PEACE RIVER
SITE C CLEAN ENERGY PROJECT

REVIEW OF ALTERNATE SITES ON THE PEACE RIVER

Prepared by

Klohn Crippen Berger Ltd., SNC-Lavalin Inc. and Hatch Ltd.

For

BC Hydro

Report No. P05032A02-23-001
January 2011

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List of Acronyms

BCSQG	BC Sediment Quality Guidelines
PBPA	Boudreau Lake Protected Area
BCUC	British Columbia Utilities Commission
BCWG	British Columbia Water Quality Guidelines
CDA	Canadian Dam Association
CEAA	Canadian Environmental Assessment Act
CCME	Council of Canadian Ministers of Environment
4QA	Four Quadrants Analysis
GIS	Geographic Information System
GW.h	Gigawatt hour
HEC-RAS	Hydrologic Engineering Center River Analysis System
IR	Indian Reserve
IDF	Inflow Design Flood
IPEC	International Power and Engineering Consultants Limited
KCB	Klohn Crippen Berger Ltd.
MDE	Maximum Design Earthquake
MAF	mean annual flows
MDL	method detection limits
PCN	Peace Canyon Dam
PGA	peak ground acceleration
PMF	Probable Maximum Flood
RCC	Roller Compacted Concrete
SLI	SNC-Lavalin Inc.
TEM	terrestrial ecosystem mapping
THLB	Timber Harvesting Land Base
TSS	total suspended solids
WSC	Water Survey of Canada
WAF	weighted average flow

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EXECUTIVE SUMMARY

Studies of the hydroelectric potential of the Peace River valley between Peace Canyon Dam and the Alberta border commenced in 1958. Early studies reviewed the potential of five sites and included assessments of preliminary engineering, environmental and social issues. These studies of alternate sites culminated in 1978 with the selection of Site C, located 7 km southwest of Fort St John for detailed investigation.

From 2001 to 2006 several studies of alternates to Site C were undertaken.

The purpose of this study was to evaluate alternate means of developing the hydroelectric potential of the Peace River between Peace Canyon Dam and Site C. The intent was to undertake a comprehensive review of all previously indentified alternates and any new alternates using a consistent evaluation process..

The reservoir created by the Site C Project would create an 83 km long reservoir with a total water surface of about 9310 hectares at the maximum normal operating level of El. 461.8 m. The reservoir would extend back to Peace Canyon Dam and flood approximately 5340 hectares of land. In selecting alternates to the Site C Project, the following alternate types were considered to reduce the reservoir impacts:

- a single dam located upstream of the Moberly River to avoid impacts on that river for which it was recognized that not all of the available head between Peace Canyon Dam and Site C could be developed; and

- cascades of two or more dams lower than the Site C dam that would reduce the area of land flooded and develop all of the head between Peace Canyon Dam and Site C, for which it was recognized that the cost of the development would increase and energy efficiency would be less.

Single dam alternates considered were:

- a dam located at historically defined axes C1 or C2, 5.5 km and 3 km upstream of Site C, respectively; and

- a dam located just downstream of Wilder Creek, 11.5 km upstream of Site C.

Cascades of multiple dams considered were:

- a 15 m lower dam at Site C plus a dam located 66 km upstream;

- a low dam at Site C, with two other low dams located 22 km and 58.5 km upstream;

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- a low dam at Site C, with three other low dams located 18 km, 38.5 km and 60.5 km upstream; and

- a very low dam located 0.5 km downstream of Site C, with six other very low dams located 10 km, 23 km, 36.5 km, 52.5 km, 65 km, and 78.5 km upstream.

The current studies developed the characteristics of each alternate including: engineering parameters; the physical footprint during construction, reservoir filling and operation; and the capital cost and generation summarized as an energy cost ratio.

A multi-attribute decision making framework was developed to assess the six alternate projects relative to the Site C Base Case. This included:

- identifying the degree to which the physical environment, biological environment, socio-economic environment and functionality would be affected by each alternate relative to the Site C Base Case, and comparing these against one another;

- ranking and weighting the affects of each alternate on the physical environment, biological environment, socio-economic environment, and functionality, and comparing the relative differences between alternates and the Site C Base Case; and

- summarizing the footprint and energy cost ratio of each alternate relative to the Site C Base Case.

The assessment was peer reviewed by a senior manager from Manitoba Hydro International.

Four of the alternates, namely a dam at axis C1 or C2 and the three, four and seven dam cascades, were screened out from further analysis. They were screened out because the higher energy cost ratio resulting from increased project cost and/or less energy production, did not provide a decrease in the relative footprint ratio, whereas for the other alternates, with higher energy cost ratios, provide a decrease in the relative footprint ratio.

The ranking of the remaining alternates and their energy cost ratios were:

1. Site C 1.00;

2. Wilder Creek 1.38; and

3. Two dam cascade 1.55.

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Development of Wilder Creek upstream of the Moberly River would produce energy costing 38% more than the Site C Base Case, while development of the two dam cascade would produce energy costing 55% more.

A series of sensitivity analyses were performed on the three remaining alternates to determine whether changing the various weightings would materially change the rankings. The following weightings were considered:

- 40/60 and 60/40 between environment and functionality compared to 50/50 used in the initial screening;
- a range of weightings on the values of the aquatic resources up to the extreme of 100% relative to the other fish bearing courses and the aquatics sub-accounts, given 100% weighting relative to terrestrial, i.e. the other fish bearing courses terrestrial impacts have no value; and
- highly valuing valley bottom agriculture and Watson Slough (a wetland that would be flooded by the Site C Base Case and Wilder Creek).

The sensitivities that gave no weight to aquatic resources, other than the Moberly River, are unreasonable given the size of the Halfway River which provides habitat for bull trout, a blue–listed species of fish. However, the results of these sensitivities demonstrate that the conclusion is not sensitive to the weighting applied to the aquatic resources of the Moberly River.

Highly valuing valley bottom agriculture and Watson Slough did not change the conclusion, indicating that it is not sensitive to the weighting applied to the terrestrial resources.

In summary, the consultants that undertook the alternates study concluded that:

- there are no environmental factors that would eliminate an alternate;
- the relative differences in environmental impacts and functionality between alternates are small; and
- in their opinion, the small relative differences in benefits between the alternates do not justify the significantly greater costs.

In the opinion of the three organizations, the multi-attribute assessment has confirmed that Site C is the preferred means for developing the hydroelectric potential between Peace Canyon Dam and Site C.

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1. INTRODUCTION

1.1 Purpose

The first steps to develop the hydroelectric potential of the Peace River in British Columbia were taken in the 1950's. In addition to potential sites at Portage Mountain (the site of the W. A. C. Bennett Dam) and Peace Canyon, five other sites were identified between Peace Canyon and the Alberta border. As described in Section 2, studies of the five downstream sites culminated in the selection of Site C in 1978.

As described in Section 3, several reviews of alternates to the proposed Site C Project were undertaken between 2001 and 2006. These reviews evaluated the engineering and environmental issues to varying degrees of completeness.

The purpose of this study was to review the previous alternates studies, identify data gaps and complete a consistent analysis of feasible alternative means of developing the hydroelectric potential between Peace Canyon and Site C, taking into consideration environmental effects, safety, capital and operating cost, reliability, energy efficiency, constructability and schedule for construction.

1.2 Report Outline

This report:

- summarizes the chronology of the proposed Site C Project, including selection of the site;
- summarizes the reviews of alternates to the proposed Site C Project which were undertaken between 2001 and 2006;
- describes the selection of the alternates to the proposed Site C Project for this study;
- summarizes the regional geology, seismicity, hydrology, physical environment, biological environment, and socio-economic environment of the project area;
- describes the proposed Site C Project and the six alternates considered in this study;
- describes the multi-attribute decision making framework that was used to assess the six alternates relative to the proposed Site C Project;

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- describes the assessment of the alternates and the sensitivity analyses that were performed; and
- presents the conclusions of the evaluation.

1.3 Authorization

On 12 May, 2009, BC Hydro authorized Klohn Crippen Berger Ltd. (KCB), SNC-Lavalin Inc. (SLI) and Hatch Ltd. (Hatch) to provide an integrated team of engineering specialists (KCB and SLI) and environmental and socio-economic specialists (Hatch) to carry out a review of alternate sites on the Peace River that would assess the most effective way of developing the hydroelectric potential between Peace Canyon Dam (PCN[1]) and Site C by:

- screening alternates to determine those that are or may be feasible;
- evaluating potentially feasible alternates to the Site C Project;
- integrating financial, environmental and social factors into a multi-criteria decision making framework; and
- documenting the study with a report satisfying the requirement under the Canadian Environmental Assessment Act (CEAA) for an assessment of alternative means of carrying out the project.

[1] Peace Canyon Dam is referred to in this report by its three letter system abbreviation of PCN.

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2. HISTORY OF THE PROPOSED SITE C PROJECT

2.1 Selection of the Site C Location

2.1.1 1958 Identification of Potential Sites

In 1958, B.C. Engineering Co. Ltd. prepared a report[2.1] for the British Thompson – Houston Co. Ltd. on the Rocky Mountain Trench area and described four dam sites between PCN and the District of Taylor (Sites A, B, C and D). A subsequent investigation identified Site E near the Alberta border.

2.1.2 1967 Site Reconnaissance

A surface geological reconnaissance of the potential sites undertaken in 1967 by International Power and Engineering Consultants Limited (IPEC)[2.2] had indicated the order of geological preference in decreasing order of preference to be Site E, Site C, Site A, Site D and Site B. Site E was favoured because the more competent sandstones and siltstone of the Dunvegan Formation outcrop on both abutments. Sites D and B were the least favoured because of landslides that exist on the left abutment at both sites. Site C was preferred over Site A because it was estimated that less overburden would be found in the riverbed and on the right bank.

2.1.3 1972 IPEC Feasibility Study

Following the completion of the W.A.C. Bennett Dam in 1968, BC Hydro commissioned IPEC, in 1972, to conduct an engineering feasibility study of the power potential of the Peace River between the proposed PCN[2] project and the Alberta border[2.3].

The location of the sites is shown in Figure 2-1 and the distances relative to PCN and the Alberta border are:

Site	Approximate Distance Downstream of Peace Canyon Dam	Approximate Distance Upstream of Alberta Border
Site A	52 km	95 km
Site B	62 km	85 km
Site C	79 km	68 km
Site D	95 km	52 km
Site E	145 km	2 km

[2] PCN is referred to in earlier reports as Site 1.

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The reach of the Peace River from the PCN to the Alberta border falls 79.2 m from El. 461.8 m at the tailrace of PCN to El. 382.5 m at the Alberta border. The 1972 IPEC study investigated the development of the available head between PCN and the Alberta border by either a single high dam near the border at Site E or two low dams, one near the border at Site E and the other between PCN and the border at either Site A, B, C or D.

If the available head between PCN and the Alberta border was developed with two low dams, the reservoir level of the downstream dam would be set at the tailwater level of the upstream dam. With the downstream dam at Site E and the upstream dam at either of Sites A or B, the reservoir level at Site E would be higher than with the upstream dams at Sites C or D. With the Site E/Sites A or B combinations, a major part of the highway bridge at Taylor would be inundated which would require complete reconstruction of the bridge. With the Site E/Site C combination, there would be limited flooding of one pier of the bridge which could be addressed by raising the south end of the bridge by approximately 3 m.

As complete reconstruction of this major bridge would be costly and as Sites A and B were not geologically or topographically more attractive than Site C, they were eliminated from further consideration in the 1972 IPEC study.

Flooding of the bridge at Taylor would be avoided with the Site E/Site D combination. However, Site D was geologically unattractive because of landslides on the left bank and topographically unattractive because of the relatively long crest length. Preliminary cost estimates for the Site E/Site C and Site E/Site D combinations indicated that the Site E/Site D development would be more costly than the Site E/Site C combination, and on this basis the 1972 IPEC report concluded that Site C would be the best site for the upstream dam.

Subsurface exploration at Sites C and E were carried out in 1971. The location of Site C in the 1972 IPEC study corresponds to the axis currently known as axis C1 (upstream of the confluence with the Moberly River, see Figure 2-2). Seven holes totaling 220 linear metres were drilled at Site C and six holes totaling 200 linear metres were drilled at Site E. Based on the geological and topographic data obtained from these investigations, the selected layout for Site C comprised a concrete gravity dam across the river channel containing the power intakes and spillway with earthfill dams on both abutments. The selected layout for a low dam at Site E comprised of an earthfill dam across the river with the spillway and power intakes in a channel in the right abutment. The selected layout for the single high dam option at Site E was also an earthfill dam across the river with the spillway and power intake in a channel in the right abutment.

Power studies were carried out for both the two dam combination and the single, high dam option. For the Site E/Site C combination, the maximum normal reservoir levels would be at El. 414.5 m and El. 461.8 m, respectively. The

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proposed installed capacity at the two sites was 750 MW at Site E and 900 MW at Site C. For the single high Site E option, the maximum normal reservoir level would be at El. 461.8 m and the proposed installed capacity would be 1800 MW. With the reservoir level at El. 461.8 m, the highway bridge at Taylor would have to be reconstructed approximately 52 m higher, the railway bridge across the Peace River near Fort St. John would have to be reconstructed approximately 43 m higher, and other highways, bridges, gas pipeline bridge crossings of the Peace River would have to be relocated or reconstructed.

The conclusions of the 1972 IPEC study were that it appeared to be technically feasible to develop the 79.2 m of head on the Peace River between PCN and the Alberta border with either a single dam option near the Alberta border or with two low dams, one near the Alberta border and the other between this dam and PCN. The best site for a single dam development was at Site E and the best sites for the two dam option were at Sites E and C. Although the single high Site E option was more economic than the two dam option, neither of the two options studied appeared to have any significant advantage over the other and it was recommended that the possibility of selecting better axes at Site E and at Site C should be investigated further.

2.1.4 1976 BC Hydro Feasibility Study

In 1976, further studies were completed at Sites C and E on the Peace River[2.4]. These included additional subsurface investigations and alternate locations for the two dam sites.

Two potential alternate axes for Site C that were identified in the 1972 IPEC study were investigated in 1976 -- axis C2, located immediately upstream of the confluence with the Moberly River, and axis C3, located about 0.8 km downstream of the Moberly River confluence. The locations of these axes are presented on Figure 2-2a.

The location of the dam at Site E identified in the 1972 feasibility study[2.3] was designated axis E-3 in the 1976 feasibility study. Three additional axes at Site E were studied in 1976; axis E-4 located about 0.5 km upstream of axis E-3; axis E-5 located about 4 km upstream of axis E-3 at the confluence of the Alces River; and axis E-6 located below the confluence of the Alces River, about 1.9 km upstream of axis E-3. The locations of these axes are presented on Figure 2-2b.

For Site C, axis C3 was selected as the preferred axis for the following reasons:

- the overburden on the abutments was less than on axes C1 and C2;
- the abutments appeared to be to more stable at axis C3; and

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- both abutments were protected by terraces from potential slides originating above the crest of the proposed dam.

During 1976, the preliminary exploration program at axis C3 consisted of eleven NQ diamond drill holes totaling 515 m, one 0.9 m diameter hole 27 m deep, trenching and excavating two exploratory adits, one 27 m long and one 61 m long.

A concrete gravity dam similar in design to PCN was envisaged at Site C, although the structures would be somewhat more massive due to the foundation conditions.

For Site E, axis E-6 was selected as the preferred axis for the following reasons:

- the absence of slide debris or deep colluvium would provide better geological conditions on the left abutment;

- greater protection from potential slides originating from the steeper slopes above the dam site would be provided by the sloping terrace on the left bank;

- the terrace on the right bank is wider, which would require less excavation to locate the powerplant and spillway on the right bank of the river channel where the bedrock is not excessively deep; and

- axis E-6 is upstream of the ecological reserve on the left bank, in which axis E-3 is partially located.

The study concluded that although it was feasible to construct the single high Site E dam on axis E-6, severe engineering problems associated with the poor foundation conditions and the extensive relocations of infrastructure upstream of the dam would result in a relatively higher capital cost. The development of the head on the Peace River between PCN and the Alberta border with two low dams at Sites C and E would be marginally more economic and environmentally less disruptive than with a single high dam at Site E. It was recommended that the option of a high dam at high Site E should not be studied further.

2.1.5 1978 Preliminary Design Study – Phase 1

The site exploration program at axis C3 continued in 1977 and 1978, and consisted of 29 HQ diamond drill holes totaling 2327 m, four 0.9 m diameter holes, trenching, extending the lower exploratory adit and 14 holes drilled in the overburden totaling 479 m. Large scale in-situ testing of the rock was performed in the adits. This work indicated that the foundation rock has a lower strength, particularly parallel to bedding, than previously indicated. As investigations continued and a better understanding of the foundation characteristics was obtained, it became evident that a concrete gravity structure across the river bed

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would not be practical on the shale bedrock but that an earthfill dam could be designed to close the main river channel.

In 1978, preliminary design work[2.5] confirmed axis C3 as the best location for the Site C Project. In addition to the reasons identified in the 1976 feasibility study, it was found that the terrace on the right abutment provides an advantageous natural location for high level spillway headworks and power intake structures. The limitations of the foundation bedrock made it necessary to locate these principal structures at a high level to minimize the hydraulic loading due to the reservoir. The terrace would minimize the excavation for these structures and their forebay channels.

The selected arrangement consisted of three diversion tunnels under the left bank, an earthfill dam across the main river channel and an approach channel on the right bank terrace to convey water from the right bank to the power intakes and spillway headworks. The powerhouse was located at the toe of the right bank terrace parallel to the river with the power intakes forming an oblique angle with the spillway headworks.

2.2 1981 Preliminary Design Study – Phase 2

Following selection of the general locations of the dam axis and the principal structures during the first phase of the preliminary design, further work during the second stage[2.6] concentrated on detailed investigations of the foundation conditions, and studies to further optimize the arrangement and alignment of the project structures. On the right bank, foundation investigations, hydraulic and layout studies were directed at determining the arrangement and alignment of the approach channel, spillway, power intakes, penstocks and powerplant for security, hydraulic characteristics and economic construction. Other investigations and studies were directed at determining the optimum location and length of the diversion tunnels, orientation of the earthfill dam, stabilization of the left (north) bank, alignment of access roads and location of areas for the relocation of surplus excavated materials.

Work included preparation of the project description in the environmental impact statement[2.7] which was presented to the BC Provincial Government in September 1980 to support the application for an Energy Project Certificate for Site C.

The 1981 design comprised a zoned earthfill dam with the power intakes and spillway on the right abutment. This layout was different from the layout developed in 1978 as the powerhouse was now located on the right bank terrace adjacent to the spillway. The 1981 location and layout for Site C are presented in Figures 2-3 and 2-4.

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2.3 BCUC Review of Proposed Site C Project

In 1981 the BC Provincial Government referred BC Hydro's application to the British Columbia Utilities Commission (BCUC) for review. In 1983, the BCUC released a report[2.8] on its review and recommended to the BC Provincial Government that an Energy Project Certificate not be issued for Site C, and subsequently the Lieutenant-Governor in Council denied the application by BC Hydro for an Energy Project Certificate for the Site C Project.

The BCUC also recommended to the BC Provincial Government that the flood reserve downstream of Site C be cancelled. The BC Provincial Government cancelled this flood reserve in 1985[2.9].

2.4 Preliminary Engineering Activities 1989 to 1991

In 1989, the potential need for new supply before 2000 was identified. BC Hydro revisited the prospect of proceeding with Site C and began further preparatory work on the project.

At the time, BC Hydro had decided to transfer engineering design to the private sector. Following a competitive selection process, a joint venture of Klohn-Crippen Consultants Ltd. (now Klohn Crippen Berger Ltd. or KCBL) and Shawinigan Integ (which was subsequently acquired by SNC Lavalin Inc. or SLI) were selected as prime consultants for Site C. Their mandate was to prepare tender designs for the early contracts; undertake studies and investigations to advance the design of major structures; and to review, modify as necessary, and accept responsibility for the preliminary design by BC Hydro.

Preparatory engineering activities for Site C commenced in 1989 and continued into 1991. In March 1991, a decision was made to suspend engineering and other work as opportunities for demand-side management and gas-fired generation appeared to be more attractive ways to meet the power demand.

At that time work had been advanced on the diversion tunnels, left bank excavation and earthfill dam but no significant work had been done on the right bank structures, which remained at a very preliminary layout stage.

2.5 2001 Resource Plan

In preparation for the 2001 resource plan, the scope of the Site C Project was reviewed, including regulatory requirements, updating project costs and the overall project schedule, as well as a consideration of alternate sites to develop the hydroelectric potential between Peace Canyon and Site C. After completion of the first year of work, the review and resource plan was cancelled and further work on Site C was postponed.

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2.6 2004 Integrated Electricity Plan

In March 2004, BC Hydro filed the 2004 Integrated Electricity Plan, which concluded that the Site C Project was technically sound with significant investigation and design, and recommended that the project be maintained as an option as it is economic and the portfolio NPV results are relatively insensitive to different gas and electricity price scenarios.

2.7 Stage 1: Review of Project Feasibility

BC Hydro adopted a staged decision-making process for the Site C Project, which allows for multiple decision-making points during project development and helps to control costs by focusing on deliverables and objectives at each stage.

The first stage was undertaken to summarize existing studies and historical information about the proposed Site C Project, review the feasibility of the project, and to determine whether it is in the best interests of BC Hydro customers to move to the next stage of project planning and development.

The review concluded that the proposed Site C Project is feasible, should continue to be examined as a potential resource option, offers sufficient overall benefits relative to the alternatives to justify further investigation, and further work on Site C provides information to guide decisions regarding Site C compared with other future resource alternatives[2.9].

2.8 Stage 2: Project Definition and Consultation

Stage 2 commenced in the fall of 2008 with pre-consultation. Two rounds of public consultation on the potential project took place in Stage 2, in addition to pre-consultation, which concluded in February 2009.

Project Definition Consultation, Round 1 was conducted from May 1 to June 30, 2008 and consulted local, regional and provincial stakeholders on key impacts, benefits and features of the potential Site C Project. The consultation sought feedback on Site C as an energy option, community and provincial benefits, project design elements, recreation, infrastructure, environment and land uses.

Project Definition Consultation, Round 2 took place from October 1 to December 3, 2008 and built on stakeholder input from Project Definition Consultation, Round 1 and Pre-Consultation. Round 2 Consultation sought feedback on Site C as an energy option, the potential powerhouse access bridge and associated access roads, provincial and community benefits – other potential infrastructure improvements, reservoir preparation considerations, sourcing dam construction materials, and relocation and reclamation of excavated soil and rock, and environment.

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In addition, Stage 2 involves extensive environmental, engineering and technical work to further define the project, to update decades-old studies, and to conduct new studies and technical work.

As part of the engineering work, it was decided to update the previous reviews of alternates to the proposed Site C Project as they had evaluated the engineering and environmental issues to varying degrees of completeness. This report presents the results of that assessment of alternates.

