules for each of the nine previously considered potential large hydro projects. BC Hydro estimated that engineering work for each of the nine potential large hydroelectric projects would require approximately two years to complete. This estimate incorporates the time requirements to complete both field work, including geological, geotechnical and environmental investigations, and to complete reviews of earlier design work. A two year engineering period may not be appropriate for several of the nine potential large hydroelectric projects as a number of these projects are located in remote locations and are subject to seasonal constraints that would provide limited windows for field study activities. Additional engineering would continue into the subsequent 5 year regulatory review period.

In estimating the regulatory approval schedule for these projects, BC Hydro used the schedule developed for Site C as the basis for assessing that it would take approximately 5 years to secure regulatory approvals. Each of the nine potential large hydro projects would have a rated name plate capacity of 50 MW or greater, thereby triggering the requirement to obtain an Environmental Assessment Certificate pursuant to B.C. *Environmental Assessment Act*[5] (***BCEAA***). In addition, these large hydro projects would result in work in or about fish habitat, and thus would trigger both the *Fisheries Act*[6] and the *Canadian Environmental Assessment Act*[7] (***CEAA***).. Finally, these potential large hydro projects would require either a Determination pursuant to section 44.2 of the *Utilities Commission Act* (***UCA***) or a Certificate of Public Convenience and Necessity pursuant to sections 45 and 46 of the *UCA*.

In addition to the *BCEAA*, *CEAA* and *UCA* review processes described above, each of the nine projects may have potential site specific regulatory issues that may further impact the firmness of estimated ISDs.

[5] S.B.C. 2002, c.43.

[6] R.S.C. 1985, c.F-14.

[7] S.C. 1992, c.37.

Finally, BC Hydro has provided an estimate for the construction/implementation schedule for each of the nine large potential hydroelectric projects. The implementation schedules for completion of the projects ranged from 4½ to 10 ¾ years. The overall schedule for the projects ranged from 11 ½ years to 17 ¾ years as a best case scenario, and from 16 ½ to 25 years as a worst case scenario.

None of the nine potential large hydroelectric projects could be in-service prior to 2019, even if work were to commence on these projects in 2008.

Estimates of Costs: Cost estimates for the potential large hydro projects described above were developed in the 1970s and 1980s for overview, feasibility and preliminary design reports. Based on current design criteria for hydroelectric projects, these previous estimates would probably only apply to the pre-feasibility level of design. Since the estimates were prepared for these reports construction costs have increased, technology has improved and the cost and level of detail required to obtain environmental and regulatory approvals has increased.

Construction costs were inflated from the original base estimates using the Statistics Canada Non-Residential Price Index (Seven City Composite – Table 327-0039). This index is the most appropriate for Heavy Civil/Mechanical/Electrical category of construction work that these large hydroelectric projects fall into and is commonly used as a cost indexing calculation tool in the major project industry. After applying this index, estimates prepared in 1975 increased 4.12 times and estimates prepared in 1983 have increased 2.27 times. These cost adjustment factors, coupled with the fact that many of these projects were in preliminary design phases, affects the accuracy of the cost estimates. Consequently, estimated accuracy for these estimates have a range from+75 per cent to -25 per cent. According to Association for the Advancement of Cost Engineers, these estimates are within industry standards for a pre-feasibility cost estimate, and fall within the acceptable accuracy range (low:-20 to -50 per cent high: +30% to +100 per cent).

Site E (both High and Low alternatives) cost estimates were factored up to reflect knowledge from the current Site C design.

When reviewing previous design reports, it was noted that in many cases the costs for regulatory approvals, as well as costs for mitigation and compensation requirements, were not included in calculating the cost estimates. Today these factors represent significant costs for B.C. hydroelectric projects. To compensate for this discrepancy, an allowance of 3 per cent of project direct construction cost was included for regulatory (public consultation, environmental studies, and work required to obtain regulatory and environmental approvals) and 3.5 per cent of project direct construction cost for mitigation and compensation.

The estimates are provided in January 2008 constant dollars and do not include loadings for inflation, financing charges (interest during construction), and corporate overheads. Cost estimates in every case are based on a design/bid/build procurement strategy, an approach commonly applied by BC Hydro. If the procurement strategy were changed to a design/build or public/private partnership approach, then the costs and schedule would likely vary.