2.9 References

2.1 B.C. Engineering Co. Ltd., "Report on Rocky Mountain Trench Area Hydro-Electric Investigation, Stage I", report for the British Thomson-Houston Co. Ltd., September 1958.

2.2 International Power and Engineering Consultants Limited internal report by R. Eastman, "Peace River Development, Sites A – E, Summary of Field Observations", May 1967.

2.3 International Power and Engineering Consultants Limited, "Peace River Area – Power Development Studies between Site 1 and Alberta Border – Feasibility Study", for British Columbia Hydro and Power Authority, July 1972.

2.4 BC Hydro, "Peace River Sites C and E, Feasibility Study", Report No. 796, May 1976.

2.5 BC Hydro, "Peace River Site C Preliminary Design Study Phase 1", Report No. 869, December 1978.

2.6 BC Hydro, "Peace River Site C Preliminary Design Study Phase 2", Report No. H1358, May 1981.

2.7 BC Hydro, "Peace Site C Project, Environmental Impact Statement", Report No. SE 7910, July 1980.

2.8 British Columbia Utilities Commission, "Site C Report, Report and Recommendations to the Lieutenant Governor-in-Council", May 1983.

2.9 BC Hydro, "Peace River Site C Hydro Project, Site C Feasibility Review: Stage 1 Completion Report", December 2007.

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3. PREVIOUS REVIEWS OF ALTERNATIVES TO SITE C

During the period 2001 to 2006 when BC Hydro was reconsidering the Site C Project as an option, four reviews of alternative means of developing the hydroelectric potential between PCN and Site C were undertaken. These reviews ranged in level from a three day workshop to prefeasibility studies. The following section describes these reviews and summarizes the key findings of each. Three reviews were based on using a cascade of lower dams and included a cascade of low dams similar to that being considered at the Dunvegan site on the Peace River in Alberta. One of the reviews was based on a single dam constructed upstream of the Moberly River.

3.1 Alternative Development Options Workshop 2001

Engineers from BC Hydro, KCBL and SLI took part in a two day workshop to consider alternative development options to the Site C Project which would develop the full head between PCN and Site C. No official report was published from the workshop and the following summary is derived from workshop notes prepared by Mr. John Nunn, P. Eng.[3.1].

The following two alternatives to Site C were identified:

- two dams of similar height, one at Site C and the other just upstream of the confluence of the Halfway and Peace Rivers; and

- a cascade of eight (8) low weirs with integrated powerhouse and spillway (similar to the proposed development at Dunvegan in Alberta).

Factors that were considered included: major technical issues and risks (including reliability of available information), economic considerations (including power generation), costs and socio-economic, and environmental issues.

The review deemed the two dam option to be uneconomic and recommended it be eliminated from further consideration.

The cascade of low weirs was thought to be a potentially viable option for developing the head between Peace Canyon and Site C. For this option to be economic however, the structures would need to:

- be low enough to qualify as low consequence category structures under the Canadian Dam Association (CDA) Dam Safety Guidelines, which would permit lower flood and seismic design criteria compared with requirements for a single large dam at Site C, and

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- be sufficiently short to accommodate all the required structures within the valley bottom.

Due to the very low confidence level in the cost and power generation estimates for the eight weir cascade, the workshop participants recommended that additional studies be carried out to improve the confidence level of the estimates for cascade development options with varying numbers of weirs that would meet the above mentioned criteria.

3.2 2002 Cursory Evaluation of Cascade Options

Commencing in October 2001, BC Hydro's Power Supply Engineering group undertook a cursory evaluation of several cascade options for developing the head between PCN and Site C[3.2].

The evaluation utilized existing information from previously completed reports, including a draft cost estimate update for Site C available at that time. While information for the proposed location of the Site C dam was readily available, information for the additional sites required for the cascade option was very limited.

Two, three, four and nine stage developments were considered. The nine stage development, based on technology proposed for the low head Dunvegan project on the Peace River in Alberta, was concluded to be inappropriate for the development of the full potential of the Peace River between PCN and the proposed Site C dam.

The locations of each dam for the two, three and four stage developments were selected to give equal heads across each dam. Sites were selected based on river morphology, cross sectional uniformity and the evaluation concept which considered that the flows through the cascade would be highly regulated. The total flow used for generation would be close to that estimated for the proposed Site C dam. The cascade development reservoirs were assumed to operate at full supply level and as run-of-river projects with daily/short term storage. Each of the staged developments considered one site located in the vicinity of Site C.

The evaluation developed project layouts (including spillway and powerhouse arrangements) for the two, three and four stage developments. Reservoir area flooding of overbank areas was concluded to be significantly less for the cascade option than that for Site C, although there was thought to be little reduction in flooding of agricultural land with a cascade development involving less than three dams.

Cost estimates were compiled for the various cascade developments and an economic evaluation conducted based on comparing average unit energy generation costs for the cascade options with that of the single stage Site C

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development. This evaluation did not take into account the peaking vs. non-peak generation. The comparative unit energy costs for the two, three and four stage cascade developments were found to be 20% to 90% higher than for Site C, with the cost increasing with the number of dams.

The evaluation concluded that a traditional cascade could be of interest for several reasons, particularly the reduction in flooded land and the potential for competitive unit energy generation costs, and that this type of development should therefore be studied in more detail.

3.3 Cascade of Low consequence Structures 2003

During 2002, KCBL and SLI undertook a prefeasibility study for a cascade of low consequence structures on the Peace River as an alternative to Site C[3.3].

Several aspects of the project were carried out in conjunction with BC Hydro, including the effects of the cascade on ice development and evaluation of socio-economic and environmental impacts.

The hydrology, geology and mapping of the river reach were reviewed to identify appropriate sites for a multi-stage cascade development. Seven sites were selected for further consideration in a cascade scheme that would develop a gross head at each site ranging from 5.4 m to 7.5 m.

An important objective of the study was to define facilities with a “Low” Consequence Category as defined by the CDA, so that the design flood and design earthquake would be relatively small and the cost of the overall development could be kept as low as possible.

The design criteria selected were:

- Inflow Design Flood (IDF) with a probability of 1 in 1000 occurring in any year;
- Maximum Design Earthquake (MDE) with a probability of 1 in 1000 occurring in any year; and
- the cascade development should cause no incremental loss of life and only “moderate” incremental socio-economic, financial and environmental damages if one of the dams of the cascade were to fail.

The study found that a cascade of seven dams and seven generating stations would satisfy this intent, with one proviso. Dam break analyses were carried out and it was found that failure of any one dam would not cause overtopping of the downstream dams in the cascade. Breach waves would attenuate substantially with distance downstream and no large impacts were anticipated downstream of the cascade in the event of a failure of one of the dams. Although no loss of life

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was expected, confirmation was required to ensure that economic consequences of failure would meet BC Hydro criteria for “Low” Consequence Category dams.

The criteria for unit selection included the following:

- the average gross head would be about 7.5 m, so propeller or Kaplan units would be the appropriate unit type, available from several manufacturers in the following configurations: bulb turbines; pit turbines; and tubular turbines, predominantly S-turbines;

- the design flow was taken as 2000 m^3/s, which was the maximum power flow discharged from the Peace Canyon powerhouse, with the number of units increased downstream of the Halfway River to account for the additional inflow from that source;

- the largest standard units were selected from manufacturer’s data to minimize powerhouse length and the number of units to maintain; and

- preference was given to direct drive generators, rather than with the use of speed increaser gearboxes, for higher efficiency and lower maintenance.

After evaluation of the data from the manufacturers, the Voith Siemens 8 MW S-turbine was selected for the conceptual design of the plants.

A typical generating unit was selected for the cascade development and layouts were generated for a typical powerhouse, service bay, switchyard, spillway, navigation lock, fish way and transition block. These standard components were laid out to suit the topography, hydraulics and diversion requirements of each site. Power transmission was examined, including development of preliminary switchyard layouts and transmission line routing.

Power studies were carried out to examine the potential for energy generation from the cascade development. These included studies based on monthly average flows, as well as studies of the effect of daily and diurnal flow variations (using hourly flows). The effect of synchronizing cascade generation with Peace Canyon generation was also considered. These studies showed that the cascade scheme would develop an annual average energy in the order of 4035 GW.h (or about 86% of the 4710 GW.h anticipated from Site C).

Cost estimates were prepared for each site of the cascade. It was found that the total cost of developing the cascade would be in the order of 1.8 times the cost of developing Site C (based on BC Hydro’s 2001 estimate of the cost of Site C).

Environmental and socio-economic impacts of the Peace Cascade Development were considered in relative terms. The study determined that the cascade would

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have a significantly lower environmental impact than would the Site C development, while socio-economic impacts of the two options would be similar.

Based on the lower generation and higher cost, the energy cost from the cascade would be about 2.1 times the cost of energy from Site C (1.8/0.86).

3.4 Review of Axes C1 and C2 2006

In May 2006, at BC Hydro's request, KCBL and SLI undertook an overview level, order of magnitude assessment of the changes in cost and schedule, both positive and negative, of relocating the dam axis for the Site C Project upstream of the Moberly River to one of the previously considered axes known as C1 and C2[3.4]. The existing axis established downstream of the Moberly River was referred to as Site C.

A key assumption of the assessment was that the project layout and structural dimensions established for Site C would be the same for the purposes of evaluating project arrangements at axes C1 and C2.

The assessment considered the history of selecting the Site C axis, the stability of the valley slopes and the general topography of the sites. In addition, simplified geological sections were developed for axes C1 and C2 in order to assess and document order of magnitude changes to the major quantities that would result by moving Site C to one of the upstream axes. Changes to the average annual energy generation as a result of lower heads and flows at the upstream axes locations were evaluated in this assessment. A number of risk factors related to topography and geology, which would likely result in cost increases, were also identified.

The key findings of the assessment were that moving the Site C axis to one of the upstream axes known as C1 or C2 would:

- significantly increase the volume of excavation and volume of earthfill required for the dam;
- reduce average annual energy generation by approximately 5 – 8%;
- nearly double the direct cost of the project; and
- increase the schedule by approximately 5 years.

The total project capital cost at one of the upstream axes was expected to more than double compared to Site C and it was the opinion of the authors that due to the adverse topography and geology, it would not be possible to develop a project layout and design at the upstream axes that would have a similar cost to Site C.

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An overview assessment of the environmental implications of moving the project upstream of the confluence with the Moberly River was undertaken[3.5]. This assessment included the implications to fish, wildlife, archaeological resources, and First Nations. The assessment also included a professional opinion, based on available information, on the uniqueness of the Moberly River system and its potential for fisheries compensation/enhancement projects.

3.5 References

3.1 Nunn, J., Personal notes taken from two day workshop, "Alternative Development Options – Peace Canyon to Site C", 2001.

3.2 BC Hydro, "Peace River Development, Preparatory Activities for Site C Project, Cursory Evaluation of Cascade Option", Report No.E77, November 2002.

3.3 Klohn Crippen Consultants Ltd. & SNC-Lavalin Inc., "Peace Cascade Development, Prefeasibility Study for a Cascade of Low Consequence Structures as an Alternative to Site C", Report No. 186 PP1448-02-01, January 2003.

3.4 Klohn Crippen Berger Ltd. & SNC-Lavalin Inc., "Peace River Development Site C Project, Review of Upstream Axes", Report No. 5032A01 02, May 2006.

3.5 Golder Associates, "Overview of Relocation of Site C Dam", Draft Report, March 2006.

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4. SELECTION OF ALTERNATES

4.1 Summary

An extensive review was undertaken to identify all possible feasible alternates to Site C. Based on the review described below, the following alternates to the Site C Project as shown on Figures 2-3 and 2-4 (the Site C Base Case) were selected:

- a single dam located upstream of the Moberly River at the more favourable of axes C1 and C2;
- a single dam located at Wilder Creek approximately 11.5 km upstream of Site C;
- two dams with a 15 m lower dam at axis C3 and a 15 m high dam located 66 km upstream;
- a cascade of three equal height dams;
- a cascade of four equal height dams; and
- a cascade of seven dams.

4.2 General

The reservoir created by the Site C Project would create an 83 km long water body and flood approximately 5340 hectares of land to create a total water surface of about 9310 hectares at the maximum normal operating level of El. 461.8 m. The water depth at the dam would increase by 52 m from the current river level. The hydroelectric potential that would be developed by the Site C Project is the mean annual flow of 1251 m^3/s and gross head of 50.8 m.

In selecting alternate means of developing the hydroelectric potential of the Peace River between PCN and Site C, the following alternate types were considered to reduce the reservoir impacts:

- a single dam located upstream of the Moberly River to avoid impacts on that river but which would not be able to develop all of the head between PCN and Site C; and
- a cascade of two or more dams lower than the Site C dam that would reduce the area of land flooded and develop all of the head between PCN and Site C.

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For a cascade alternate, increasing the number of dams lowers the height of each dam and thus reduces the area for land flooded, however; increasing the number of dams and powerhouses increases the cost of the development.

4.3 Single Dam Alternates

A topographically suitable potential site was identified in the vicinity of Wilder Creek upstream of the confluence of the Moberly and Peace Rivers, where terraces are located on each bank of the river not far above the Site C reservoir level. At Wilder Creek, the mean annual flow is 1240 m^3/s and the gross head is about 44.4 m at the mean annual flow, resulting in about 87% of the hydroelectric potential of Site C. For the purpose of this study, which was to assess the most effective way of developing the hydroelectric potential between PCN and Site C, Wilder Creek was considered to be the upstream limit for the construction of a single dam.

As shown on Figure 4-1, the terraces terminate downstream of the Wilder Creek reach. From there to the Moberly River, the slopes of the valley go from the river level up to the plateau. Historically, two axes (C1 and C2) were identified between Tea Creek and the Moberly River. In this section of the Peace River, the south side of the valley is a relatively flat vegetated slope, formed for the most part by inactive slumps and river terraces; while the north side of the valley is steeper, less vegetated and is actively eroding and slumping.

One of the flat slopes on the south side of the valley appears to be formed by colluvium from a landslide in the shale. Many of the slumps on the north bank seem to be associated with a white clay layer which is located at about El. 432 m. At axes C1 and C2, the north bank rises steeply for nearly 230 m to the plateau at about El. 640 m. The lower part of the south bank has a relatively flat slope to El. 490 m and then rises steeply to the plateau at about El. 625 m. At these two axes, the valley walls would be up to 170 m above the crest of a dam.

No other suitable dam sites were identified between Wilder Creek and Site C either historically or in this study. Therefore the following single dam alternatives were selected:

- Site C (historically sometimes referred to as C3 as it was the third site evaluated for Site C), which is the base case that the other alternates will be compared to and referred to hereafter as the Site C Base Case, or Site C;
- the better of Sites C1 and C2; and
- Wilder Creek.

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Each single dam alternate would have a maximum normal reservoir level of El. 461.8 m as proposed for the Site C Base Case.

4.4 Cascade Alternates

4.4.1 Two Dams

As described in Section 3.2, the locations of the dams in the two stage development considered in 2002 were selected to give equal head across each dam. Each dam would have developed a net head of 24.8 m; the downstream dam located at Site C would have had a reservoir level at El. 437 m and the upstream dam would have had a reservoir level at El. 461.8 m. As shown in Figure 3-1, the upstream dam would have been located just downstream of the confluence of the Halfway and Peace Rivers opposite the Attachie Slide. There is evidence that a number of large landslides have occurred on the south bank of the Peace River near the confluence. The last of these, the 14 million m^3 Attachie slide which occurred in 1973, blocked the Peace River for about 18 hours. Construction of a dam in the vicinity of the Attachie Slide is not considered desirable.

Both of the dams in the two dam cascade shown in Figure 3-1 would be constructed on the Shaftesbury shale which is a relatively weak rock, and each dam was assumed to be similar to the Site C Base Case with earthfill dams and similarly sized spillway, power intakes powerhouse, etc.

PCN is constructed on rocks of the Gates Formation which provide better dam foundations. Therefore, the upstream dam location selected for the two dam cascade in this study was near the downstream end of the Gates Formation to maximize the head on the better foundations. The selected location is close to the location for the second dam previously selected for the seven dam cascade described in Section 3.3; therefore the two dam cascade is referred to as 7b/Low C3 (Figure 4-2).

4.4.2 Three Dams

As described in Section 3.2, the locations of each dam in the three stage development considered in 2002 were selected to give equal heads across each dam. Each dam would develop a net head of 16.5 m, and the downstream dam located at Site C would have a reservoir level at El. 428.7 m, the middle dam would have a reservoir level at El. 445.3 m, and the upstream dam would have a reservoir level at El. 461.8 m.

All three dams in the three dam cascade shown in Figure 3-2 would be constructed on the Shaftesbury shale and each dam was assumed to be similar to the Site C Base Case with earthfill dams and similarly sized spillway, power intakes powerhouse, etc.

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The arrangement shown on Figure 3-2 was selected as the three dam cascade for this study.

4.4.3 Four Dams

As described in Section 3.2, the locations of each dam in the four stage development considered in 2002 were selected to give equal heads across each dam. Each dam would develop a net head of 12.4 m. The downstream dam located at Site C would have a reservoir level at El. 424.6 m, the second dam would have a reservoir level at El. 437 m, the third dam would have a reservoir level at El. 449.4 m and the upstream dam would have a reservoir level at El. 461.8 m.

All four dams in the four dam cascade shown in Figure 3-3 would be constructed on the Shaftesbury shale and each dam was assumed to be similar to the Site C Base Case with earthfill dams and similarly sized spillway, power intakes powerhouse, etc.

As shown on Figure 3-3, dam 4b would be located just downstream of the confluence of the Halfway and Peace Rivers. This is not a desirable location due to the proximity to potential landslides from the Attachie area. A large, rapid slide at Attachie would generate a large wave on the reservoir. Hydraulic model testing undertaken for the design of the Site C Base Case[4.1] showed that a wave generated by a landslide from Attachie would attenuate fairly quickly as it travelled along the reservoir. This indicates that it would be feasible to locate a dam downstream of Attachie, provided that the dam was located far enough away from the potential landslide for the wave to attenuate sufficiently, and that the freeboard provided on the dam would prevent overtopping of the dam by the wave. This could require moving the dam a kilometre or so downstream, which would not materially affect the results of the study.

The arrangement shown on Figure 3-3 was selected as the four dam cascade for this study.

4.4.4 Seven Dams

Section 3.3 describes the conceptual design of a series of seven small hydroelectric developments in a cascade between PCN and Site C developing gross heads from 5.4 m to 7.5 m. It also describes the requirements for the "Low" Consequence Category as per the CDA guidelines.

Early in this study of alternates, BC Hydro advised that, due to the magnitude of the investment that would be required to construct the seven dam cascade and the financial, environmental and social consequences of the loss of a dam in the cascade, it would not be acceptable to design the cascade to the "Low" Consequence Category. Instead, the seven dam cascade should be designed

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for the same natural hazards as the Site C Base Case, namely the Probable Maximum Flood (PMF) and a MDE with a 10,000 year annual probability.

As described in the 2003 study[4.2], the water surface profile used in the selection of the sites was taken from work done in 1976 and the backwater curves upstream of each dam computed at a flow of 1100 m^3/s. More recent, but incomplete, river profile data obtained late in the study departed significantly from the water surface profile used for site selection in some areas. The most significant differences in the more recent profiles were in the vicinity of Attachie Slide; at high flows the profile was similar to the 1976 profile, while at lower flows there was a far more uniform river gradient past the slide toe. It was considered that this difference could simply be a result of changes to the river morphology in the period between the original profile survey and the later aerial photography used to derive the more recent profiles, as the 1976 survey was done three years after the Attachie Slide had formed a natural dam across the Peace River. The 2003 study noted that if the river profile had changed in the manner suggested by the new profiles, it would affect the gross heads and dam heights at the individual sites and dam 7d would have to be relocated downstream of the Halfway River confluence.

As described in Section 6.5, a new river profile was prepared from LiDAR[3] data as part of this study of alternates. Based on this new river profile, dam 7d was moved downstream to develop as much of the head as possible. The arrangement shown on Figure 4-3 was selected as the seven dam cascade for this study.

4.5 References

4.1 Northwest Hydraulic Consultants Ltd, “Peace River Site C Project, Model of Landslide Waves at Attachie and Bear Flat Areas”, June 1983.

4.2 Klohn Crippen Consultants Ltd. & SNC-Lavalin Inc., “Peace Cascade Development, Prefeasibility Study for a Cascade of Low Consequence Structures as an Alternative to Site C”, Report No. 186 PP1448-02-01, January 2003.

[3] LiDAR (Light Detection and Ranging) is a remote sensing technology that measures the distance to the surface using laser pulses.

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5. REGIONAL GEOLOGY AND SEISMICITY

5.1 Geology

5.1.1 Overburden

The overburden in the area is the product of in-situ weathering of parent rocks, glacial deposits and alluvial deposits within the Peace River and its tributaries riverbeds. The weathered parent rocks typically classifies as medium to high plasticity silt.

Glacial deposits are exposed along the Peace River and consist mainly of sand, gravel and cobbles in a silty sand matrix, as well as glaciolacustrine silts and clays deposited in lakes created by glaciers.

The riverbed contains very coarse alluvial deposits of sand, gravel, cobbles and boulders, which range in depth up to 10 m.

5.1.2 Bedrock

Between PCN and approximately river marker[4] 41.5, rocks of the Gates Formation are exposed as islands and along the bed and banks of the Peace River. Downstream of river marker 41.5, rocks of the Shaftesbury Formation are exposed along the banks of the Peace River. The estimated contact between the Gates Sandstone and the Shaftsbury Formation is shown on Figure 10-16. In some locations, Dunvegan Sandstone overlies and forms a resistant cap to the Shaftsbury Formation.

Both the Gates Formation and Shaftsbury Formation are marine sedimentary sequences of dark grey, fine grained, very thinly bedded siltstone, shale and sandstone. The bedrock has a regional dip of about 1° northeast, although local variations of 1 or 2 degrees from this regional dip are common.

In general, the shale readily exfoliates and crumbles on exposure to air and water. The bedrock is cut mainly by 3 sets of fractures which are characteristic of valleys eroded in flat-lying, weak sedimentary rocks, namely:

- fractures of softened rocks parallel to bedding;
- steep relaxation fractures parallel to slopes; and
- low angle shear zones of limited displacement.

[4] River markers are the distance in kilometres downstream of W.A.C. Bennett Dam measured along the river.

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The characteristic strengths of the Gates Formation are:

- cross bedding: cohesion = 2068 kPa and friction angle = 50°; and
- along bedding: cohesion = 0 and friction angle φ = 40°.

The characteristic strengths of the Shaftesbury Formation are:

- cross bedding: cohesion = 250 kPa and friction angle = 45°; and
- along bedding: cohesion = 0 and friction angle φ = 10° to 13.5°.

The strength of the Shaftesbury Formation along bedding is controlled by the presence of shears, clay layers and other discontinuities parallel to the bedding.

The rocks of both formations have very low permeabilities, but the Gates Formation is considered to provide better foundations for hydroelectric structures than the Shaftesbury Formation due to its higher strength.

5.2 Seismicity

An interim seismic hazard assessment undertaken in 2008 and 2009 as part of the Site C Stage 2 engineering studies established a mean peak ground acceleration (PGA) of 0.23g for the MDE, which has a 10,000-year annual exceedance probability.

The Site C MDE was assumed to apply to all of the alternates.

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6. HYDROLOGY

6.1 Hydrologic Regime

The Peace River is in northern British Columbia and is formed at the confluence of the Finlay River which flows southwards in the Rocky Mountain Trench, and the Parsnip River which flows northwards in the Rocky Mountain Trench (Figure 6-1).

From the confluence of these two rivers, the Peace River flows eastward through the Rocky Mountains to Alberta. After entering Alberta, it flows in a northeasterly course, eventually discharging into the Arctic Ocean via the Slave and Mackenzie Rivers. In total, the Peace River is 1923 km long and has a watershed area of 287,000 km^2 upstream of its confluence with the Athabasca River in Alberta.

The reach of the Peace River where the various dam alternatives are located is between PCN, which is located approximately at river marker 20.5, and the furthest downstream dam located approximately at river marker 106. The hydrologic regime of this reach is dominated by the regulated releases from the W.A.C. Bennett Dam. Williston Lake, which is impounded by W.A.C. Bennett Dam, has a drainage area in the order of 68,900 km^2 and has multi-year storage capacity, allowing for regulation of the inflows. PCN is located some 20 km downstream of W.A.C. Bennett Dam and impounds Dinosaur Lake, which backs up to the tailwater of W.A.C. Bennett Dam. There are no major tributaries along this reach of the river; therefore the inflows into the reservoir are approximately equal to the releases from W.A.C. Bennett Dam. Dinosaur Lake does not have sufficient capacity to regulate the inflows and therefore the releases from PCN, for the most part, mimic the releases from W.A.C. Bennett Dam. The contributing drainage area to PCN is 71,250 km^2.

There are a number of tributaries that contribute unregulated flows to the Peace River within the 85 km long reach between Peace Canyon and Site C, including Maurice Creek, Lynx Creek, Farrell Creek, Halfway River, Cache Creek, Wilder Creek, Tea Creek and the Moberly River. The main tributaries are the Halfway River, which is located midway along the reach, and the Moberly River, which is located near the downstream end of the reach. The Halfway River, with a drainage area of 9450 km^2, drains about 75% of the local catchment between PCN and Site C. The Moberly River has a drainage area of approximately 1520 km^2. The total catchment area at Site C is approximately 83,680 km^2, of which the flow from the upstream 71,250 km^2 is regulated.

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6.2 Extreme Flood Flows

The PMF inflow and routed outflow at Site C are 20,810 m^3/s and 17,500 m^3/s, respectively[6.1]. The PMF at Site C is based on an extreme storm located over the Halfway River basin, therefore the Site C PMF was used for all dams located downstream of the Halfway River. For dams upstream of the Halfway River, the PMF outflow from PCN of 9300 m^3/s given in the Operation, Maintenance and Surveillance (OMS) Manual[6.2] was used.

6.3 Mean Annual Flows

An updated analysis was performed to determine the mean annual flows (MAF) in the reach of the Peace River between PCN and Site C.

Data from Water Survey of Canada (WSC) gauge #07EF001 (Peace River at Hudson's Hope) just downstream of PCN was used to estimate the MAF at Hudson's Hope. The recorded daily average flows at this gauge from 1979 to 2007 gives a MAF of 1141 m^3/s, which was used as the MAF for each alternate located upstream of the Halfway River.

Data from WSC gauge #07FA004 (Peace River above Pine River) just downstream from Site C was used to estimate the MAF at Site C. The recorded daily average flows at this gauge from 1979 to 2007 gives a MAF at Site C of 1251 m^3/s, which was used as the MAF for each alternate located downstream of the Moberly River.

The MAF in the Moberly River is 0.9% of the MAF at Site C[6.3], therefore the MAF for each alternate located between the Halfway and Moberly Rivers was assumed to be 1240 m^3/s (99.1% of 1251 m^3/s).

The discharge capacity of the generating station at PCN is approximately 2000 m^3/s, which was used as the generating station capacities for alternates upstream of the Halfway River. The generating station capacities downstream of the Halfway River was taken as 2118 m^3/s, which is the historical rated power flow at Site C[6.1].

6.4 Diversion Flood Flows

A diversion design flow of 2600 m^3/s was assumed for all dams located upstream of the Halfway River, which is the diversion flow adopted for the construction of Peace Canyon Dam and equals the full turbine output of G.M. Shrum powerhouse plus a 10-year rainfall in the local catchment.

A 50-year diversion design flood was assumed for all dams located downstream of the Halfway River. A flood frequency analysis was performed during Stage 2 using the 24 years of available stream flow data (1984 to 2007). Based on this

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analysis, the 50-year diversion flood magnitude (maximum mean daily flow) from the Site C local catchment is estimated to be about 3000 m^3/s. It was assumed that Williston Reservoir discharges would be 1440 m^3/s prior to the flood and would be reduced to 600 m^3/s for five days during the flood peak.

6.5 River Profile

In order to determine the available head at each site, river profiles were developed for flows equal to the generating station capacities and the MAF from LiDAR data acquired during Stage 2.

The LiDAR data for the river reach had been acquired on different days and different river flows, therefore the water levels from the LiDAR data had to be adjusted to the required flows. This was done by using an existing HEC-RAS[5] model of the Peace River obtained from BC Hydro.

Firstly, the range of average daily flows associated with the LiDAR (based on the days it was flown) was determined from historical records. Next, the differential water level between the required flow and the average flow on the day the LiDAR had been acquired was determined from the HEC RAS model.

For example, around Hudson's Hope at river marker 27 to 30, the LiDAR was flown on September 3, 2006 and the average flow that day from WSC Gauge #07EF001 was 428 m^3/s. In order to determine the water levels at river markers 27 to 30 for the maximum operating flow of 2000 m^3/s, the HEC RAS model was run at both 428 m^3/s and 2000 m^3/s to obtain the difference in the water levels between these two flows at each location. This difference in water level was then added to the LiDAR water level to obtain the river profile at that location for a flow of 2000 m^3/s. This process was repeated for every kilometre along the Peace River reach, and profiles were developed for both required flows.

6.6 Determination of Power and Energy for Alternates

In order to calculate power and energy at each dam location, it was necessary to determine the gross and net head. The tailwater levels for the single dam options were found by taking the water level from the river profile at the locations of the dams. For the cascade dams, backwater analyses were undertaken using the HEC-RAS model to determine the increase in reservoir level resulting from backwater effects. The analyses were conducted by isolating each dam location and determining the increase, if any, in the reservoir level at the upstream end of the reservoir due to the flow through the shallow upstream portion of the reservoir. Gross heads were then calculated at each dam location as the

[5] HEC-RAS (Hydrologic Engineering Center River Analysis System) is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program was developed by the US Department of Defense, Army Corps of Engineers in order to manage the rivers, harbors, and other public works under their jurisdiction.

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difference between upstream pool level and the downstream tailwater level adjusted for possible backwater effects.

Once the gross head had been established at each dam location, the next step was to calculate the net head. This was done by calculating the head losses through the power conveyance system (from the upstream end of the intakes to the downstream end of the draft tubes including the exit loss) of each dam and subtracting the total head loss from the corresponding gross head. For the generating station capacities, the head losses were calculated at each dam. For the MAF the head losses were pro-rated by the square of the ratio of the mean annual and maximum operating flows. Additional adjustments were made as described below.

For the MAF at Site C, the head loss was found by pro-rating the head loss value of 1.2 m at the generating station capacity[6] by the square of the flows, resulting in a head loss of 0.42 m [1.2 m x (1251 m^3/s / 2118 $m^3/s)^2$ = 0.42 m]. A check of this value was done by determining the flow and pro-rated head loss for the weighted average flow at Site C based on the exceedance curve at WSC Gauge #07FA004. The exceedance curve was split into 10% segments and the average flow and corresponding head loss of each segment was found (again by the square of the flows) and the sum equaled 0.46 m, which is slightly greater than 0.42 m. Since the weighted average flow method is more representative of real flow conditions and therefore the head loss, the value of 0.46 m was adopted as the head loss at Site C for the MAF.

For all of the other dam locations, the head losses for the MAF were calculated using the following procedure based on the weighted average flow (WAF) relationship determined at Site C:

- a factor “k” was determined based on the original flow and calculated head loss at Site C [k = 0.42 m / (1251 $m^3/s)^2$ = $2.69E^{-7}$];
- a weighted average flow was calculated from the head loss value of 0.46 m [WAF = $(0.46 / 2.69E\text{-}7)^{0.5}$ = 1314 m^3/s];
- the head losses for the other dams were then calculated based on pro-rating the WAF instead of the MAF;
- for locations upstream of the Halfway River where the MAF is 1141 m^3/s instead of 1251 m^3/s, the WAF was found by multiplying the MAF by a factor of 1314 m^3/s / 1251 m^3/s, resulting in a WAF of 1199 m^3/s; and
- for locations upstream of the Moberly River but downstream of the Halfway River, the same method was applied resulting in a WAF of 1303 m^3/s.

[6] Head loss determined in previous studies[6.1] and confirmed by independent check.

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The capacity at Site C is 900 MW, the average annual energy is 4600 GW.h and the firm energy is 4000 GW.h[6.4]. The net heads at the generating station capacities were used to calculate the power at each site, while the net heads at the mean annual flows were used to calculate the energy. The power and energy for all the dam options other than Site C were determined by pro-rating the Site C values by the ratios of the applicable net heads and the following flow ratios:

- for generating stations upstream of the Moberly River and downstream of the Halfway River a MAF ratio of 0.991 was used to account for the difference in MAF due to the Moberly River inflow;

- for generating stations upstream of the Halfway River a MAF ratio of 0.912 (1141 m^3/s / 1251 m^3/s) to account for the difference in MAF due to the inflow from the Moberly and Halfway Rivers;

- for the seven dam cascade, an adjustment was made to account for the expected energy losses at dams 7d, 7e, 7f and 7g due to ice affects on the small reservoirs based on estimated amounts and return periods determined in the previous study[6.5]; and

- 4% was taken from the calculated energy for all dams in the seven dam cascade due to the loss of energy from synchronized generation of flows with PCN, requiring some reservoir drawdown in order to generate during high load hours.

6.7 References

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6.3 Klohn Crippen Berger and SNC Lavalin Inc, “Peace River Development, Site C Project, Review of Upstream Axes”, Report 5032A01 02, May 2006.

6.4 BC Hydro, “Peace River Site C Hydro Project, Stage 1 Review of Project Feasibility”, December 2007.

6.5 Klohn Crippen Consultants Ltd. & SNC-Lavalin Inc., “Peace Cascade Development, Prefeasibility Study for a Cascade of Low Consequence

[7] Klohn Crippen Consultants Ltd. in Association with Shawinigan Integ was known as Klohn Crippen Integ.

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Structures as an Alternative to Site C", Report No. 186 PP1448-02-01, January 2003.

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7. PHYSICAL ENVIRONMENT

The following section describes the physical environment of the reach of the Peace River from PCN to below Site C.

7.1 Climate

The climate of the Peace River region is classified as being cold and relatively dry and clear. Temperatures typically range from an average minimum of -13 ºC in January to an average maximum of 22ºC in July. Mean annual precipitation is 398 mm, with November through March precipitation falling as snow. Wind speeds across the Peace River valley average 7 km/h near Hudson Hope and 10 km/h near Fort St. John; the dominant directions are southwest in summer and southwest or northeast in winter.

7.2 Physiography

The Peace River valley has formed through progressive down-cutting of the glacial overburden and underlying sedimentary rock by the flow of water. This has resulted in a broad, flat bottomed river valley up to 230 m below the top of the surrounding plain[7.2], which is part of the Alberta Plateau [Interior Plains] physiographic region. Most tributaries of the Peace River system are considered[7.3] to be in a 'youthful' stage whereas the Peace River has reached a mature stage in its development, although many of the valley slopes are still unstable and active.

Landslides have been identified as playing a significant[7.3] role in the development of the Peace River valley in the project area upstream of Site C. Since the beginning of the century, several significant slides have occurred, including the Cache Creek Slide in the early 1900's, which involved up to 69 million m^3 of shale and sandstone, and the Attachie Slide in 1973, which involved 18 million m^3 of overburden. Some of the valley slopes are still considered to be only marginally stable.

Flow regulation associated with the W.A.C. Bennett Dam has altered the morphology of the Peace River resulting in a narrowing of the river by abandonment of side channels and riparian vegetation succession on gravel bars[7.9].

7.3 Topography

Topographic conditions within the project area are characterized by the Peace River valleylands and the surrounding tablelands, which are part of the Alberta Plateau. The tablelands consist of a relatively flat to rolling topography plain

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through which the Peace River has cut a deep U-shaped valley 180 to 230 m deep.

The bottom of the Peace River valley is typically 1.6 to 2.4 km across. The valley has a maximum width of 4.8 km at Lynx Creek and has a minimum width of 600 m at Site C[7.3]. The valley side slopes generally rise steeply from the river to the plateau level. The lower valley slopes are typically terraced, often with steep river slopes 30 m above river level. The main valley side slopes vary from 1.7:1 to as flat as 5:1[7.3]. However the slopes in overburden generally range between 2.5:1 and 4:1. Downstream of Site C, the Peace River is well confined by either terraces or the valley slopes with a very slightly meandering river pattern.

7.4 Geology and Surficial Soils

The most abundant rock formation in the project area is the cretaceous Fort St. John Shale (Shaftesbury Formation) which can be found frequently exposed along the banks of the Peace River from Farrell Creek to the Alberta border. The Fort St. John Shale has thin interbeds of silty and sandy shales that are moderately weak and more susceptible to rebound[7.3]. These formations are overlain by the Dunvegan Sandstone. Upstream of Farrell Creek, the older Gates Sandstone is present beneath the Fort St. John Shale. The Gates Sandstone is considered more competent and is relatively resistant to erosion[7.3].

Previous study has mapped 13 different soil map units (types) within the proposed Site C reservoir area[7.10]. These soils are typically associated with the 'Alluvial' soil series and include common textures such as sandy loam, silt loam and gravel. About 4490 ha (74%) of these soils were identified as having characteristics that could support some form of agricultural use (e.g. alfalfa, domestic forage, grazing) and 409 ha (7%) identified as highly productive for a wide range of agricultural crops.

7.5 Surface Water

The hydrologic regime of the Peace River is described in Section 6.

From PCN, the Peace River flows 85 km to Site C with an average gradient of 0.0006 m/m. Although discharges from PCN are virtually sediment free, due to the presence of the upstream Williston Reservoir, there is a significant annual sediment load in the reach between PCN and Site C[7.5]. The large tributaries; the Halfway and Moberly Rivers are the sources of most of the annual sediment load. The Halfway River contributes the largest sediment load, estimated at 2.3 million tons per year[7.5]. In comparison, the estimated annual suspended sediment load in the Peace River at the Town of Peace River is 35 million tonnes[7.9].

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Currently, ice cover rarely occurs in the Site C area, due partially to the effect of releases of warmer water from the W.A.C. Bennett Dam[7.1]. Incidents of periodic ice jam formations have in the past occurred further downstream at Taylor and the Town of Peace River[7.6].

7.6 Groundwater

Information describing groundwater conditions within the project area is limited. Previous study information describes the most important unit for groundwater as the basal gravel which serves as an aquifer of "appreciable potential"[7.3]. The aquifer is overlain by relatively impermeable silt, clay and till, although the gravel does appear to be part of a surface recharge system.

The groundwater pattern in the high banks of the overburden has been described as "very complex", exhibiting a high range of permeability, possibly perched water tables and high piezometric pressures. Seepage from both low and high shale banks has been recorded[7.3]. Groundwater has been identified as an important factor governing the occurrence of slumps and landslides along the Peace River.

7.7 Mineral and Aggregate Resources

There is low metallic mineral (e.g. gold, silver and copper) potential in the Site C reservoir area and there are no mineral or placer claims in the reservoir area or in the 3 km buffer area[7.1]. The Site C reservoir and downstream area are known to have good coal potential, but it is unlikely that surface coal mining would occur in the reservoir area due to scarcity of natural outcrops. There is a coal license in the project footprint in the vicinity of Lynx Creek[7.15]. The license area is a total of 6670 ha, with about 97 ha in the project footprint. The best potential for relatively less deformed coal seams is at depths between 400 and 700 m[7.15].

The Site C reservoir area has ±1560 ha of land in sand and gravel tenures and 50 placer claims locally[7.1]. An Order In Council gives precedence to hydro development over placer claims. A previous survey of granular resources identified ~1300 million m^3 of granular material in the project area with about 6% of the volume in the Site C reservoir[7.14]. It was concluded that a very large inventory of aggregate would remain after the project.

7.8 Oil and Gas Resources

There are eight wells and four oil and gas facilities within the Site C reservoir and project footprint area[7.15]. Identified areas of tenures include:

- 1946 ha of drilling licenses and 2077 ha of oil and gas leases in the proposed reservoir area;

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- 245 ha of drilling licenses and 114 ha of oil and gas lease at the dam site (based on an estimated dam site area of 733 ha); and

- 700 ha of drilling licenses and oil and gas leases along the transmission line (based on an estimated transmission line right of way area of 812 ha).

Oil potential within the project area is considered negligible[7.15]. Conventional gas potential was identified within 1695 ha area mostly within the Site C reservoir. Coalbed methane potential is considered to be present throughout the entire project area.

7.9 Water Quality

Baseline water quality data, river sediment and water temperature information was collected in 2006 to 2007 for the Peace River and its tributaries from 24 sample sites between PCN and the BC-Alberta border[7.4]. In 2008, a second round of sampling was conducted at 18 Peace River and tributary sites[7.17]. In addition, limnological studies at three sites in the Dinosaur Lake Reservoir were conducted.

The study indicated that most water samples that exceeded British Columbia Water Quality Guidelines (BCWG) and Council of Canadian Ministers of Environment (CCME) guidelines for the protection of freshwater aquatic life were in the category of total metals, whereas most dissolved metal concentrations, with some exceptions, were below method detection limits (MDL)[7.4].

In terms of total metals, aluminum, antimony, arsenic, cadmium, copper, iron, manganese, selenium, silver, thallium, vanadium, and zinc exceeded guidelines. Virtually all exceedences of total metals were associated with the timing and distribution of elevated levels of total suspended solids (TSS) originating from the tributaries. In terms of dissolved metals, aluminum, cadmium, copper, iron, selenium, zinc and manganese exceeded guidelines at one or more of 13 sample sites. There were more instances of exceedences and a wider range of dissolved metals exceeding guidelines in 2008 than was observed in 2007.

Total and dissolved levels of mercury were below the MDL for all 2007 sample sites, but detected at very low levels on one occasion in 2008. Total metals concentrations in the Peace River tend to increase with downstream distance from PCN. The observed increases were considered to be a result of the cumulative influence of tributary inflows (i.e. increased sediment load) into the Peace River.

In terms of sediment samples, arsenic and nickel exceeded either CCME and/or BC Sediment Quality Guidelines (BCSQG) at most sediment sample sites. Cadmium, copper, and iron also exceeded guidelines but for fewer sites. Mercury

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was below MDL for most samples taken, except in July and August, 2007 where it was detected in one of two samples at different locations.

Measurements of Peace River water temperatures were found to be cooler in the summer months than in tributaries, but warmer in the winter months; reflective of the influence of PCN releases. Peace River water temperatures increase the further downstream from the PCN such that the mean monthly water temperature downstream of Kiskatinaw River was 4.7°C warmer in July 2007 than that recorded downstream of PCN. The study indicated that the influence of tributary inflows on Peace River water temperatures was not evident. Water temperatures were slightly warmer at Peace River sites in 2008 than in 2007.

7.10 References

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7.14 F.F. Slaney and Company Limited and Associates, Environmental – Land Use- Social and Economic Impacts, Application. BC Hydro and Power Authority for Energy Project Certificate Site C Peace River. Volume 1 of 2. January 1982.

7.15 Socio-Economic Baseline and Preliminary Effects Assessment Methodology Site C Project Volume B—Land and Resource Uses. Lions Gate Consulting Inc. June 2009.

7.16 Peace River Site C Hydro Project Stage 2 Preliminary Clearing Considerations - Costs and Schedule Preliminary Draft. Industrial Forestry Service Ltd. June 2009.

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8. BIOLOGICAL ENVIRONMENT

The following section describes the biological environmental for the section of the Peace River from PCN to below Site C (as appropriate).

8.1 Aquatic Habitat and Fish Species

8.1.1 Peace River Mainstem

The Peace River is a large northern river that is typically 300 m to 400 m in width. Mainstem aquatic habitat is dominated by run/glide habitat, with the section between PCN and Pine River confluence consisting of ~20 km^2 of run/glide, ~3 km^2 of riffle, 0.65 km^2 of pool, 0.31 km^2 of bar and 0.01 km^2 of debris accumulation. Average depth at runs and riffles ranges from 3 m to 4 m, with depth of deep holes increasing upstream towards PCN (maximum depth 5 m to 7.6 m below Cache Creek, increasing to ~24 m in a deep hole below PCN)[8.5] (AMEC & LGL, 2008d). Bank habitat within the mainstem of the project area is predominantly armoured, representing approximately 70% of the total length. Depositional and erosional banks make up most of the remaining bank habitat downstream of Maurice Creek, with depositional habitats more abundant and generally associated with tributary mouths and islands. Canyon and armoured bank habitat is prevalent in the short reach between PCN and Maurice Creek[8.26].

Numerous side channels and islands provide slower velocity backwater habitat, often with fine sediments that promote the growth of aquatic and emergent vegetation in protected areas. This side channel habitat increases as one moves downstream from PCN, increasing from 26% of total habitat in the reach near Maurice Creek to 35% of total habitat in the reach between Halfway River and Cache Creek, to approximately 43% of total habitat below the Beatton River. Island complexes increase in abundance as one moves downstream, and are the primary factor in the increase in side channel habitat[8.26].

Thirty-one fish species have been documented in the Peace River fish community (see Table 8.1[8.9]).