Interim project cost estimates for Site C can be found in the Site C Stage-1 Report, published in December 2007.

TABLE 1 - LARGE HYDRO CONSTRUCTION COST ESTIMATES FOR GENERATION

Report Reference	H2258	H1595	H1688	H1688	H1688	H1199	H1782	796	796	H1719	H1630	H1630	H1674	H1674
Level of Design	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview	Overview
Base Cost Estimate	Oct.'89	Oct.'82	Oct.'83	Oct.'83	Oct.'83	Oct'79	Oct'84	June'75	June'75	Oct.'83	Oct.'83	Oct.'83	Oct.'83	Oct.'83
MW	275	200	290	420	185	360	275	675	1800	2490	1128	700	170	810
# of Units	5	2	2	2	1	2	5	6	6	6	6	4	2	3
MW per Unit	55	100	145	210	185	180	55	112.5	300	415	188	175	85	270
Annual Energy in GWHours	1418	945	1473	2121	964	1673	1794	3210	8500	14,112	6701	4012	701	3592
			Hamathko Development							Liard Development			Iskut	
FACILITY	**Border**	**Elaho River**	**Mosley Creek**	**Waddington**	**Nude Canyon & Tat. Storage**	**McGregor - Lower Canyon**	**Murphy**	**Site E**	**High Site E**	**Liard - Devil's Gorge**	**Liard - Low Beavercrow**	**Liard - Hell Gate**	**More Creek**	**Iskut Canyon**
Total Capacity	275 MW	200 MW	290 MW	420 MW	185 MW	360 MW	275 MW	675 MW	1800MW	2490 MW	1128MW	700 MW	170 MW	810 MW
COST ESTIMATE ELEMENTS														
LAND & RIGHTS	5.721	5.980	4.400	1.700	1.200	0.900	16.000			65.300	24.700	3.200	4.100	13.500
FLOWAGE	61.476	16.100	3.200	3.700	3.400	17.300	17.500	20.944	186.648	323.900	6.000	5.500	16.300	13.500
ACCESS & CLEARING	21.836	10.870	124.200	17.600	31.400	10.200	6.700	2.618	2.772	7.200	242.100	39.200	11.600	74.800
DIVERSION & COFFERDAMS	5.242	26.480	18.100	27.400	22.800	30.700	12.800	15.862	18.172	209.500	369.400	42.300	26.100	62.800
DAMS AND OTHER	129.560	78.040	101.700	153.000	82.100	102.100	80.200	41.734	153.846	526.700	218.700	93.700	113.700	219.800
SPILLWAY	46.904	41.310	40.800	42.900	5.900	19.900	41.700	74.690	147.840	231.100	757.100	58.400		53.400
POWER INTAKES	0.000	8.210	8.800	6.500	4.800	21.100		59.752	144.914	78.600	142.900	43.800	10.000	36.600
PENSTOCKS/POWER TUNNELS	0.000	53.540	86.600	19.800	62.100	21.500		inc'd above	inc'd above	136.700	259.000	18.500	14.300	72.400
POWERHOUSE & SWITCHGEAR														
- CIVIL	173.609	22.900	73.700	147.700	29.100	19.500	118.900	93.324	137.984	357.400	148.700	114.600	51.600	139.400
- MECH	141.253	14.990	18.700	24.400	11.100	17.200	95.000	66.220	81.774	100.800	113.500	123.100	14.700	44.000
- ELEC	91.000	32.500	39.500	47.300	18.700	20.000	82.900	64.218	121.044	150.500	110.200	81.200	24.900	80.100
CONSTRUCTION SERVICES	27.064	18.650	31.200	29.500	18.800	11.200	21.500	6.160	14.938	131.300	143.500	37.400	17.400	48.600
DIRECT CONSTRUCTION COST	703.665	329.570	550.900	521.500	291.400	291.600	493.200	445.522	1,009.932	2,319.000	2,535.800	660.900	304.700	858.900
CONTINGENCIES	148.387	98.840	103.900	95.600	54.000	38.700	57.200	70.224	173.250	332.600	366.400	108.600	42.500	121.000
MGMT & ENGINEERING	97.986	35.120	65.500	61.700	34.300	29.700	78.900	64.988	131.978	212.000	232.200	77.000	31.300	84.300
HEARING COSTS	2.700					0.000	2.300							
MITIGATION & COMPSTN	28.000					0.000	11.400							
CONSTN INS & BONDS	8.521	4.280	6.500	6.200	3.500	3.300	5.300	0.000	0.000	26.400	29.000	7.700	3.500	9.800