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Table 8.1
Fish Species of the Peace River

Sportfish (cold/cool water)	Sportfish (cool/turbid water)	Suckers	Minnows	Sculpins
Arctic grayling Bull trout Kokanee Mountain whitefish Lake whitefish Rainbow trout Lake trout Pygmy whitefish Brook trout	Walleye Goldeye Burbot Northern pike Yellow perch	Largescale sucker Longnose sucker White sucker	Flathead chub Lake chub Finescale dace Longnose dace Northern pikeminnow Peamouth chub Redside shiner Spottail shiner Trout perch Northern redbelly dace Pearl dace	Prickly sculpin Slimy sculpin Spoonhead sculpin

Mountain whitefish is the most abundant species within the river being distributed throughout the river system from PCN to the Alberta border[8.17, 8.18, 8.19, 8.20, 8.21, 8.22 & 8.23]. It is found mainly in deep runs and riffles with cobble/gravel substrates and is uncommon in pools and areas of fine substrate[8.24 & 8.25]. Mountain whitefish spawn and rear throughout the mainstem of the river, but may also utilize larger tributaries such as the Halfway and Moberly Rivers[8.3].

Arctic grayling, rainbow trout and walleye are the next most common sportfish species, with less common ones being bull trout, kokanee, lake whitefish, northern pike, burbot and goldeye[8.5]. Arctic grayling are found mostly in the reach below Cache Creek, spawning and rearing in the Moberly River, and possibly also within the mainstem between Cache Creek and the Beatton River[8.1]. Rainbow trout and kokanee are found mainly in upper reaches below PCN, and utilize local tributaries (Maurice, Lynx and Farrell) for spawning[8.16]. Bull trout are distributed throughout the river, and utilize the mainstem for feeding and as a transportation corridor between major spawning tributaries (Halfway and Pine Rivers).

Cool/turbid water species (burbot, walleye, yellow perch and northern pike) are more prevalent in downstream sections below Cache Creek. Walleye are found largely downstream of the Beatton River to the Alberta border. Two groups of walleye were identified, with one group (~50% of fish tracked during radiotelemetry studies) exhibiting distinct spring spawning movement into and out of the Beatton River, and utilization of the Peace River mainstem between Beatton and Moberly Rivers outside the spawning season. The second group remained within Peace River mainstem below Beatton mouth into Alberta with no distinct seasonal movements[8.3].

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Generally, the proportion of sport fish in the local community declines from upstream to downstream, while suckers significantly increases[8.3]. Forage/minnow species also becomes more abundant as one moved downstream[8.16]. The mainstem from PCN to the Alberta border provides year-round foraging habitat for all fish species, and summer/winter refuge for species that use smaller tributaries for spawning and rearing[8.5].

8.1.2 Peace River Tributaries

Aquatic habitat in tributaries between PCN and Site C varies widely depending on their gradient and flow regime. Large tributaries, such as the Halfway and Moberly Rivers, provide year-round foraging and refuge habitat, while many of the smaller creeks provide seasonal habitat during high flow periods[8.6].

The Moberly River is characterized as a moderate size, low gradient and meandering, cobble-embedded channel with a fairly broad floodplain comprised of gravel bars (many of them vegetated) and various tertiary channels, typically at meanders. Its gentle gradient and broad floodplain result in a diversified mix of main channel, tertiary channel and off-channel habitats interspersed with islands and gravel bars, particularly at meanders[8.5]. It has the highest diversity of habitat of all the tributaries surveyed, and is used by the widest assemblage of fish species (20)[8.6]. It is used by arctic grayling and mountain whitefish for spawning and rearing, as well as northern pike[8.6], and likely contributes more to annual recruitment than any other tributary upstream of Site C[8.3].

The Halfway is a large river that extends well into the Rocky Mountains with fast flowing conditions and a low percentage of fines (<10%) within the lower 28 km[8.6]. Riffles comprise broad areas of moderate water depth, while pools are quite deep with some cover. Runs typically consist of extensive lengths of deep water with virtually no suitable cover for fish. The river has the least diversity of habitat of all tributaries surveyed[8.5], but recorded the presence of 16 species during recent surveys with mountain whitefish being the most abundant species[8.6]. The river is known to provide spawning and rearing habitat for mountain whitefish, bull trout, arctic grayling and rainbow trout[8.6]. Radiotelemetry investigations in 2007 demonstrated that bull trout can move considerable distances (up to 450 km annually) with two individuals moving from the Pine River system to the upper Halfway River in late summer, and then returning to the Pine River in late fall after the spawning period was over. Juvenile bull trout have been found at various locations within the Halfway River[8.2, 8.3 & 8.4].

Other tributaries contain mostly seasonal habitat and/or limited fish populations:

- Wilder Creek has the potential for spring spawning when flows are adequate, but is unlikely to be used for fall spawning due to lack of flow[8.5]. Three species (longnose dace, peamouth and flathead chub) were found during recent surveys[8.5, 8.6];

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- Cache Creek has ample spawning gravel and some good off-channel habitat in the lower reach[8.5]. It has been used for spawning by mountain whitefish, and arctic grayling as well as sucker and minnow species (longnose sucker, redside shiner, lake chub, longnose dace and northern pikeminnow)[8.6, 8.7, 8.8 & 8.27];

- Farrell Creek has ample spawning gravel and limited amounts of off-channel habitats (mostly in the upper reach) that were found to be aggraded and lacking flow during a 2005 survey[8.5]. Sportfish collected included rainbow trout, arctic grayling and mountain whitefish, and non-sportfish include longnose sucker, longnose dace, redside shiner and lake chub and slimy sculpin[8.5, 8.6 & 8.27]. The creek is used by arctic grayling, rainbow trout and longnose suckers for spawning, and juvenile mountain whitefish have been found[8.7, 8.8 & 8.27];

- Lynx Creek has adequate spawning gravel within the lower reaches, but is generally of poor quality due to excessive fines[8.5]. Species collected in Lynx Creek include bull trout, rainbow trout, mountain whitefish, arctic grayling, longnose sucker, white sucker, longnose dace, northern pikeminnow, and redside shiner[8.6]. Rainbow trout, arctic grayling and longnose suckers utilize the creek for spawning and rearing[8.6]; and

- Maurice Creek is similar to Lynx Creek but wider and more bedrock controlled, with more favourable rearing habitat due to more and better quality pools, more boulders in riffles, and good overhead cover[8.5]. Species collected in the creek include rainbow trout, mountain whitefish, arctic grayling, bull trout, slimy sculpin, prickly sculpin, longnose sucker, white sucker, and longnose dace[8.1 & 8.5]. The creek is an important spawning and rearing area for rainbow trout, and is also used for spawning by longnose sucker and mountain whitefish[8.6].

8.1.3 Rare and Listed Fish Species

No COSEWIC (federal) listed species are found in the project area, although spottail shiner is BC red-listed, while bull trout, goldeye and pearl dace are BC blue-listed [8.5]:

- Spottail shiner is a common and abundant minnow throughout Canada from Ontario to Alberta and into the northern US, and is at the western limit of its distribution range in the Peace River system[8.28];

- Bull trout are found throughout the river system, with a significant portion from the Halfway River (57% of tagged fish in 1996-1999 study) migrating to the Peace River mainstem and spending ~70% of their time in the Peace River. Of those migrating to the Peace, 29% were found below the Moberly confluence, while 56% were found above the Halfway River, and the rest

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were found between those two areas[8.2]. Some bull trout undertake extensive movements – i.e. spawn (and rear) in the Halfway River, then move to the Pine River to forage. A group within the Pine River rears and forages primarily in the Pine River, and spawns in the Burnt River[8.3];

- Goldeye are widely distributed in Canada from northwestern Ontario to Alberta, into the Peace River drainage in BC, and into the northern US. Its typical habitat is quiet, turbid water of large rivers and connected waterbodies, using deep water habitat for overwintering[8.28]. Goldeye have been found throughout the project area in low numbers[8.23, 8.24, & 8.25]; and

- Pearl dace are widely distributed in Canada from the Maritime Provinces to Alberta, and are typically a minnow of cool, clear headwater streams, beaver ponds, and/or bog drainage streams, ponds and small lakes[8.28]. They were reported once from Lynx Creek during surveys in 1989[8.7].

8.2 Riparian Habitat and Species

8.2.1 Wetlands

Along the Peace River corridor, there is one 20 ha wetland area (Watson Slough) located near Bear Flats. Along the existing transmission corridor on the south shore from near Site C to PCN, there is approximately 70 ha of wetland which would be affected by corridor expansion[8.10 & 8.11].

8.2.2 Shoreline Vegetation Community

River corridor vegetation communities were mapped as part of the Terrestrial Ecosystem Mapping process. River shorelines are generally forested and in variable stages of succession. Predominant community types are cottonwood-spruce-red osier dogwood (FM02), currant-horsetail dominated by balsam poplar (SH) and spruce-aspen-step moss (AM). Willow-horsetail-sedge community (WH) and gravel bars (GB) are common at bends and tributary mouths[8.10 & 8.11].

8.2.3 Islands and In-water Structures

Numerous forested islands and gravel bar islands (approximately 30) are located within the river between PCN and Site C. Gravel bars (GB) and willow-horsetail-sedge riparian wetland (WH) are typically the predominant feature on the upstream and downstream ends of the islands, while forested ecosystems (FM02 most often, also SH, So, SC, SW and AM) are present on higher ground centrally on the islands[8.10 & 8.11].

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8.2.4 Rare and Listed Species

Preliminary reports[8.12] suggest that three blue-listed plant species are present within the area to be inundated by Site C (two in Watson Slough, one on a gravel bar near dam 7c). More work is required to determine distribution and composition of rare plant species/communities.

8.3 Terrestrial Habitat and Species

8.3.1 Vegetation

8.3.1.1 Species and Communities

Terrestrial ecosystem mapping has been undertaken within the Peace River corridor to map the various vegetation communities. Predominant community types within the potential reservoir inundation zone are cottonwood-spruce-red osier dogwood (FM02), spruce-aspen-step moss (AM) and spruce-horsetail (SH) [8.10 & 8.11].

8.3.1.2 Rare and Listed Species

Fifty-six red- or blue-listed plant species and five red- or blue-listed plant communities were found in the area between PCN and the Alberta border during surveys in 2005 and 2006. Steep, warm aspect slopes are most productive in terms of diversity and number of rare flora, and are mostly out of the development zone (for reservoirs at least). Future studies are required to provide more information[8.12 & 8.15].

8.3.2 Wildlife

8.3.2.1 Butterflies

Twelve blue-listed butterfly species (of 16 potential) were found in the project area during 2006 surveys. Habitat suitability ratings are being prepared to correlate life stages with habitat, particularly river associated habitat[8.12 & 8.15].

8.3.2.2 Bats

Nine bats species potentially occur in Peace River area. All are insectivores and roost in trees, although some may utilize other habitat (buildings, rock crevices and/or cliffs). Six species (little brown myotis, long-legged myotis and northern myotis, hoary bat, silver-haired bat and big brown bats) were collected during preliminary surveys in 2005 and 2006, and were confirmed to be reproducing in the area. Balsam poplar stands are heavily used for roosting, while wetlands and slow moving creeks support the greatest degree of foraging activity. Northern myotis is blue-listed in BC[8.13 & 8.14].

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8.3.2.3 Songbirds

Seventy-seven passerine species were found during surveys undertaken in 2005 and 2006 to assess presence and habitat use within the project area. Blue-listed black-throated green warbler and Canada warbler were found within or directly adjacent to the river floodplain. The red-listed Cape May warbler and bay-breasted warbler were associated with mature coniferous stands and upland habitat (possible transmission corridor interaction). Nelson's sharp-tailed sparrow and Le Conte's sparrow are associated with herbaceous wetlands (i.e. Watson Slough). The blue-listed rusty blackbird was found in wetland and river island habitats. The red-listed Connecticut warbler is typically associated with balsam poplar/spruce islands along the Peace River[8.12].

8.3.2.4 Waterfowl and Shorebirds

Forty-two species of waterfowl were recorded on the river during 2006, with most use during fall migrations (3-4 times those recorded during other times of year). Five blue-listed species were encountered during 2006 surveys, being surf scoter, sandhill crane, great blue heron, California gull and Caspian tern, with no breeding noted (mainly fall observations). Canada goose and mallard were the most common waterfowl observed, while Franklin's gull was the most common gull. Species found mainly on the main river channel include gulls, Canada geese, common loons, common mergansers, spotted sandpiper and surf scoter. Species found mainly in back-channel habitat include green-winged teal, northern shoveler, northern pintail, ring-necked duck and trumpeter swan. Generally, gulls were found on open gravel bars along the main river channel, diving ducks preferred the fast flowing, main channel and dabbling ducks preferred the slow flowing or stagnant back channels. Wetlands were found to be used primarily in spring[8.12 & 8.15].

8.3.2.5 Raptors

Eleven species of diurnal raptors (bald eagle, golden eagle, red-tailed hawk, northern goshawk, northern harrier, sharp-shinned hawk, Cooper's hawk, Osprey, American kestrel, merlin and broad-winged hawk) were reported in the core and periphery area during studies in 2005. Twenty-one active bald eagle nests were reported from an aerial survey[8.15]. In 2006, 19 nests were observed in the lower portion of the river channel and on islands upstream of Site C, with nine being active. All nests were found in large balsam poplar trees[8.12 & 8.15].

8.3.2.6 Owls

Six species of owls were documented during studies in 2006, including northern saw-whet (most common), great horned and barred (both relatively abundant), and short-eared, boreal and great gray owls. Nesting habitat is typically the limiting factor for owl distribution, with large balsam poplars the ideal nesting tree

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for great gray, great horned and gray owls due to the large tree size and appropriate limb configuration (owls take over stick nests constructed by other birds of prey) [8.12 & 8.15].

8.3.2.7 Amphibians

Five species of amphibians were found in the project area during surveys in 2005 and 2006, including long-toed salamander, western toad, boreal chorus frog, Columbia spotted frog and wood frog. Western toads, wood frogs, and boreal chorus frogs were recorded in river back channel sites. Amphibians were also detected at Watson Slough. Amphibians are sensitive to development as they are aquatic breeders that rely on wetlands, ponds, and/or slow water river back-channel habitat for breeding[8.12 & 8.15].

8.3.2.8 Beavers

A survey of beaver lodges in 2005 found 67 active and 60 inactive lodges in the river reach from Hudson Hope to the Moberly River. Assuming 5 beavers/colony, these counts result in a population estimate of 335 animals, which is similar to the population estimate from a previous survey in 1990 (380 animals)[8.12].

8.3.2.9 Ungulates

Moose, deer and elk were surveyed in 2006 to determine their abundance and distribution. Compared to 1991 surveys, numbers of moose were similar in all areas (river bottom, south aspect and north aspect slopes). Deer numbers were similar on north aspects and the river bottom, but lower on south aspect slopes. Elk numbers have increased, and were mostly present on south aspect slopes and the river bottom[8.12].

8.3.2.10 Other Species

Adult Harlequin ducks (non-breeding) were found on the river during the mid-1970s, but have not been seen since. They require fast flowing waters with good benthic production and adjacent island habitat for nesting/loafing[8.12]. Fishers are blue-listed and were the target of 2006 furbearer investigations, but none were observed (possible tracks). Large balsam poplar trees within the river valley are important reproductive and resting habitat for the fisher. Other species encountered included marten, lynx, otter, mink, unknown weasel, red squirrel, snowshoe hare, coyote and wolf[8.12].

8.3.2.11 Rare and Listed Wildlife Species

Fourteen red- or blue-listed wildlife species were found within the project area during surveys in 2005 and 2006. They were found within the river bottom and upper slopes along the Peace River corridor and in the lower portion of the Moberly River valley. Species detected included western toad, California gull,

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Caspian tern, great blue heron, sandhill crane, surf scoter, black-throated green warbler, Canada warbler, Connecticut warbler, Nelson's sharp-tailed sparrow, rusty blackbird, broad-winged hawk, peregrine falcon and short-eared owl[8.12 & 8.15].

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9. Socio-Economic Environment

9.1 Land and Resource Use

The project area contains two categories of land: public or Crown land, and private land. More than two-thirds of land in the project area is Crown land, primarily provincial Crown lands which straddle two Regional Land Use Plan areas (Dawson Creek and Fort St. John). A large portion of private land in the project footprint is owned by BC Hydro. There is no Indian Reserve (IR) in the project area[9.1].

The project area includes the proposed Peace River – Boudreau Lake Protected Area (PBPA). Though not formally established as a protected area, the proposed boundary will include some 23,803 hectares on a large part of the south bank of the Peace River valley, lower Moberly River valley, and Peace River Islands between Maurice Creek and Moberly River.

The project area includes land in the agricultural land reserve and land with high soil capability, although not all of this land is currently in agricultural use. There has been a moderate shift towards consolidation of farm holdings; farms tend to be larger than elsewhere in British Columbia[9.2]. The main crops grown are alfalfa and alfalfa mix hay and fodder, wheat, oats, canola, and barley. As of 2006, the value of land and buildings in the area potentially affected by the project was over $1 million. There has been a rise in cattle ranching in the past 3 decades, and the project area straddles roughly 11 range tenures[9.1].

Forestry is second only to oil and gas as a private sector source of income, and accounts for roughly 16% of community income in the Dawson Creek area, and 7% in the Fort St. John area[9.1]. Some of the project area is presently productive forest land, with forest tenures. Although the project area is comprised of Timber Harvesting Land Base (THLB) in three forest management units (Dawson Creek timber supply area, Fort St. John timber supply area, and Peace River supply block of tree farm license 48), the amount of project area THLB land in the three management units is not substantial. There are currently no Old Growth Management Areas directly in the project area[9.1].

The northeast of British Columbia has 95% of the province's oil and gas exploration and development activity. In the Fort St. John region, roughly one-third of community income is derived from oil and gas. Nonetheless, oil potential within the footprint of the project area is considered negligible[9.1]. There are eight wells and four oil and gas facilities, and a number of drilling licenses and oil and gas leases within the project area. Existing development to date is all vertical drilling; horizontal drilling has yet to be tested and proven locally.

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There are nine mineral reserves in the area, but with low metallic mineral potential and with restricted or no staking conditions of use. The project area is part of the original reserve for hydroelectric development granted by an Order In Council, and as such is excluded from permanent mineral development[9.2]. There are no existing or past metal mines, developed prospects, or mineral or placer claims in the project area. There have been some exploration activities, primarily near Farrell Creek and on a coal license near Lynx Creek.

Aggregates are relatively scarce in the northeast of British Columbia, but aggregate from private pits near Fort St. John largely meet local needs. There are a number of gravel pits in the project area, including nine Crown-owned pits, larger commercial pits downstream of the project area near Taylor, and a private operating pit (the Goertz pit) at the Halfway River. Current annual demand for aggregates is around 1 million cubic metres. There is more than 12.3 million cubic metres of proven aggregate reserves in the project area[9.1].

There are roughly 7 water licenses in the project area, and several water intakes currently in use along the Peace River.

9.2 Transportation, Infrastructure, Public Health & Safety

The road network in the project area is critical for the movement of people, goods, and materials in the region. Road safety has decreased in the project area in the past decade, with Fort St. John and Dawson Creek areas accounting for most traffic incidents. Road maintenance is often hindered by poor soil and climate conditions, as well as heavy industrial traffic loads. Load restrictions are in place each spring that limit road users to 70-100% of legal axle loading, and commercial and industrial transport companies limit trucking during this season. Highway 29 is the main corridor linking Hudson's Hope with Fort St. John, and several secondary roads also service this area[9.3].

The public currently has access to the Peace River in the project area, and there are four boat launches in the project area. Most sections of the south bank of the Peace River in the project area are only accessible by boat[9.1].

9.3 Culture and Heritage

Over 20 studies and surveys since 1978 have located over 250 pre-contact archaeological sites in the project area. Most pre-contact sites are lithic sites, but several cultural depression sites (cache pits, roasting pits, and house pits) have also been identified.

Thirty-five historic heritage resources have been identified in the project area, including the Rocky Mountain Fort. Fur trade forts and early homesteads are of particular significance, and several other historic sites are potentially of ethnic significance to nearby Athabaskan and Cree communities[9.1].

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Studies of archaeological sites, historic sites, and paleontological sites are ongoing to meet current standards and expectations[9.1]. Heritage site studies to date have largely excluded traditional use sites.

9.4 Recreation and Tourism

The project area is popular for river-based and wildlife-related tourism and recreational activities. While the Peace River is a navigable water way, it does not support significant commercial boating navigation[9.2]. Currently, the river environment of the Peace River is valued, particularly by anglers, for its sense of relative isolation, due to islands that create low line-of-sight interaction with others[9.1]. Currently, the upper reaches of the Moberly and Halfway Rivers are relatively inaccessible[9.1].

While fishing is a popular recreational activity along the Peace River, productivity of the region's fishery is low and the share of total provincial fishing activity is low. Angling activity declined by 9% between 2000 and 2005. Main species caught are arctic grayling, mountain whitefish, rainbow trout, and bull trout. The Moberly and Halfway tributaries provide particularly good angling environments.

The quality and value of hunting along the Peace River is considered above the regional average, and 99% of animals hunted in the project area are deer, moose, elk, and black bear. The proportion of elk in the region has increased since 1996. The number of resident hunters grew by 12% from 1995 to 2005. The hunting season runs from late August to late November. The islands and north shore slopes with a south-facing aspect along the Peace River are where wildlife is more abundant, particularly in the winter. The south shore is currently accessed by hunters by boats launched from Taylor, Halfway River, and Lynx Creek. The project area consists of registered territories of at least four guide outfitters. There are several no-hunting and restricted hunting zones in the project area[9.1].

There are 14 traplines in the project area, but on average only 5% of the total trapline area falls within the project area. Revenue from trapping comes largely from marten, squirrel, and beaver. The value of pelts has increased over the last 4 years.

There are roughly 24 informal recreation reserves and sites in the project area, supporting fishing and hunting, canoeing, hiking, and boating activities. Campsites are the most common feature, followed by boat launches and shore access points. None of these sites are registered with the Crown, or officially recognized by government. The most common outdoor summer recreation activities are camping, fishing, sightseeing, canoeing, boating, and hunting.

Tourism in the project area is limited, and dominated by tourists travelling along Highway 97 to and from Alaska. Accommodation and outdoor adventure

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businesses benefit the most from tourism revenue. The two tourism facilities in the project area are campgrounds. The scenic values along the Peace River have been classified by the Ministry of Forests and Range's Visual Landscape Inventory as Preservation Visual Sensitivity class. The City of Fort St. John Tourism Development Plan 2007-2010 report highlights the lack of campgrounds along the Peace River, and the goals of promoting the natural environment as an attraction, and encouraging the development of industrial tours[9.1].

9.5 Employment & Economic Opportunities, Community Services

The labour market in the project area is tight, with relatively low unemployment. Trades, transport, and equipment operators account for roughly one quarter of the total labour activity in the area[9.1]. The services and construction industries in Fort St. John reported experiencing a labour shortage in 2007, particularly in trades and technical skills[9.1]. The average income in the area is higher than the provincial average, reflecting the relative labour scarcity. Fort St. John experiences relatively large population flows, with a large transient population in the region for seasonal work or short term employment.

The population of the community of Taylor is increasing at around 3-5%, faster than that of Fort St. John. Accommodation vacancy rates in Fort St. John were less than 1% in 2006, but there has been a 12% increase in rental housing stock in the past 3 years. In Fort St. John, there are roughly 12 subdivision projects under construction or planning. Trends in housing starts, listing and sales activity, and housing prices suggest that the development of new houses and sources lag behind demand, and these sources of supply can shrink as demand drops[9.3].

Northern Health is responsible for the delivery of health care in the region, and the Fort St. John Hospital and Health Centre as well as local medical clinics provide access to walk-in clinic services. There are three ambulances stationed in Fort St. John to service the nearby regions, one ambulance in Hudson's Hope, and three ambulances in Dawson Creek.

The Fort St. John's RCMP detachment has one of the highest caseloads in the province, with future deployment not predicted until year 2010. Policing and court services also need expansion. The Fort St. John fire department is planning to build a new fire hall and add a second ladder truck and new water tanker[9.3].

The school district in Fort St. John (School District 60) has seen increasing enrolment, with schools generally considered at or beyond capacity. Fort St. John is home to a First Nations Education Centre and Northern BC Distance Education/Key Learning Centre. Schools in Dawson Creek can accommodate new students[9.3].

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The project area is home to numerous community recreation facilities, and the communities plan to attract visitors to use these facilities as a way of diversifying tourism. Fort St. John has a shortage of soccer pitches and indoor ice rinks.

The project area falls within the financial jurisdiction of the City of Fort St. John, District of Taylor, and Electoral Area C of the Peace River Regional District. Most local government revenues are generated from property taxes, utility shares, and user fees. In the last 8 years, the Dawson Creek and Fort St. John communities have received substantial capital project spending, including funding from the federal government. BC Hydro currently makes contributions to local government revenues as a resident business. Most government expenditures are for transportation and transit, parks, recreation, and culture, as well as protective services and solid waste management[9.1].

The project area has relatively low economic hardship compared with provincial averages, with less of its population reliant on assistance. The region has lower rates of infant mortality and fewer children in care[9.3].

Surveyed local residents have expressed values such as environmental protection, scenic attributes, and preservation of landscapes[9.1].

9.6 First Nations

The project area straddles the traditional territory of several Treaty First Nations, as well as other groups within the Sekani, Slavey, and Beaver people. Sekani groups include the McLeod Lake Indian Band; Slavey groups include the Denet'saa Tse K'Nai First Nation (Prophet Rivet Band); and Beaver or Beaver-Cree groups include the Blueberry River First Nations, Doig River First Nation, Halfway River First Nations, Saulteau First Nation, and West Moberly First Nations[9.1]. The West Moberley and Saulteau First Nations reside mostly within the Peace Moberley Tract, and hold Treaty Rights including fishing, hunting, and trapping rights[9.1]. Key non-Treaty First Nations who reside in the project region are the Tsay Keh Dene Bank and Kwadacha First Nation, as well as four Métis communities[9.2].

Primary economic activities of First Nations communities in the project area include trapping, big-game building, cattle ranching, slashing, fire fighting, silviculture, logging, contract road maintenance, gravel excavation and sales, and backhoe contracting[9.11].

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10. STUDY OF ALTERNATES

10.1 Summary

This section of the report describes the Site C Base Case and each alternate that was evaluated in this study. The alternates were studied to different levels of detail as summarized in Section 10.2.

Layouts were developed so that the key facility characteristics listed in Appendix A1 could be defined for each alternate. The characteristics included the engineering parameters of each alternate as well as defining the physical footprint. A key characteristic used in the review of the alternates is the energy cost relative to the Site C Base Case. The energy cost ratios for the six alternates to the Site C Base Case are shown in Table 10.1.

Table 10.1
Energy Cost Ratio

C1/C2	Wilder Creek	Two Dams	Three Dams	Four Dams	Seven Dams
2.14	1.38	1.55	1.88	2.27	1.76

The energy cost ratio of 1.38 for Wilder Creek means that energy from Wilder Creek would cost 38% more than from the Site C Base Case. All six alternates would cost more to construct than the Site C Base Case and would produce less energy.

10.2 Methodology

Wilder Creek and the two dam cascade (7b/Low C3) are new alternates that had not been previously studied. Layouts for these alternates were, therefore, developed and the dimensions of the various components determined in sufficient detail to allow the major quantities to be estimated so that the facility characteristics, including comparative energy costs, could be determined.

Dams at C1 and C2 had been previously studied and the facility characteristics were based on the previous work. Since the previous study, the MDE has been increased and allowances for the measures required to mitigate rebound for the Site C Base Case have been made. The intent was to update the previous study to include allowances for the increased MDE and the measures required to mitigate rebound at C1/C2 only if the initial screening (Section 12.1) indicated that one of the axes could be competitive with the Site C Base Case.

A cursory evaluation had previously been done of three and four dam cascade alternates, which had developed layouts based on the topography at Site C and assumed that suitable, topographically similar sites could be found upstream. In

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this current study, it was assumed that the dam locations and layouts would be as identified in the previous evaluation, however the dimensions of the various components were updated so that the facility characteristics could be determined on a consistent basis with the other alternates. The intent was to undertake detailed topographic studies, detailed layouts and cost estimates for dams 3a and 3b, and/or 4a, 4b and 4c, only if the initial screening (Section 12.1) indicated that the three dam and/or four dam cascade could be competitive with the Site C Base Case.

The seven dam cascade had been previously studied and was updated so that the facility characteristics would be determined on a consistent basis with the other alternates. In particular, allowances were made for increasing the spillway capacity to the PMF and increasing the number of anchors to withstand the new MDE. The intent was to undertake detailed studies, (increasing the maximum normal reservoir level at dam 7a and replacing the post tensioned anchors with mass concrete), only if the initial screening (Section 12.1) indicated that the seven dam cascade could be competitive with the Site C Base Case.

10.3 Energy and Cost Considerations

The two single dam alternates would develop less head than the Site C Base Case and would therefore produce less power and energy.

As discussed below, from an energy cost perspective, the cascade alternates have two significant disadvantages:

- multiple dams are less energy efficient; and
- multiple dams cost more to build.

Hydraulic head (e.g., the difference between the river level at PCN and Site C) is a measure of the potential energy that can be developed. As water flows through the intakes, penstocks and powerhouse at a hydroelectric dam, some of this energy is dissipated (i.e., lost) due to friction and turbulence. In a cascade, the water passes through multiple dams so the head losses are greater than for a single dam. For example, at maximum discharge from PCN, the hydraulic head between PCN and Site C is 50 m. At this flow, the head losses for the Site C Base Case would be 1.2 m and the total head losses for the three dam cascade would be 3.4 m. An additional 0.2 m of head would be lost in the cascade due to backwater effects at the two upstream dams. The net head available for generation at the Site C Base Case is, therefore 48.8 m and for the three dam cascade it is 46.4 m, which means that about 5% of the energy potential would be lost because of the additional head losses in the cascade.

Using a simple methodology for checking first order of magnitude costs for hydro projects, based on a statistical analysis of cost data from over 170 projects[10.1], a

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three dam cascade alternate would be expected to cost in the order of 60% more than the Site C Base Case. The dams themselves are lower and, therefore, each dam costs less. However, there are more dams. In addition, each dam has to have a spillway to pass floods, and intakes and penstocks to convey the water to the powerhouse. The peak PMF inflow at Site C is 20,810 m^3/s but the peak spillway outflow from the Site C Base Case is 17,500 m^3/s. This attenuation (reduction) of the flood outflow occurs because the reservoir level rises during the PMF, thereby storing water which is released later. The lower cascade dams have smaller reservoirs and attenuate the flood less, requiring larger spillways. The three spillways in the three dam cascade would have 26 large spillway gates compared to six for the Site C Base Case, resulting in the total volume of concrete being 3.5 times greater. The lower head at each cascade dam means that larger turbines would be required to pass the maximum power flow from PCN. For the three dam cascade, 7.2 m diameter turbines would be required, compared to 6.7 m diameter for the Site C Base Case, resulting in a total powerhouse volume 3.6 times greater.

10.4 Site C Base Case

10.4.1 Topography

Downstream from PCN the Peace River has eroded through overburden and into the underlying sedimentary rock. The river has formed a broad, flat bottomed valley up to 230 m below the top of the surrounding plain, which is part of the Alberta Plateau. The maximum normal reservoir level of Site C has been fixed at El. 461.8 m by the tailwater level at PCN.

At Site C the river occupies a broad U-shaped valley about 1 km wide. The left (north) bank rises steeply from the river at El. 410 m to about El. 570 m, 100 m above the crest of the dam and then rises relatively gently to El. 610. The right bank rises steeply to El. 450 m where a broad terrace is located. The terrace rises gently to El. 480 m followed by a relatively flat slope to El. 630 m.

Site C is located at river marker 105.5.

10.4.2 Site Geology

Extensive investigations have been carried out at Site C since 1976 and as of June 2008, approximately 868 boreholes had been drilled and 275 test pits had been excavated. There has been extensive field and laboratory testing of the bedrock and overburden.

Shale bedrock is exposed along the left bank at El. 467 m and at El. 445 m on the right bank. Bedrock in the river is up to 18 m below the surface elevation of the island in the middle of the river.

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The steep slope of glaciolacustrine silts and clays on the left bank is actively slumping and sliding and would have to be stabilized in order to construct the dam.

The bedding of the shale dips 1° north. There are a number of discontinuities within the bedrock consisting of inclined relaxation joints generally parallel to the river; nearly horizontal bedding plane discontinuities; and cross-cutting shear zones.

Bedding plane discontinuities are typically found either adjacent to concretion layers, sandy-silty laminations or within weaker units. Most are discontinuous hairline partings with little or no infilling; however some appear to be continuous and infilled with silty clay. Significant bedding planes are:

- BP-8 which is a white clay possibly from volcanic ash;
- BP-12 which is a layer of marl;
- BP-18 which is significant due to its continuity and silty clay infill;
- BP-25 which is significant due to its weakness, continuity, and location;
- BP-28 which is significant due to its weakness, continuity, and location approximately 2 m below the bedrock surface in the river channel; and
- BP-31.

BP-25 is a continuous discrete, weak plane found on both banks near river level at the base of a 1.7 m thick weak, black shale bed which in turn lies below a massive, unjointed siltstone bed. There is some evidence of poorly developed slickensides oriented approximately perpendicular to the river in BP-25 beyond the relaxed zone in the right abutment. Clay-size materials are almost always found on BP-25, formed either as gouge from shearing movements or from softening of the shale by groundwater circulation. Although this clay sized material is commonly observed, there are locations where it is not present and rock to rock contact occurs. It is located at approximately El. 416 m under the right bank and governs the stability of the spillway.

BP-31 is the deepest continuous bedding plane discontinuity recorded within the shale under the proposed power intake structure. It is a continuous discrete, planar, surface found on both banks. Clay-size materials are found within the bedding plane discontinuity as either gouge from shearing or from softening of the shale by groundwater circulation. It is located at approximately El. 389 m under the right bank and governs the stability of the power intakes and penstocks.

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The foundation rock at Site C is susceptible to short term and long term swelling (called rebound).

Short term swelling due to the removal of the weight of soil and rock during excavation would be addressed during construction with careful foundation treatment and construction planning. The design of the spillway, power intakes, penstocks and powerhouse would have to consider long term swelling, which would occur over decades under those parts of the project where the weight of the structure is less than the weight of soil and rock excavated to reach the foundation of the structure. The majority of the concrete structures on the right (south) bank are susceptible to rebound due to the depth of excavation.

10.4.3 Layout

Figure 10-1 shows the general arrangement of the Site C Base Case.

The dam would be a zoned earthfill dam consisting of a central impervious core with outer shells of sands and gravels. The dam would be approximately 1120 m long at the crest (Figure 10-2) and 60 m high above river level (Figure 10-3). The base of the impervious core would be set in a trench excavated through the river bed and into the base rock to provide a watertight seal (Figure 10-3).

A major excavation would be required to stabilize the left bank slope above the dam, which would involve removing approximately 18 million m^3 of earth material.

The spillway, power intakes, penstocks and powerhouse would be located adjacent to the dam on the right bank terrace (Figure 10-4). An approach channel would convey water from the reservoir to the spillway and the power intakes.

The power intakes would convey water from the reservoir to the turbines. The intakes would be located adjacent to the spillway structure and would be 96 m in total width and approximately 40 m high. There would be six separately gated openings each connected by a steel penstock to a turbine in the powerhouse (Figure 10-5). The 9.35 m diameter penstocks would be encased in concrete and partly buried in granular backfill behind the intake structure. The powerhouse would contain six Francis turbines and associated generators rated at approximately 150 MW each (total 900 MW) under a net head of 48.8 m.

The spillway would have gated headworks with a concrete lined chute leading to a submerged stilling basin energy dissipater (Figure 10-6). The energy dissipater would absorb sufficient energy from the spillway discharge to prevent downstream erosion from endangering the dam or power station. The spillway would have six radial gates with sills at El. 446.5 m.

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Following transformation to 138 kV, power from the generators would be delivered by cable to the switchgear building located above and to the south of the power station.

10.4.4 Allowances for Rebound Mitigation and Seismic Stability

The potential for foundation rebound at Site C was first identified in the 1980s, but the work on the project was postponed before assessment and field testing could be done. A preliminary evaluation of the potential long term rebound including laboratory testing of shale samples was done in 1990, but work on the project was terminated before the results of this evaluation could be integrated into the design.

During Stage 2, conceptual methods for mitigating rebound were assessed. It was concluded that movement due to rebound could be limited to acceptable levels by the following methods:

- increasing the foundation pressures by adding weight to the structures;
- adding anchors to load the foundation;
- changing the excavation profile and the shape of structures to minimize differential rebound; and
- articulating the structures to allow for movement without damage.

Allowances for rebound mitigation using the above conceptual methods were developed and incorporated into the cost estimate for the Site C Base Case.

The MDE described in Section 5.2 is larger than used in earlier studies. The stability of the earthfill dam under the new MDE was assessed and no changes were required to the dam section to provide adequate seismic stability. The seismic stability of the left bank was also assessed and it was found that the slope had to be flattened to 1V:4H to provide adequate seismic stability.

The spillway headworks and the power intakes retain the reservoir and must be designed for the same extreme loads as the dam. The earlier design of these structures was governed by normal conditions, i.e. static loading. However, seismic loading now governs the stability of these structures due to the increase in the MDE.

During Stage 2, conceptual methods for improving the seismic stability of the structures were assessed. It was concluded that adequate stability could be provided by:

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- installing large diameter reinforced concrete piles under the spillway headworks to increase the sliding resistance along BP-25; and

- installing drainage tunnels into the rock beneath the spillway, power intakes and penstocks.

Allowances for improving the seismic stability using the above conceptual methods were developed and incorporated into the cost estimate for the Site C Base Case.

10.4.5 Sequence of Construction and River Diversion

It would take approximately seven years to construct the dam and structures. The four main activities would be:

- pre-diversion work;

- work undertaken during river diversion;

- reservoir filling; and

- commissioning of the generating units and completion of the project.

The pre-diversion work would take approximately 21 months and include:

- construction of access to the dam site and associated facilities; the bridge and roads would be permanent, except for those roads to the construction camps, borrow areas and sites for relocation of surplus excavated materials;

- construction of the diversion tunnels and portions of the cofferdams required to divert the Peace River during construction;

- construction of low cofferdams to isolate excavation areas on the left and right bank from the river;

- construction of dykes along the left bank of the river to contain some of the relocated surplus excavated materials; and

- excavation of the bulk of the overburden and rock on both banks.

Two 9.8 m diameter concrete lined tunnels would be constructed through the right (north) bank for river diversion. The tunnels would be approximately 790 m and 890 m long. Each would have a gated concrete intake structure at the upstream end.

After completion of the two diversion tunnels, the Peace River would be diverted through the tunnels by completion of the upstream and downstream cofferdams

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across the river. During the 46 month diversion period, the earthfill dam would be constructed incorporating the upstream and downstream cofferdams into the dam and the main structures on the right bank would be completed. In addition, the mechanical and electrical work for the first two generating units would be completed.

After the earthfill dam, spillway, power intakes, penstocks and powerhouse structure have been completed, the reservoir would be filled which would take approximately two months. Testing and commissioning of the first two generating units would commence as soon as the reservoir had been filled.

During filling of the reservoir, one tunnel would be closed using the intake gate and permanently blocked with a concrete plug. Until the reservoir reached the spillway crest level, water would be released through the second tunnel to satisfy downstream requirements. This tunnel would then also be closed and plugged.

After reservoir filling it would take about 15 months to complete and commission all of the generating units and complete the remainder of the project including final paving, landscaping and reclamation.

10.4.6 Highway 29 Relocation

Four sections of Highway 29 totalling approximately 23 km would be relocated to avoid the area flooded by the reservoir. New bridges would be constructed at Halfway River, Cache Creek, Lynx Creek and Farrell Creek.

10.4.7 Transmission

The Site C Project would be connected to the existing provincial transmission system by two 500 kV transmission lines that would run from Site C to the existing Peace Canyon Generating Station via an existing 76 km transmission corridor presently used by two 138 kV lines. Line terminations and associated switching facilities would be installed at both Site C and Peace Canyon. This equipment could be accommodated within the existing substation boundaries at Peace Canyon and within the development area at Site C.

10.5 Axis C1 or Axis C2

10.5.1 Topography

Axis C1 is located at river marker 100 (Figure 10-7) and axis C2 is located at river marker 102.5 (Figure 10-9). Both axes are located between Tea Creek and the Moberly River. In this section of the Peace River valley the left bank rises steeply for nearly 230 m to the plateau at about El. 640 m. The lower part of the right bank has a relatively flat slope to El. 490 m and then rises steeply to the

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plateau at about El. 625 m. At these two axes the valley walls would be up to 170 m above the crest of the dam (Figures 10-8 and 10-10).

The flatter slopes and the presence of the right bank terrace make Site C significantly more attractive topographically than axis C1 and C2.

10.5.2 Site Geology

The 6 km length of the north bank of the Peace River between Tea Creek and the Moberly River is an area where the post glacial Peace River left its ancestral valley and cut down through bedrock to form a new bedrock valley 4 km to 5 km north of the old valley. The south side of the current valley is a relatively flat, vegetated slope formed for the most part by inactive slumps and river terraces. The north side of the valley is steeper, less vegetated and is actively eroding and slumping. Many of the slumps seem to be associated with a thin white clay layer near El. 432 m, which forms a boundary between disturbed rock above and undisturbed rock below.

The inherent slope instability is a significant issue for the construction of a dam. Slopes can become destabilized due to the excavations required for access roads and structures. Major additional excavations are required to stabilize slopes and remove active slides.

Three old bedrock slides and one slope with potential for sliding have been identified on the north bank between Tea Creek and Site C. Immediately downstream of axis C1, the north bank is 120 m high and slopes at about 40°. This steep raveling slope could be the result of either a slide of about 1 million m^3, or gradual sloughing of surface layers due to river erosion. A small amount of debris from this sloughing remains along the river's edge.

The following three slides have been identified on the north bank at or near axis C2:

- a rotational bedrock slump consisting of about 3 million m^3 of disrupted shale;
- a slide of about 2 million m^3 of overburden and rock that originated from the top of a steep slope and travelled to the river; and
- a slump of about 3 to 4 million m^3 of highly disrupted rock with similar features to the first slide listed.

The first two slides listed above are contiguous and the third slide is a short distance downstream. The three slides form an unstable section of bank nearly 2 km long.

At axis C1 the following overburden depths were assumed[3.4] (Figure 10-8):

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- across the river the overburden depths shown on the borehole logs for holes C1 to C7 drilled at the axis in 1971;
- 15 m on the left slope; and
- on the right slope 15 m at the river and 46 m at El. 457 m.

The bedrock surface beneath the top of the left bank was assumed to be at El. 580 m and the bedrock surface beneath the right bank was estimated to be at El. 550 m by assuming the dip of the bedrock surface across the valley is the same as at Site C[3.4].

At axis C2 the following overburden depths were assumed[3.4]:

- 24 m near the right bank of the river channel and 6 m near the left bank of the river;
- 24 m on the left slope and 6 m near the river; and
- 24 m on the right slope.

The bedrock surface beneath the top of the left bank was assumed to be at El. 590 m. Photographs taken during the site reconnaissance in November 2005 showed a shale outcrop between El. 540 m and El. 590 m.

Based on the observations made during the site reconnaissance, it was considered that the most plausible bedrock surface elevation on the right bank was El. 580 m.

The following weak planes parallel to bedding were assumed at both axes[3.4] (Figures 10-8 and 10-10):

- weak clay seams beneath the river encountered in boreholes C3 to C6;
- a thin white clay layer BP8 at El. 432 m; and
- the bedding planes found at Site C were assumed to occur at axis C1 and were projected from Site C to the axis based on the bedding plane dip observed at Site C.

The properties of the shale bedrock at both axes were assumed to be the same as Site C.

10.5.3 Layout

Layouts for axis C1 and axis C2 are shown in Figures 10-7 and 10-9, respectively. The foundation conditions preclude the use of concrete gravity

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dams and the layouts are based on the well developed layout for the Site C Base Case. The earthfill dam, spillway, power intakes, penstocks and powerhouse would be the same as at Site C except as discussed below.

At both axes considerable excavations would be required to stabilize both steep high banks.

Features that have a significant effect on the cost of the dam at axis C1 are as follows:

- the large amount of slide debris that would have to be excavated for the foundations of the earthfill dam and the right bank structures; and
- the excavated slope at the right bank structures would be about 200 m high, 115 m in rock and 85 m in overburden (in comparison the excavation at Site C has a total slope height of about 45 m).

The total quantity of excavation at axis C1 would be over 100 million m^3 more than at Site C and the total volume of dam fill would be over 10 million m^3 more.

The upstream end of the diversion tunnels at axis C1 would be complicated by the proximity to Tea Creek. With the upstream portal as shown on Figure 10-7, it should be possible to pass under Tea Creek; however that would need to be confirmed as the bedrock levels in that area are not known. The construction of the upstream cofferdam and tunnel portals may be complicated by any flow from Tea Creek; therefore a plan would be required for dealing with Tea Creek flows. The inside tunnel would have a length of about 926 m and the outside tunnel would have a length of about 1041 m. It might be possible to move the tunnel portals to the east side of Tea Creek which might require moving the dam further downstream. While this could allow for shorter tunnels it would add the risk of debris flows from Tea Creek blocking the diversion tunnels.

Features that have a significant effect on the cost of the dam at axis C2 are as follows:

- the large amount of slide debris that would have to be excavated for the left bank stabilization, the earthfill dam and the right bank structures; and
- the excavated slope at the right bank structures would be about 200 m high, 145 m in rock and 50 m in overburden, compared to a total slope height of about 45 m at Site C.