INDIRECT CONSTRUCTION COST	285.594	138.240	175.900	163.500	91.800	71.700	155.100	135.212	305.228	571.000	627.600	193.300	77.300	215.100
TOTAL CONSTRUCTION COST	989.259	467.810	726.800	685.000	383.200	363.300	648.300	580.734	1,315.160	2,890.000	3,163.400	854.200	382.000	1,074.000
SUBTOTAL - INFLATED TO JANUARY 2008$ (millions)	1750.891	1048.696	1649.785	1554.902	869.837	1049.174	1498.847	2392.211	5417.525	6560.098	7180.697	1938.974	867.113	2437.905
DEFINITION PHASE ALLOWANCE	52.527	31.461	49.494	46.647	26.095	31.475	44.965	71.766	162.526	196.803	215.421	58.169	26.013	73.137
MITIGATION & COMPENSATION ALLOWANCE		36.704	57.742	54.422	30.444	36.721		83.727	189.613	229.603	251.324	67.864	30.349	85.327
TOTAL COST IN CONSTANT JANUARY 2008$ (millions)	1803.418	1116.861	1757.021	1655.971	926.377	1117.371	1543.813	2547.705	5769.664	6986.504	7647.442	2065.008	923.476	2596.369
ENGINEERING REQ'D PRIOR REGULATORY SCHEDULE Years	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
REGULATORY SCHEDULE Years	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
IMPLEMENTATION SCHEDULE Years	7.500	4.000	7.000	7.000	6.000	5.500	6.500	6.500	8.750	9.500	9.500	6.500	5.750	6.750
TOTAL DURATION TO FIRST UNIT IN-SERVICE Years	14.500	11.000	14.000	14.000	13.000	12.500	13.500	13.500	15.750	16.500	16.500	13.500	12.750	13.750
BALANCE OF IMPLEMENTATION TO LAST UNIT ISD Years	2.000	0.500	0.500	0.500	0.000	0.000	1.500	1.000	2.000	1.250	1.250	0.750	0.000	0.500
TOTAL LIKELY DURATION TO FINAL UNIT IN-SERVICE Years	16.500	11.500	14.500	14.500	13.000	12.500	15.000	14.500	17.750	17.750	17.750	14.250	12.750	14.250
BEST SCHEDULE (ESTIMATION) Years	15.500	10.500	13.500	13.500	12.000	11.500	14.000	13.500	16.750	16.500	16.500	13.250	11.750	13.250
WORST CASE SCHEDULE (ESTIMATION) Years	22.500	16.500	20.500	20.500	19.000	18.500	21.000	20.500	24.000	25.000	25.000	20.250	18.750	20.250

Note: All estimates are in millions. Costs do not include Transmission Costs, IDC, Corporate Overhead or future inflation.

Estimates were all taken from Engineering Reports most of which were completed in the early 1980's and inflated to Januarary 2008$ using the non-Residential Construction Seven City Composite Statistics Canada Price Index. Site E estimates were based on 1976 Feasibility Report and then adjusted to relect Site C design.

Allowances for Definition Phase and Mitigation and Compensation were added if left out of estimates. Definition Phase was estimated at 3% of Total Construction Cost and 3.5% for Mitigation & Compensation.

The estimated accuracy of these cost estimates is -25%/+75%. There is a great accuracy spread on these estimates because they are all based on work done in the 1970's and early 1980's .

The schedules have included an allowance of two years for Engineering required to begin the Regulatory Process, an allowance of 5years for the reulatory process based on Siobhan Jackson e-mail (Dec 10,2007) and construction schedules were based on past reports.

The schedule ranges are based on a willingness of the Provincial Cabinet to proceed with the project. Otherwise the ranges could be exceeded even more.