The total quantity of excavation at axis C2 would be about 95 million m^3 more than at Site C and the total volume of dam fill would be about 8 million m^3 more.

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It was necessary to move the upstream and downstream tunnel portals further into the hillside to provide sufficient rock cover for the assumed overburden depths. The inside tunnel would have a length of about 457 m and the outside tunnel a length of about 657 m. This reduces the length of the tunnels but increases the volume of excavation for the portals. There is a risk that the downstream end of the tunnels could be located in slide debris, in which case the tunnels would have to be extended up to 400 m downstream to avoid the slide area.

10.5.4 Adjustments to Site C Base Case Design Allowances

The 2006 study[3.4] concluded that the fully loaded construction costs at axis C1 and C2 (taking into account interest during construction) were essentially the same, and each about 2.3 times the cost of the Site C.

Since the cost of development at axis C1 or C2 is significantly greater, the cost estimate was not updated to include allowances for the increased MDE, or the measures required to mitigate rebound. The intent was to do this work only if the initial screening (Section 12.1) indicated that one of the axes would be competitive with the Site C Base Case.

Preliminary estimates indicate that updating the cost estimate to include these allowances could increase the cost from that used in this study by about 15% for flattening the excavated slopes on both banks for seismic stability; upgrading the seismic stability of the structures; and rebound mitigation.

10.6 Wilder Creek

10.6.1 Topography

The Wilder Creek site is located at river marker 94, immediately downstream of the confluence of Wilder Creek and the Peace River and approximately 11.5 km upstream of Site C (Figure 4-1). The site is topographically suitable due to the relatively flat, wide natural terraces that exist on both banks at this location, which are not much higher than the reservoir full supply level, El. 461.80 m.

The river valley floor lies at approximately El. 417 m. The valley width, approximately 1 km, is similar to the width at Site C. The left and right river banks rise up to the terraces at relatively steep slopes of approximately 1.5H:1V, giving the river valley a fairly uniform cross-section. The left bank terrace is approximately 50 m above river level at El. 468 m and up to 200 m wide. The right bank has two terraces approximately 60 to 70 m above river level at El. 475 m and El. 485 m, respectively and is up to 400 m wide in total. Beyond the terraces, the valley sides rise up to the upper plateau at varying slopes flatter than about 2H:1V.

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10.6.2 Site Geology

On the left bank downstream from the dam location, the topography indicates debris slides from a fairly deep eroded channel. There is evidence of a large number of landslides and earth flows on the left bank. The Wilder Creek valley itself appears to be deeply incised and its appearance is unlike any other tributary channel in the area.

Although shale bedrock is not exposed along the river banks at the proposed Wilder Creek axis location, terrain mapping and shoreline stratigraphy investigations carried out in 2008 mapped bedrock exposures up to approximately El. 476.0 m on the right (south) bank, 2.9 km downstream of the axis location.

As part of the assessment of the Wilder Creek site, a two day field reconnaissance trip was undertaken by senior geotechnical engineers from KCBL and SLI. The objective of the trip was to make general observations of terrain features and possible bedrock outcrops at the site for the purpose of assessing the suitability of the Wilder Creek site. Based on all available sources of information, bedrock was estimated to be at approximately El. 462 m on the right bank where the structures would be located.

The Wilder Creek site has not previously been investigated and very little information exists regarding the foundation and general geological conditions. Since little information is available, the assessment of the Wilder Creek site assumed that foundation and general geological conditions were similar to those at Site C, for which extensive information is available, i.e. for the purposes of the technical assessment, the foundation and general geological conditions at the Wilder Creek site were assumed to be no better or no worse than at Site C. This assumption could only be confirmed through detailed site investigation but seemed fair given the available information and limited reconnaissance undertaken.

10.6.3 Layout

The Wilder Creek site is topographically similar to Site C (Figure 10-11) and the site is assumed to be geologically similar to Site C; therefore the same type and proportions of earthfill dam would be assumed. The power flows and flood flows are the same; therefore the size of the power intakes, penstocks and spillway would be the same as for the Site C Base Case.

Cursory consideration was given to separating the power facilities and spillway onto opposite banks of the river in an attempt to minimize overall excavation quantities on the right bank. This could, however, potentially impact construction sequencing, the alignment and construction of the diversion tunnels as well as

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increase tailrace excavation requirements. This concept was thus not pursued and the Site C Base Case configuration was used for the Wilder Creek alternate.

As shown on Figure 10-12, the project would comprise the following major components:

- a 53.6 m high earthfill dam (crest El. 469.4 m);
- a six bay, reinforced concrete, radial-gated spillway with a reinforced concrete stilling basin;
- a reinforced concrete intake headworks structure feeding six 9.35 m diameter steel penstocks; and
- a reinforced concrete powerhouse with six vertical axis Francis turbines.

The structures would be arranged on the right bank terrace and a trapezoidal approach channel would be excavated into bedrock to El. 435 m to convey flow from the reservoir to the spillway and power intakes.

During construction of the earthfill dam, the river would be diverted through twin 9.8 m diameter tunnels on the left bank. The dam axis was set sufficiently downstream of Wilder Creek to facilitate tie-in of the upstream diversion tunnel portal into the embankment. The axis location also maximized the shortest cross-valley width while providing sufficient room to accommodate the layout of the right bank structures on the available terrace space.

The Site C Base Case project arrangement requires a significant excavation (+/-18 million m^3) to stabilize the left bank above the dam. The 200 m wide terrace on the left bank at the Wilder Creek site could potentially eliminate such an excavation if the bedrock profile at the valley side walls is confirmed to be relatively close to the surface. For the purposes of the evaluation of the Wilder Creek site, the reasonable assumption was made that exposing bedrock at both abutments would not require significant excavation into the valley walls and thus no left bank excavation would be required to stabilize overlying overburden materials.

Access to the dam site would be via a new access road on the left bank that would be constructed down from the plateau to the terrace. The access road would tie onto the crest of the dam and also lead to a new access bridge that would be located approximately 1 km downstream of the dam and which would provide access to the powerhouse on the right bank. It was assumed that this road could be constructed without destabilizing any of the landslide debris.

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Laydown areas during construction would utilize the left and right bank terraces, as well as open space available on top of the plateau at the start of the new left bank access road.

Transmission would be via two proposed 500 kV lines running from the switchgear building on the right bank to the existing 138 kV transmission line corridor that currently exists on the south bank and runs to PCN (see Figure 4-1). This transmission corridor would be widened to accommodate the two new 500 kV proposed lines.

10.6.4 Adjustments to Site C Base Case Design Allowances

For the purposes of estimating the direct construction costs for the project at Wilder Creek, the same design allowances adopted in the Base Case design were applied to the project components at the Wilder Creek site. Modifications and adjustments were, however, made to accommodate the project parameters and site specific topography at the Wilder Creek site. For example, the dam at Wilder Creek is 6.4 m lower than at Site C (due to the river gradient), and the volume of dam material is a function of the crest length and the height of the dam. The quantities of the dam materials at Wilder Creek were estimated from the Site C Base Case volumes by the ratios of the crest length and dam height at each site. Since the crest lengths are essentially the same and the dam is 6.4 m lower at Wilder Creek than at Site C, the volume of dam material at Wilder Creek is less than at Site C. Typical dam cross sections for the Wilder Creek site are presented on Figure 10-13.

The average natural ground level of the right bank terraces at Wilder Creek is higher than at Site C. This would result in substantially more overburden and rock excavation for the right bank structures (predominantly for the approach channel) than at Site C.

The measures developed during Stage 2 to mitigate rebound at Site C are described in Section 10.4.4. These same rebound mitigation measures were assumed at the Wilder Creek site. Adjustments were made to take into account the shorter spillway chute and penstock lengths at Wilder Creek (due to higher base elevations of the spillway and powerhouse) and greater height of excavated material over the spillway due to the higher natural topography of the right bank terrace.

To enable the structures to withstand the updated MDE, the Site C Base Case allowances developed during Stage 2 described in Section 10.4.4 were adopted at the Wilder Creek site.

A typical section with details of the design allowances adopted for the spillway section at the Wilder Creek site is presented on Figure 10-14. Similarly,

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Figure 10-15 provides details of a typical section through the intake, penstocks and powerhouse at Wilder Creek.

10.7 Two-Dam Cascade

10.7.1 Topography and Site Geology

The upstream dam would be located at river marker 39.5, slightly upstream from the second site of the seven dam cascade and therefore this location is known as site 7b.

As shown in Figure 10-16, site 7b is located just upstream of the boundary between the rocks of the Gates Formation and the Shaftesbury Formation. The site is dominated by sandstone islands and near vertical riverbanks, creating two river channels. It was assumed that the foundations for all structures would be entirely in the better rocks of Gates Formation.

The downstream dam would be located at river marker 105.5 (Site C, axis C3) and is known as Low C3. See Sections 10.4.1 and 10.4.2 for descriptions of the topography and geology of Site C.

10.7.2 Dam 7b layout

The general arrangement of dam 7b is shown on Figure 10-16. The intakes, powerhouse and a three bay gated regulating spillway and diversion sluiceway would be constructed in the north channel between the mid-channel island and the north river bank (Figures 10-17 and 10-18). A concrete gravity dam section would connect the powerhouse to the north bank. A roller compacted concrete (RCC) dam with an overflow spillway would be constructed in the south channel between the island and the south river bank (Figure 10-19).

Construction of the powerhouse and spillway/diversion facilities in the dry (Figures 10-16 and 10-20) would be done by closing off the north channel by two cofferdams, and confining the river flows to the south channel during Stage 1 of the diversion. As the north end of the concrete gravity dam crosses Highway 29, the north end of the dam would be constructed first so that the highway could be relocated beyond the end of the structure with minimum disruption to traffic.

When the structures across the north channel were complete enough to sufficiently retain the forebay during Stage 2 of the diversion, and the spillway was able to pass flows through the sluices temporarily without rollways, the north channel cofferdams would be removed and replaced by two cofferdams across the south channel. The river flows would then all pass through the three spillway/diversion sluices.

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With the south channel closed off and dewatered, the RCC dam and overflow spillway would be completed within one year. During this period, the powerhouse and upper part of the gated spillway would be completed in the north channel, along with unit installation. The spillway rollways would be constructed in the spillway, bay by bay, during the low flow period of the year. When the last rollway was closed off for construction, impounding would occur. The downstream cofferdam would be removed from the right channel, and the overflow spillway on the RCC dam would be ready for use.

10.7.3 Layout of Low Dam at C3

For the two dam alternate, the maximum normal reservoir level at Site C would be 15.1 m lower than for the Site C Base Case. For this alternate, it was assumed that the layout for the low dam at C3 would be the same as for the Site C Base Case with all structures lowered by 15.1 m.

As an alternative to the earthfill dam for the low dam at Site C, the use of a RCC gravity dam was investigated. The construction of a RCC gravity dam on weak rock foundations is without precedent and therefore the following staged approach was used in the conceptual design:

- the stability of the RCC dam along the concrete/bedrock contact was assessed by conventional rigid block methodology for various load cases and a conceptual layout was developed, upon which a cost estimate could be based;

- if the RCC dam option appeared to be significantly lower cost than the earthfill dam option, then further detailed analyses would be done to assess how the relatively rigid RCC structure would behave on the more flexible rock foundation and to establish whether it would be feasible to actually construct a concrete gravity dam on these foundations; and

- if the cost estimate for the RCC dam option was significantly more than the earthfill dam option, then no further analyses would be done and the RCC dam option would not be pursued further in this study of alternatives.

The advantage of the RCC dam option is that it would allow the power intakes, powerhouse and spillway to be constructed in the river channel and not on the right abutment as is the case with the earthfill dam, thus eliminating the approach channel to these structures on the right abutment and the associated earthworks and foundation rebound problems.

Stability analyses for the RCC dam option was done for a number of load cases and the shape of the concrete gravity dam was determined by iteration so that the stability requirements were met for all load cases. The load cases considered were:

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- a “creep” load case with the reservoir at the maximum normal level, normal tailwater level and an assumed strength of the concrete/rock contact of cohesion equal to zero and friction angle equal to 8°;

- static loads with maximum normal reservoir level immediately after construction, where high uplift pressures are expected to occur in the bedding plane prior to the dissipation of excess pore pressures caused by the weight of the dam;

- normal loads with reduced uplift pressures assuming a drainage system at the upstream end of the dam;

- normal load as above but including ice loads for the winter load case;

- flood loads with PMF water levels in the reservoir and tailrace and associated increased uplift pressures; and

- pseudostatic and hydrodynamic seismic loads for the MDE (PGA of 0.23g).

In all cases, except the “creep” load, the assumed strength used for the concrete/rock contact was cohesion equal to zero and friction angle equal to 13.5°. This assumes a low strength bedding plane at or just below the RCC/rock contact.

The following uplift conditions were assumed:

- <u>for all cases other than construction and seismic:</u> the uplift pressure under the drainage gallery in the dam, nominally located 3 m from the upstream face of the dam, was reduced to 1/3 of the difference between the headwater and tailwater pressure plus the tailwater pressure, with a linear distribution from the reservoir pressure at the upstream heel and tailwater pressure at the downstream toe to the pressure at the drains;

- <u>construction:</u> uplift along the bedding plane equal to 0.2 times the weight of the dam directly above the plane; and

- <u>seismic:</u> the uplift pressure at the line of the drains was zero with a linear distribution from the reservoir pressure at the upstream heel and tailwater pressure at the downstream toe to the pressure at the drains.

The drainage gallery would be located beneath tailwater level and seepage water into the gallery would be pumped out. Due to the low permeability of the shale bedrock, the seepage into the gallery would be low. The assumption for all cases other than construction and seismic assumes that the pumps are not operating as expected and that the gallery drains by gravity to tailwater. This allows for sufficient time to undertake additional drainage measures if a lower

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than expected drain efficiency is measured after the reservoir has been filled, and also means that the dam would remain stable if there was a long duration failure of the pumping system. The assumption for seismic assumes that the pumps are operating as expected when the MDE occurs.

In order to achieve the required stability for all of the load cases except for the seismic load case, the shape of the RCC dam had to have both the upstream and downstream faces sloped at 1V:0.7H with a crest width of 6 m. This shape is closer to that normally used for a rockfill dam and is without precedent when considered for a RCC dam.

No reasonably practical shape for the RCC dam could be found to satisfy the seismic load cases. As the friction angle was only 13.5°, the horizontal resistance on the sliding plane is given by the vertical force times the tangent of the friction angle, i.e. 0.24 times the weight of the dam on the bedding plane. But the driving force under seismic loads includes the hydrostatic and hydrodynamic loads from the reservoir plus approximately two thirds of the PGA of 0.23g, namely 0.15 times the weight of the dam. Very flat upstream and downstream slopes of the RCC dam were required to satisfy the seismic stability criteria by the mass of the dam alone. Such flat slopes were considered to be completely unpractical to construct using RCC and completely uneconomic.

To improve the seismic resistance of the RCC dam to seismic loads, the shear resistance of concrete piles constructed across the sliding plane was considered. These piles effectively introduce an equivalent cohesion on the bedding plane that governs the sliding stability. The use of large reinforced concrete piles for this purpose is also without precedent. For the seismic load case, rows of 1.35 m diameter reinforced concrete piles would have to be drilled from the concrete dam into the rock below the dam, at 5 m spacing both ways for the full width under the RCC dam, each row containing 17 piles in the upstream/downstream direction.

The estimated capital cost for the RCC alternative was considerably higher than for the earthfill dam and therefore this option with the RCC dam across the whole width of the river was not pursued further.

A variation of the RCC dam was also investigated using RCC in the river channel for the power intake and spillway sections of the dam only and the earthfill dam for the remaining width of the river channel. Large RCC gravity retaining walls would have to be constructed to contain the earthfill adjacent to the spillway section. The earthfill dam would occupy approximately 70% of the total width of the river channel with the remaining 30% occupied by the retaining wall, spillway intake and powerhouse and a RCC wing dam up the right abutment.

The retaining walls would form one of the spillway training walls in addition to retaining the earthfill dam. To achieve the required stability of these walls, the

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back face against the earthfill dam would have a slope of 1V:1H. All load cases were met except for the seismic load case. Reinforced concrete piles were required under the retaining wall across the low strength bedding plane to provide an effective cohesion on this bedding plane to increase the strength to meet the seismic load case acceptance criteria. This type of retaining wall with piles on the low strength bedding plane is without precedent.

The estimated capital cost of this hybrid alternative was lower than that for the full RCC dam, but was still higher than that for the earthfill dam option. As the design and construction uncertainties for such a hybrid RCC/earthfill dam are significantly higher than those for the more conventional earthfill dam alternative, the hybrid alternative was not pursued further in the study of alternatives.

10.8 Three Dam Cascade

10.8.1 Topography and Site Geology

The three dams would be located at river markers 47, 83.5 and at Site C (Figure 3-2). Detailed topographic studies were not done for the two upstream dams. The approach was to determine the layout for dam 3c located at Site C where the topography and geology are well known, and then assume that the layouts would be similar at the two upstream dams and make allowances for the possible differences in topography. The intent was to do detailed topographic studies, detailed layouts and cost estimates for dams 3a and 3b only if the initial screening (Section 12.1) indicated that the three dam cascade would be competitive with the Site C Base Case.

10.8.2 Layout

The same layout was adopted for this study as was developed in the 2002 cursory evaluation (Figures 10-26 and 10-27) with changes as described below.

It was assumed that the same cutoff depth would be required beneath the earthfill dam as for the Site C Base Case, as alluvium in the river bed and the weathered rock beneath the alluvium would have to be excavated to provide a sound cutoff. The width of the bottom of the cutoff would be 0.8 times the head, the same criterion used for the Site C Base Case.

The crest length of the earthfill dam would be about 700 m as the concrete structures would be located in the river bed. The volume of fill in the dam and cutoff would be approximately 3 million m^3.

The left bank above the dam would require flattening as slides onto the earthfill dam could not be tolerated. The length of the excavation would be less than for the Site C Base Case due to the shorter base width of the lower dam. Approximately 7.6 million m^3 would require excavation from the left bank. It was

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estimated that 1 million m^3 of excavation would be required to stabilize the right bank.

Due to the small size of the reservoirs impounded by the low dams, it was assumed that there would be minimal attenuation of the PMF; therefore the spillways would have to be designed to pass the full PMF inflow. Due to the low head, it was assumed that the spillway would be constructed with the gate sills just above the normal tailwater level. The spillway at dam 3a would require six gates 17 m high by 14.7 m wide, and the spillways at dams 3b and 3c would each require ten gates 18.0 m high by 17.5 m wide. The left side walls of the spillways would retain the dam fill. Since the wider spillways would be required due to the lower head, the total volume of spillway concrete for the three dams would be about 3.5 times the volume in the Site C Base Case spillway.

The power intakes and penstocks would be similar in size and arrangement to those for Site C Base Case. The total volume of concrete in the intakes for the three dams would be about 3 times the volume in the Site C Base Case intakes.

The head on each of the dams would be about one third of the head on the Site C Base Case but the power flow would be the same; therefore the turbine diameters would be larger. Each powerhouse in the three dam cascade would have six 50 MW units with 7.2 m diameter propeller turbines compared to the 6.7 m diameter Francis turbines in the Site C Base Case powerhouse. As a result, the dimensions of each powerhouse in the three dam cascade would be about 7.5% greater than the Site C Base Case powerhouse resulting in a total volume of powerhouse concrete 3.6 times greater than for the Site C Base Case powerhouse.

10.9 Four Dam Cascade

10.9.1 Topography and Site Geology

The four dams would be located at river markers 45, 67, 87.5 and at Site C (Figure 3-3). Detailed topographic studies were not done for the three upstream dams. As with the three dam cascade, the approach was to determine the layout for dam 4d located at Site C, where the topography and geology are well known, and then assume that the layouts would be similar at the three upstream dams and make allowances for the possible differences in topography. The intent was to do detailed topographic studies, detailed layouts and cost estimates for dams 4a, 4b and 4c only if the initial screening (Section 12.1) indicated that the four dam cascade would be competitive with the Site C Base Case.

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10.9.2 Layout

The same layout was adopted for this study as was developed in the 2002 cursory evaluation (Figures 10-26 and 10-27) with changes as described for the three dam cascade in Section 10.8.2 and below.

Approximately 6.2 million m^3 would require excavation from the left bank. It was estimated that 1 million m^3 of excavation would be required to stabilize the right bank.

The spillway at dam 4a would require eleven gates 13.0 m high by 12.2 m wide, and the spillways at dams 4b, 4c and 4d would each require twenty-one gates 13.0 m high by 13.0 m wide. Since the wider spillways would be required due to the lower head, the total volume of spillway concrete for the four dams would be about 4.6 times the volume in the Site C Base Case spillway.

The power intakes and penstocks would be similar in size and arrangement to those for Site C Base Case. The total volume of concrete in the intakes for the four dams would be about 4 times the volume in the Site C Base Case intakes.

The head on each of the dams would be about one quarter of the head on the Site C Base Case but the power flow would be the same; therefore the turbine diameters would be larger. Each powerhouse in the four dam cascade would have six 37.5 MW units with 7.5 m diameter propeller turbines compared to the 6.7 m diameter Francis turbines in the Site C Base Case powerhouse. As a result, the dimensions of each powerhouse in the four dam cascade would be about 12% greater than the Site C Base Case powerhouse resulting in a total volume of powerhouse concrete 5.3 times greater than for the Site C Base Case powerhouse.

10.10 Seven Dam Cascade

10.10.1 Topography and Site Geology

The locations of the seven dams are shown in Figure 4-3.

Dam 7a would be located near Hudson's Hope at river marker 27 and is the closest site to PCN. The site layout is controlled by the steep riverbanks, a large island in the river and access available from the right bank. Bedrock at the site is the Gates Formation.

Dam 7b would be located at river marker 40.5 about 11 km downstream of Hudson's Hope. It is the most attractive dam site in the river reach located close to the downstream extent of the Gates Formation. The site is dominated by sandstone islands and vertical riverbanks, creating two river channels.

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Dam 7c would be located at river marker 53 about 13 km upstream of the Halfway River. The site has a relatively low flood plain on the left bank and has access available on that bank. Bedrock at the site is Shaftesbury shale.

As described in Section 6.5, LiDAR data was used to update the river profile. In order to develop the same gross head at dam 7d that was used in the 2003 study[3.3] the dam would have to be moved 6.5 km further downstream from the location selected in 2003 to river marker 69, putting it downstream of the Halfway River and the Attachie Slide. This location presents some risks for the design of dam 7d due to the potential for further large landslides at Attachie which could block the headpond behind the dam. Access is available from the left bank. Bedrock at the site is Shaftesbury shale.

Dam 7e would be located at river marker 82.5 immediately downstream of Cache Creek, and the topography is similar to that of site 7c. Access would be from the left bank. Bedrock at the site is Shaftesbury shale.

Dam 7f would be located at river marker 95.5 just downstream from Wilder Creek. It has a wide flood plain on the left bank an island in the river and a steep right bank. Access would be from the left bank. Bedrock at the site is Shaftesbury shale.

Dam 7g would be located at river marker 106, 0.5 km downstream of Site C. The site has fairly steep slopes on the left bank, islands in midstream surrounded by channels of substantial width and a small flood plain on the right bank. Access would be from the left bank. Bedrock at the site is Shaftesbury shale.

10.10.2Layout

Figures 10-28 and 10-29 show typical arrangements of dams in the cascade.

At dam 7a, the concrete dam components, including a barrage and powerhouse, would be placed close to the right bank, with the service bay and switchyard at the right bank. The river closure would be completed with an earthfill embankment. The dam would have a maximum normal reservoir level at El. 460.0 m, develop a gross head of 5.7 m, and the powerhouse would have an installed capacity of 77 MW using 16 units.

At dam 7b, the spillway and powerhouse would be sited in the two channels on each side of the island to minimize excavation quantities. The road access is from the left bank of the river, so the barrage would be constructed in the left hand channel, providing access to the remaining work in the right channel. The powerhouse would be in the right hand channel with the navigation lock. The dam would have a maximum normal reservoir level at El. 454.1 m, develop a gross head of 7.7 m and the powerhouse would have an installed capacity of 118 MW using 16 units.

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At dam 7c, the barrage would be built on the flood plain, then after the diversion canal had been extended to the river on the upstream and downstream sides of the barrage, the main stream of the river would be coffer-dammed off and the powerhouse constructed in the river channel. The dam would have a maximum normal reservoir level at El. 446.2 m, develop a gross head of 7.7 m, and the powerhouse would have an installed capacity of 107 MW using 16 units.

The layout of dam 7d would be similar to dam 7c, however the powerhouse would have one additional unit to utilize the tributary inflow from the Halfway River. The dam would have a maximum normal reservoir level at El. 438.2 m, develop a gross head of 7.0 m and the powerhouse would have an installed capacity of 101 MW using 17 units.

The layout of dam 7e would be similar to that of dams 7c and 7d. The dam would have a maximum normal reservoir level at El. 431.0 m, develop a gross head of 5.9 m and the powerhouse would have an installed capacity of 94 MW using 17 units.

At dam 7f, the river channels on either side of the island are too narrow to accommodate the powerhouse or spillway, so the layout envisages a diversion channel through a barrage on the left bank flood plain, enabling the powerhouse to be built in the right hand river channel and across most of the island. The dam would have a maximum normal reservoir level at El. 425.0 m, develop a gross head of 7.7 m and the powerhouse would have an installed capacity of 130 MW using 17 units.

The layout of dam 7g anticipates that the islands would be used for diversion, allowing the barrage to be built in the left hand channel while the river is confined to the right channel with cofferdams. After construction of the barrage, the river would be diverted through the left channel and the powerhouse constructed behind cofferdams in the right channel. The dam would have a maximum normal reservoir level at El. 417.0 m, develop a gross head of 6.5 m and the powerhouse would have an installed capacity of 121 MW using 17 units.

As the majority of dams in the cascade would have gross heads in the range 7.0 m to 7.7 m, components were designed for a head of 7.5 m and the same design was used for all seven sites. Figures 10-30, 10-31 and 10-32 show sections thought typical components of the cascade dams.

Based on limited information on the river cross sections, it was assumed that the riverbed was 4.1 m below the 1978 river profile.

Freeboards of 2.5 m above flood level to the crest of the earth embankments and 1 m to the crest of concrete structures were selected. Flood levels used were 2 m above the maximum normal reservoir level.

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The powerhouse layout is largely controlled by the geometry of the generating unit, and provides space for the turbine and generator ancillary equipment as well as the auxiliary electrical and mechanical equipment. The intake sill would be set at riverbed level to achieve the required submergence, but would be subject to the passage of sediment. The level of the powerhouse roof would be higher than the reservoir flood level, so would not be subject to overtopping flows. Draft tube stoplogs would be located within the powerhouse. As there would be fewer power transformers than units, all transformers and switchgear would be located in a switchyard adjacent to the powerhouse. This enables the tailrace deck to be eliminated. A service bay would be located at the end of the powerhouse more directly accessible by road.

The spillway crest would be set at riverbed level so it would not be higher than the power intake sill, which results in the spillway being a gated barrage. The barrage would comprise an invert slab at riverbed level and a series of piers carrying vertical lift gates with one hoist per gate. The flow would be subcritical through three of the barrages and in the worst case only slightly supercritical, so no energy dissipater would be required. A riprap apron would be provided upstream of the spillway and a short concrete apron and cutoff wall, and riprap apron on the downstream side.

The embankment dam section would be similar to that developed for Site C, and be designed to accommodate the very weak foundation conditions. A central core of clay would be bounded by filter zones upstream and downstream. The core width would be a minimum of 50% of the upstream water level. The core would be founded on bedrock and a single grout curtain would be installed in bedrock along the dam centerline. The shells would be granular soils with outer slopes of 2.5H:1V. The upstream slope would be protected by riprap.

A concrete gravity transition would be required between the concrete structures and the embankment fills which would be 1.5 m higher due to the higher freeboard. The transition would have a sloping crest and a length to suit the designated slope of the embankment fill. Drainage and grouting galleries would be provided within the base of the transition block.

A navigation lock was provided at each site and sized for the passage of pleasure boats.

At least one fish way was provided at each site. The alignment of the fish way was folded to be compatible in length with the other dam components.

The open-air switchyard would be constructed in close proximity and at an elevation similar to that of the powerhouse.

For structures founded on the weaker Shaftsbury Formation, it would be necessary to mobilize the cross-bedding strength of the rock strata to ensure the

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stability of the structures. As an alternative to an uneconomically deep shear key, arrays of tensioned multi-strand anchors would be used.

A transmission line on a route on the left (north) side of the river would be required to connect dam 7g to dam 7a, and from there to the Peace Canyon GS Substation. The load carrying capacity of the line would vary from about 200 MW at dam 7g to approximately 1000 MW from dam 7a to Peace Canyon.

The seven dam cascade is not directly comparable to the Site C Base Case for the following reasons:

- dam 7a has a maximum normal reservoir level of El. 460.0 m, 1.8 m lower than the Site C Base Case, which reduces the energy; and
- the stability of the seven dams relies on the use of post tensioned anchors, which means that the longevity of these structures may be less than at Site C where the stability is provided by the weight of the structures.

These two differences are offsetting with respect to the relative energy cost. Increasing the maximum normal reservoir level of dam 7a to El. 461.8 m would increase the gross head to 7.5 m, which would increase the generation from the cascade by about 4% without increasing the cost as the dam components were all sized and costed based on a gross head of 7.5 m. Replacing the post tensioned anchors with concrete so that stability would be provided by weight alone would significantly increase the cost of the dams. The intent was to carry out detailed studies (increasing the maximum normal reservoir level at dam 7a and cost estimates for replacing the anchors), only if the initial screening (Section 12.1) indicated that the seven dam cascade would be competitive with the Site C Base Case.

10.10.3 Adjustments to the 2003 Layouts and Design

The 2003 layouts and design were based on the assumption that the structures would be classified as “Low” Consequence Category. As noted in Section 4.4.4, based on the size of the investment and the consequences of the failure of a dam in the cascade, the seven dams in the cascade would be designed for the 10,000 year MDE and the PMF.

In the 2003 study, all the dams for the seven dam cascade were designed for a 1000 year return period IDF and a discharge capacity of 8000 m^3/s upstream of the Halfway River and 8400 m^3/s downstream. To increase the discharge capacity at each site to the estimated PMF discharge, the number of bays in the sluiceway at each dam was increased by the ratio of the PMF discharge at each site to the 1000 year flood. The arrangement at all the sites was then adjusted to include these additional spillway bays. The number of additional bays varied from three at site 7a up to twenty-nine at site 7g.

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The original design of the structures for the seven dam cascade was based on the seismic loading of 0.07g for a 1 in 1,000 year return period earthquake. To carry the additional seismic loads for the MDE of 0.23g, the number of post-tensioned anchors was estimated such that the total horizontal force on the concrete/rock contact was carried by the horizontal component of the post-tensioned anchor. Typically, the number of anchors required for the powerhouse, sluiceways, and navigation lock was increased by 1/3 and was doubled for the transition block.

The cost estimates for each site were adjusted for the increased number of spillway bays to pass the PMF and for the additional post-tensioned anchors required to carry the MDE. The costs for the spillway at each site were increased in proportion to the number of additional bays needed to pass the PMF. Adjustments were made for the corresponding reduction of the earthfill embankments in the locations of the additional spillway bays and the increase in excavation for the approach and discharge channels for the additional bays. The costs for the anchor system at each site in the original estimate were increased in proportion to the total number of additional post-tensioned anchors required at each site to the total anchors required at each site for the 1 in 1,000 year seismic loading.

10.11 Facility Characteristics

The key facility characteristics that were defined for each alternate are presented in the facility characteristics matrix in Appendix A1. In addition to defining the engineering parameters of each alternate, the matrix presents the physical footprint of each alternate.

Dam footprint areas were defined for each site that included the facility itself, access roads and bridges, temporary construction facilities such as laydown and camp areas, and spoil/disposal area requirements.

Reservoir areas were defined for each alternate to determine the incremental area of land beyond the existing Peace River that would be affected by the impoundment of each reservoir.

Footprints for new transmission line corridors and switchyards that would be required were defined for each alternate. The various Highway 29 relocation alignment rights-of-way were also established.

For each alternate, the physical footprint areas described above were overlaid on terrestrial ecosystem mapping (TEM) data and physical environment themed data. These data was subsequently “clipped” to determine the impact of each footprint area on the physical environment, biological environment and socio-economic environment. The TEM categories and environmental themes, as well

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as the areas of the data affected by each footprint category, are shown in the matrix presented in Appendix A2.

Maps that present examples of the various TEM data and physical environment theme layers are provided in Appendix F.

Estimated quantities of fuel, cement, steel and copper used in the construction of the alternates were prepared to enable estimates to be made of the greenhouse gas production during construction.

10.12 References

10.1 J. L. Gordon, “Hydropower Cost Estimates”, Water Power & Dam Construction, November 1983.

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11. MULTI-ATTRIBUTE DECISION MAKING FRAMEWORK

11.1 General

A multi-attribute decision making framework was developed to assess the six alternate projects relative to the Site C Base Case. The decision making framework (shown below in Figure 11-1), involved the following steps:

i. Confirming with BC Hydro the project alternates the Project team was to compare against the Site C Base Case, then defining the characteristics of each of the alternate projects and the Base Case;

ii. Identifying the degree to which the physical environment, biological environment and socio-economic environment attributes, and the operations and safety (functionality) attributes would be affected by the given set of engineering characteristics associated with each of the project alternates relative to the Site C Base Case, and comparing these against one another;

iii. Ranking and weighting various sub-accounts within each of the four main accounts (physical environment, biological environment, socio-economic environment, and engineering functionality), for the purpose of comparing the relative differences between alternate projects relative to the Site C Base Case. Two multidisciplinary decision making workshops were then convened to review, confirm and/or challenge the rankings and weightings; and

iv. Using a proprietary model developed by Hatch, the rankings and weightings for each of the four accounts were summarized as "footprint[8]" values for each of the project alternates, relative to the Site C Base Case, and plotted against the energy cost ratio calculated for each of the project alternates.

[8] Footprint is defined here as the land or water area covered by a project. This includes direct physical coverage (i.e., the area on which the project physically stands) and direct effects (i.e., the disturbances that may directly emanate from the project, such as noise). http://www.ceaa.gc.ca/013/0001/0004/a_e.htm

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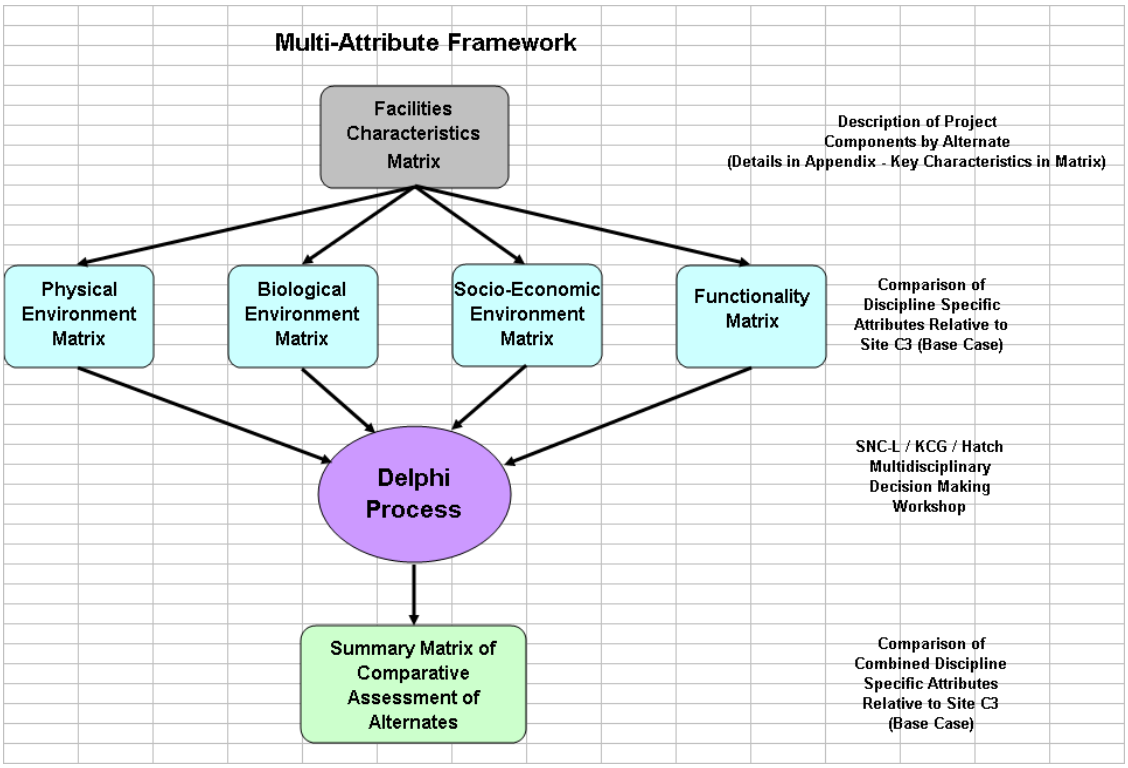
Figure 11–1: Multi-Attribute Decision Making Framework



11.2 Data Sources

The Project team relied on a variety of information sources upon which to compare the Site C Base Case against each of the six proposed project alternates, including:

- internal BC Hydro reports;
- external consultant and literature reports;
- interviews with various discipline leads within BC Hydro;
- terrestrial ecosystem maps;
- agricultural capability maps; and
- thematic geographic information system (GIS) plots.

11.3 Information Matrices

Five separate sets of information matrices were developed based on the review of and assembly of available data. These included:

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i. Facility Characteristics – physical design and construction characteristics of the Site C Base Case and the six alternate projects were compiled into a matrix (Appendix A1). The facility characteristics matrix was then used to define the construction and operation processes and footprints of the various alternates, against which the physical environment, biological environment, socio-economic environment, and engineering functionality of each of the alternates could be compared against the Site C Base Case;

ii. Physical Environment – information on the relative differences of the physical environment effects of each alternate project compared against the Site C Base Case, for both construction and operation phases, were compiled into a matrix (Appendix B). The sub-accounts include: climate; physiography; topography; soils; shoreline stability/erosion, flows and water levels; suspended sediment/turbidity, channel morphology; groundwater; mineral and aggregate resources; oil and gas resources; water quality; and air quality;

iii. Biological Environment – information on the relative differences of the biological environment effects of each alternate project compared against the Site C Base Case, for both construction and operation phases, were compiled into a matrix (Appendix C). The sub-accounts include: aquatic habitat and fish species; riparian habitat and species; terrestrial habitat and species;

iv. Socio-economic Environment – information on the relative differences of the socio-economic environment effects for each alternate project, for both construction and operation phases, compared against the Site C Base Case were compiled into a matrix (Appendix D). The sub-accounts include: land and resource use; transportation, infrastructure, public health and safety; culture and heritage; recreation and tourism; employment, economic opportunities and community services; and First Nations; and

v. Functionality – information on the relative differences of the functional engineering environment compared against the Site C Base Case were compiled into a matrix. The sub-accounts include: dam safety factors and life cycle factors.

Using a bottom up approach, impact rankings were assigned on a seven-point scale for each separate sub-attribute (or sub-account) relative to that same sub-attribute for the Site C Base Case (Site C Base Case always ranked as 4 = neutral). Once all the sub-attributes were ranked, weightings were assigned to the sub-accounts, to provide an overall weighted ranking for each of the four accounts for a given alternate project relative to the Site C Base Case. For the most part, the rankings were based on quantitative comparison of such things as

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inundation areas, number of terrestrial ecosystem units, length of road or transmission line between alternates. However, where quantitative data were not available, discipline leads applied professional judgment in the rankings, and again for the weightings between the sub-accounts.

11.4 Multidisciplinary Decision Making Workshop

Two separate decision making workshops, involving experts from different disciplines, convened as a form of mini-Delphi session to review, confirm and/or challenge the rankings and weightings assigned by the discipline experts to the respective sub-accounts and accounts. The first workshop focused on the three environmental accounts, with participants representing the three discipline areas (physical environment, biological environment, and socio-economic environment). A senior environment manager from BC Hydro also took part in this process to ensure that all relevant data sources were captured in the analysis. The outcome of this first workshop was a refinement of the rankings and weightings within and between the three environmental accounts.

The second workshop focused on all of the discipline areas (engineering and environment) and was attended by discipline leads from the Project team, the Peer Reviewer (see Section 11.6 below), and representatives of BC Hydro's engineering and environmental teams. The outcome of this second workshop was a further refinement of the environmental rankings and weightings, as well as refinement of the engineering rankings and weightings. Outputs of the process were entered into and run through Hatch's proprietary Four Quadrants Analysis (4QA) decision making model (see Section 11.5 below) and tested using sensitivity analysis.

11.5 Four Quadrant Analysis (4QA) Model

The summary rankings and weightings data for each of the four accounts was entered into Hatch's proprietary 4QA model. The Excel-based 4QA model is a tool that enables the simultaneous comparison of project alternatives on both financial and sustainability criteria. The power in its application comes from the ability to identify the key drivers in a decision and determine how each can affect the outcome of the analysis (i.e. sensitivity to change).

Together, the four accounts represent the footprint of each of the alternate projects relative to the Site C Base Case. The footprint for each project is plotted against an energy cost ratio, that is, the anticipated capital cost of a given alternate project normalized to reflect the relative percentage difference in energy output that would be achieved by the Site C Base Case. Sensitivity analysis were conducted at various levels, first by adjusting the relative ranking and weighting of sub-accounts within individual footprint accounts, and then by adjusting the relative weighting between each of the four footprint accounts.

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11.6 Peer Review Process

The Project team enlisted the services of a senior manager from Manitoba Hydro International[9] to act as an external peer reviewer at critical steps throughout the Project team's evaluation of alternate project configurations. His involvement included:

- Reviewing the draft Analysis Framework: screening the proposed analysis framework to ensure that the key parameters that would reasonably be expected to form part of the analysis were not overlooked;

- Reviewing Outcome of Comparative Analysis: reviewing the overview comparative assessment of alternatives to ensure that the depth and breadth of analyses were consistent with that of an assessment of Alternative Means of Delivering the Project;

- Providing Input to the Multidisciplinary Decision Making Workshop: participating in the second workshop as an independent fairness auditor to confirm an unbiased approach to the evaluation process, and, in the event that an impasse was reached in certain areas, suggest possible ways forward, where appropriate; and

- Reviewing the Draft Report: reviewing the Draft Report on Alternate Means of Delivering the Project. The purpose of this final peer review was to ensure that the presentation of the overview comparative assessment was consistent with what is expected in a CEAA comprehensive review.

[9] Mr. Mike Saxton, Department Manager, Project Sustainability Review & Coordination, Manitoba Hydro International

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12. Evaluation of Alternates

12.1 Initial Screening

As described in Section 11, the information contained in the Facilities Characteristics Matrix (Appendix A1) was used to assess the relative differences between the effects of each alternate and Site C on:

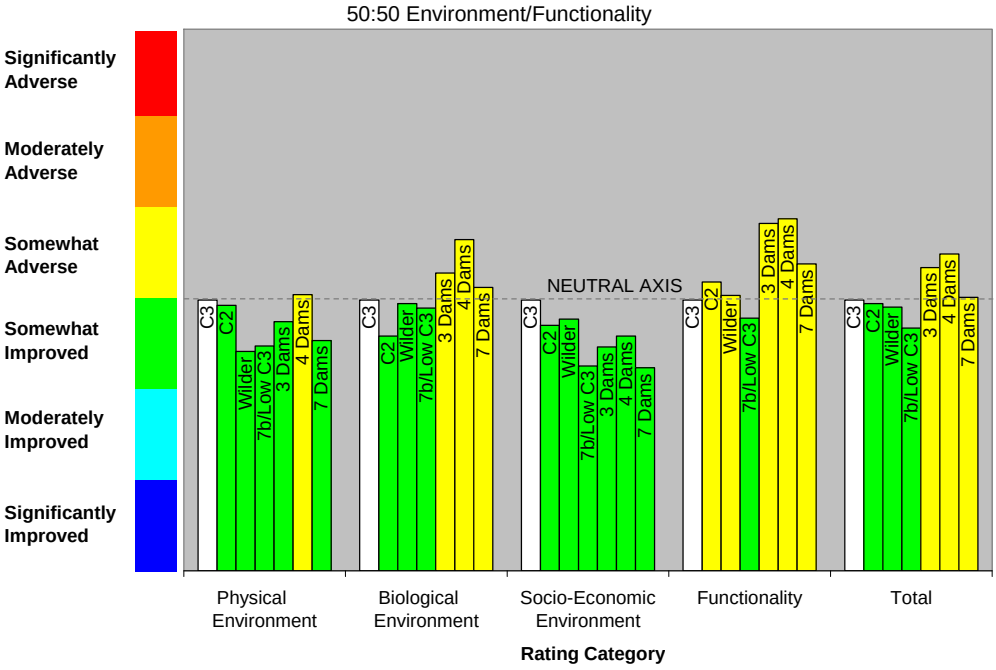
- the Physical Environment (Appendix B);
- the Biological Environment (Appendix C); and
- the Socio-economic Environment (Appendix D).

A Base Case with the following weightings was used for the initial screening: physical environment 10%; biological environment 20%; socio-economic environment 20%; and functionality (dam safety and life cycle factors) 50%. The ratings for each category and the combined (total) ratings for the seven alternates are shown in Figure 12-1.

Figure 12-1

Matrices Results - Base Case

50:50 Environment/Functionality



As shown in Figure 12-1, the C1/C2 and three and seven dam cascades were each considered somewhat better than the Base Case for the physical environment, while the four dam cascade was somewhat worse. Parameters influencing the 'better' ratings for the C1/C2, 3 dam and 7 dam options (and

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4 dam option in most cases) included less effect on physiography, less soils/lands inundated, less effect on oil and gas resources, and less effect on shoreline stability/erosion and associated effects on water quality (Appendix B). Local climate effects due to the completed project were also better with the 3, 4 and 7 dam cascades (i.e. smaller reservoirs). The 4 dam option was somewhat worse overall due to its larger disturbance (4 large dams at 4 sites with associated access roads and infrastructure), its larger predicted effects on water and air quality during construction, and higher greenhouse gas production (substantial excavation and construction materials, concrete, etc.).

Within the biological environment, the 3, 4 and 7 dam cascades were all somewhat worse than the Base Case largely due to greater impacts to Peace River fish communities, their habitat (spawning, rearing, foraging and refuge) and associated impacts on fish movements during both construction and operations due to multiple dams/work sites (Appendix C). The smaller post-project reservoirs also provide less opportunity for development of reservoir fish communities and would have higher operational impacts due to entrainment and turbine mortality at multiple sites. These aquatic effects were partially offset by less effect to terrestrial habitats and species, as the smaller cascade reservoirs would inundate less terrestrial and riparian habitat. The somewhat better overall rating for the C1/C2 option was a result of its lack of effect on the Moberly River and valley. The retention of aquatic and terrestrial habitats and species within the valley rated highly, resulting in the highest rating for an alternative in this category.

For the socio-economic environment, the 2, 3, 4 and 7 dam options all rated higher than the one dam options. Factors affecting this outcome include less effect on land and resource use, fewer archaeological sites and cultural resources affected, less effect on trapping and hunting, and greater employment and economic opportunities for local communities associated with the longer construction period needed for the multiple dam options (construction of multiple sites phased over time, providing a longer period of employment and economic benefit). These improvements over the Base Case were partially offset by more adverse transportation, infrastructure and health and safety aspects, as well as greater effects on recreational boating during both construction and operation. During the operational period, multiple sites would also provide higher levels of employment, and greater economic benefit to local companies and industries associated with the maintenance of the facilities (Appendix D).

While the 3, 4 and 7 dam cascades provide a ‘somewhat improved’ socio-economic rating, the presence of the additional sites/facilities adversely affects the functionality of the project. Engineering parameters of importance in this rating (Appendix E, Section A) include dam safety factors such as hydrology (increased potential for spillway gate malfunctions due to large number of gates) and landslide risk (dam in close proximity to previous slide) as well as resilience and robustness of the structures (multiple gates and turbines increase potential

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for malfunction). Life cycle factors, such as operation and maintenance, system integration and personnel safety all rate low as well (i.e. many small units at multiple sites significantly increases effort and risk for those factors).

When the functionality ratings are combined with the environmental ratings, the 3, 4 and 7 dam cascades all rate as somewhat adverse compared to the Base Case and the other one dam options.

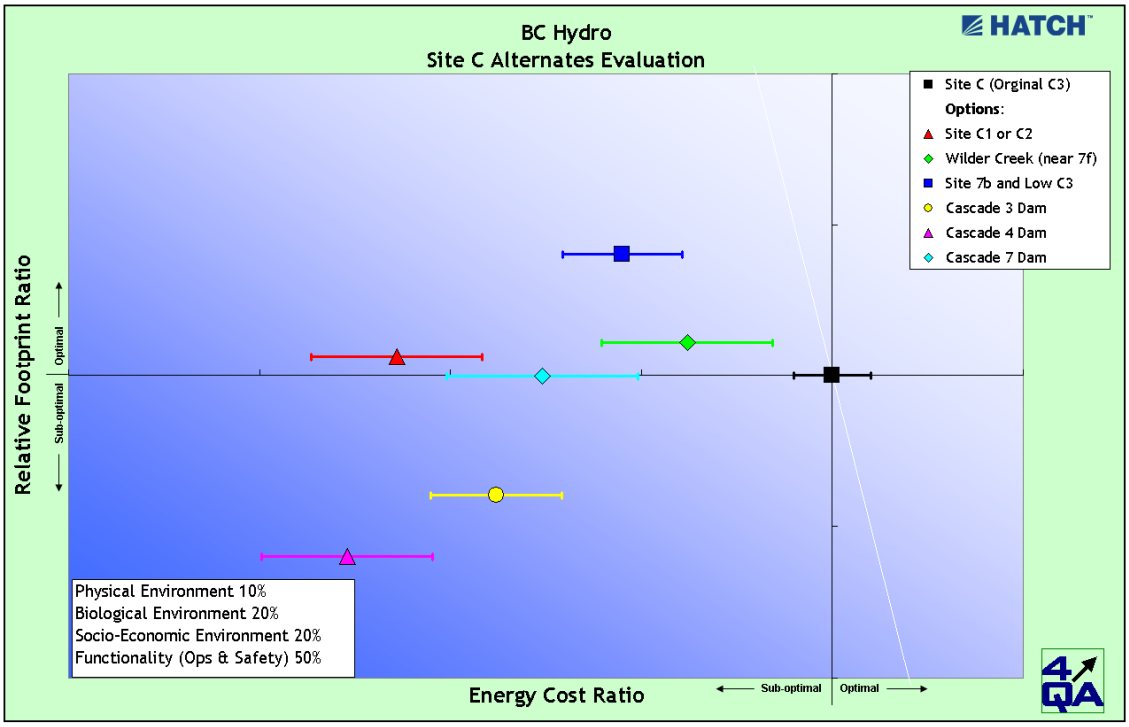
As described in Section 10.3 and shown in Appendix A, each of the alternates to Site C develops less energy and costs more. Therefore, the results of the analyses were normalised by plotting the results against the Energy Cost Ratio, which is simply the ratio of the cost of energy of an alternate to the cost of energy from Site C. An Energy Cost Ratio of 1.1 for an Alternate would mean that the cost of energy from that alternate would be 10% more than the cost of energy from Site C.

The results of the initial screening are shown in the 4QA plot in Figure 12-2, which plots the relative footprint ratios against the Energy Cost Ratios.

Relative differences in physical risks, construction factors and schedule and cost certainty between each alternate and Site C (Appendix E, Sections B, C and D) were included in the ranges of Energy Cost Ratios shown in Figure 12-2.

Figure 12-2

Initial Screening of Alternates



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In Figure 12-2 the expected values of Energy Cost Ratio are indicated by the symbols and the range of Energy Cost Ratios are indicated by the horizontal bars.

It can be seen from Figure 12-2 that four of the alternates, namely C1/C2 and the three, four and seven dam cascades are dominated alternates[10] and therefore were screened out from further analysis.

The expected Energy Cost Ratios for the Wilder Creek and the two dam cascade (7b and low C3) are 1.38 and 1.55, respectively.

The expected energy cost ratio for Wilder Creek is higher than Site C because:

1. the annual generation at Wilder Creek would be 15% less than at Site C due to the lower head (see Appendix E); and

2. while the direct construction cost of Wilder Creek and Site C are similar, higher amounts were included in the Wilder Creek estimate to allow for additional site investigations, engineering, contingency and risk since the foundation conditions at Wilder Creek are unknown.

The expected energy cost ratio for the two dam cascade is higher than Site C because:

1. the annual generation of the two dam cascade would be 4% less than at Site C due to higher head losses (see Appendix E);

2. the direct construction cost of the two dam cascade would be 34% higher than for Site C;

3. higher amounts were included in the estimate for the two dam cascade to allow for additional site investigations, engineering, contingency and risk since the foundation conditions at site 7b are unknown; and

4. interest during construction is higher due to the longer overall construction schedule.

[10] For the dominated alternates increasing the energy cost ratio, i.e. increasing the project cost and/or getting less energy, does not provide a decrease in the relative footprint ratio, whereas for the non-dominated alternates increasing the energy cost ratio provides a decrease in the relative footprint ratio. For example the move from the Site C Base Case to Wilder Creek increases the energy cost ratio and decreases the relative footprint ratio, moving from Wilder Creek to the two dam cascade increases the energy cost ratio and decreases the relative footprint ratio but moving from the two dam cascade to the seven dam cascade increases the energy cost ratio and increases the relative footprint ratio.

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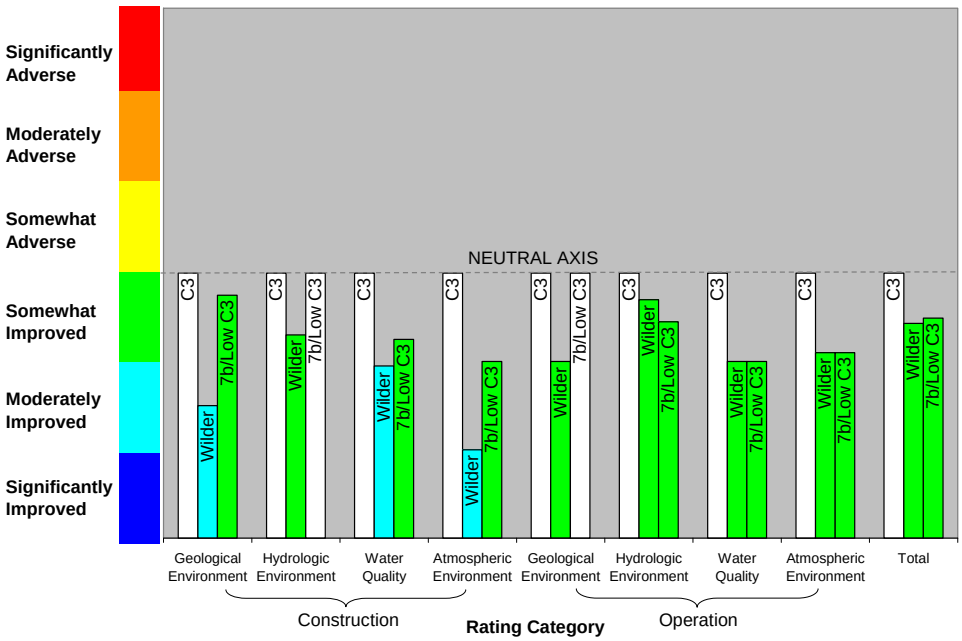
The C1/C2 option has been eliminated because it is dominated by the Wilder Creek and 7b/low C3 options from both the standpoint of its environmental footprint and its energy cost.

12.2 Sub-Accounts

The rating of the physical environment sub-accounts for the Base Case for the three non-dominated alternates is shown in Figure 12-3.

Figure 12-3

Physical Environment Matrix - Base Case



As noted in Figure 12-3, Wilder Creek rated highly for all of the physical environment factors during the construction period as it would affect the shortest length of the Peace River valley (73 km vs 85 km for other two options) and would avoid any impacts to the Moberly River valley, resulting in the highest rating in each physical environment sub-category (i.e. geological, hydrological, etc.). For the operational period, Wilder Creek and Site 7b/Low C were very similar for most sub-categories with the exception of the geological environment. Here, the shorter length of shoreline around the perimeter of the Wilder Creek reservoir results in less potential for shoreline erosion and stability issues. Summing all physical sub-categories for both construction and operation, the difference between Wilder Creek and Site 7b/Low C is minimal.

The rating of the biological environment sub-accounts for the Base Case for the three non-dominated alternates is shown in Figure 12-4.

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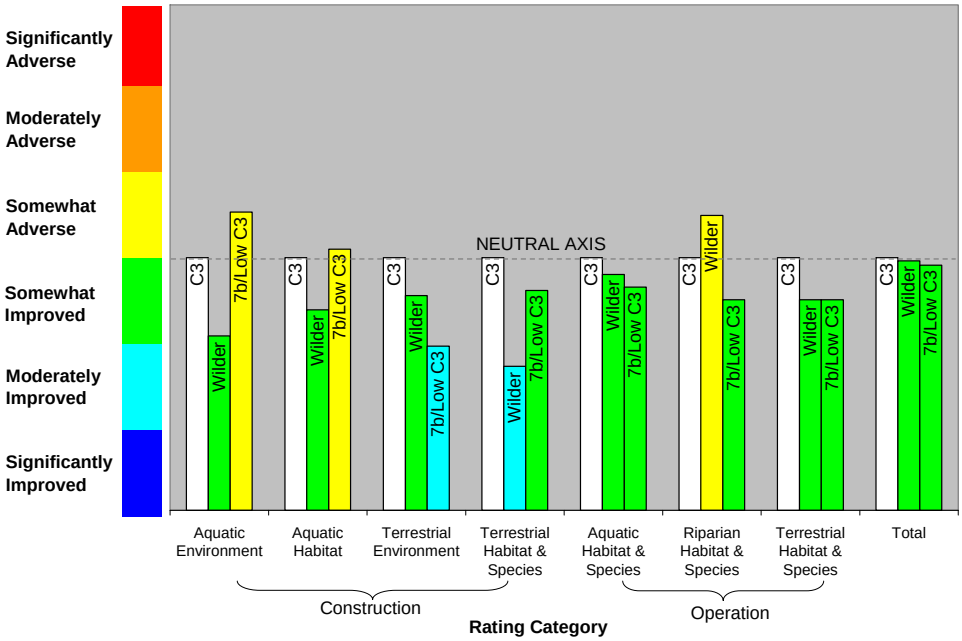
Figure 12-4

Biological Environment Matrix - Base Case



As with the physical environment, Wilder Creek rated highly within most biological environment sub-categories during the construction period due to its shorter Peace River length and avoidance of the Moberly River valley. The one exception was in the Riparian Environment sub-category, where the Site 7b/Low C had less effect on wetlands. Site 7b/Low C was also rated worse than the Base Case and Wilder Creek for aquatic fauna and habitat due to the presence of two work sites within the river valley and associated effects on fish community and habitat (i.e. more disturbance to movement patterns including migrations, larger footprint area, greater potential for sediment releases/water quality impairment from work at two sites compared to one, etc.). Operationally, Wilder Creek and Site 7b/Low C were similar for most sub-categories with the exception of Riparian Habitat, where Wilder Creek had the shortest length of shorelines. Overall, the aquatic impacts/benefits of one option were generally offset by the riparian/terrestrial impacts/benefits of the other option, such that only very small differences were present between options in the final analysis.

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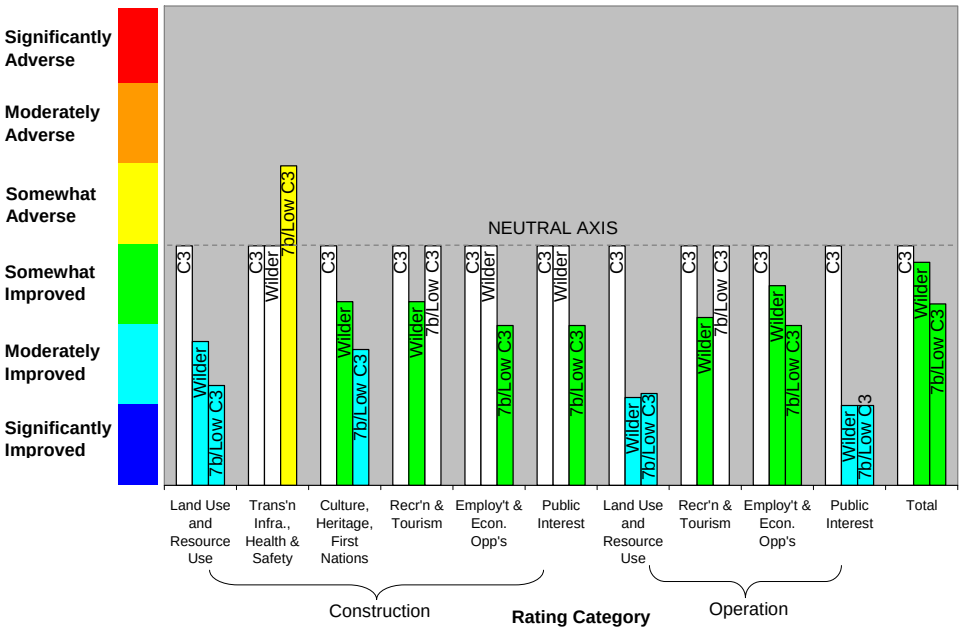
The rating of the socio-economic environment sub-accounts for the Base Case for the three non-dominated alternates is shown in Figure 12-5.

Figure 12-5

Socio-Economic Environment Matrix - Base Case



As with the physical and biological environment, each option has its own positive and negative aspects. During the construction period, Site 7b/Low C is better than the other two options in the Land and Resource Use; Culture, Heritage and First Nations; and Employment and Economic Opportunities sub-categories, largely due to the presence of two sites, which result in less inundation of valley lands and terraces, and provides a longer construction period (more employment and economic opportunities). These positive aspects for Site 7b/Low C are however partially offset by greater Transportation, Infrastructure and Health and Safety sub-category concerns generated as a result of the two sites (longer travel distances with project traffic affecting a larger area, need for services and infrastructure at two sites, etc.). Recreation and Tourism sub-category effects are less for the Wilder Creek option, largely due to less effect on recreational boating and navigation (i.e. Moberly River not affected) and proposed protected areas (i.e. Peace Boudreaux). For the operational period, Wilder Creek and Site 7b/Low C are both better than the Base Case in the Land and Resource Use, and Public Interest sub-categories. Again, this is related to the smaller inundation area and less effect on future land use. Wilder Creek is better in the Recreation and Tourism sub-category, again due to the retention of the Moberly River valley and positive effects on downstream recreational fisheries. The two facilities associated with Site 7b/Low C would provide additional employment opportunities and greater economic benefits to the local communities. In the final

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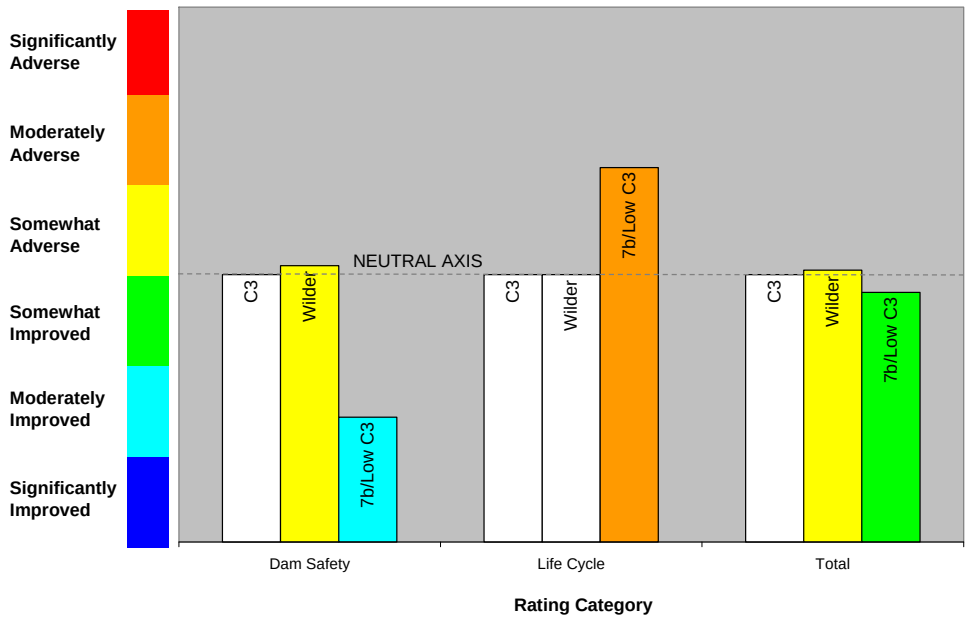
analysis, both of the options are somewhat better than the Base Case, with Site 7B/Low C slightly better than Wilder Creek.

The rating of the functionality for the Base Case for the three non-dominated alternates is shown in Figure 12-6.

Figure 12-6

Functionality Matrix - Base Case



Functionality consists of a number of factors related to dam safety and life cycle of the facilities (Appendix E). The Site 7b/Low C option rated better than the other two options on all dam safety factors (i.e. reservoir evacuation capability, reservoir evacuation time, ability to pass high inflows, landslide risk, seismic risk, geological condition, consequence of failure, and resilience and robustness) as smaller dam/reservoirs present less risk, but rated worse than the other options for most life cycle factors. This is because the increased number of plants/units/gates, etc. are more difficult to operate and maintain, are harder to integrate into the electrical system and provide more opportunities for worker safety and/or environmental incidents. The two site option does, however, improve generation reliability, in which the increased number of units from two facilities results in less effect on the system should one unit be lost for maintenance or repairs. In the final analysis, the potential dam safety advantages of a two site development are offset by the negative life cycle factors of that option, resulting in all options being quite similar.

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12.3 Sensitivity Analyses

A series of sensitivity analyses were performed on the three non-dominated alternates to determine whether changing the weightings would materially change the rankings.

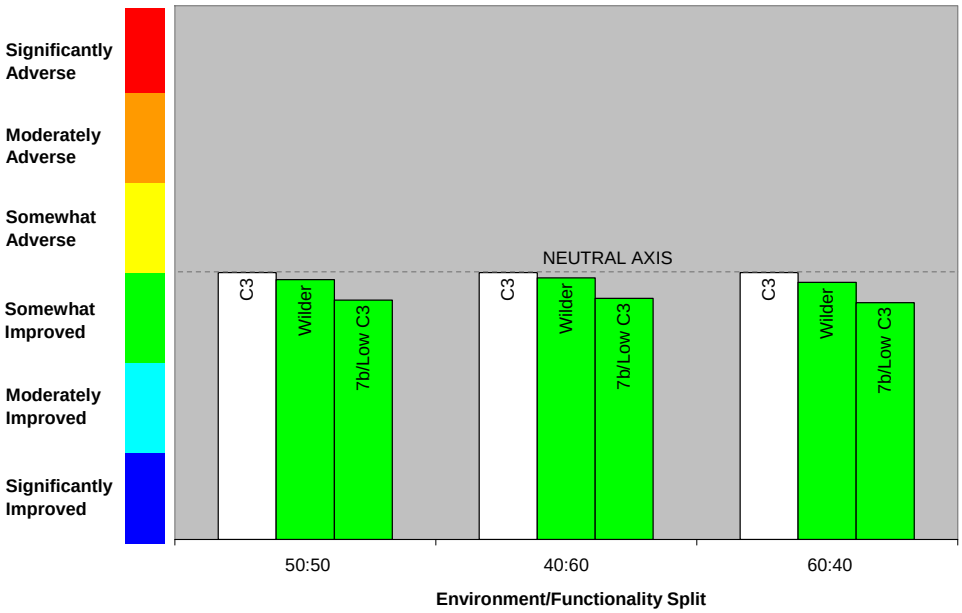
12.3.1 Weighting Between Environment and Functionality

Figure 12-7 shows the results of the sensitivity of increasing and decreasing the split between environment and functionality. Given the nature of the project, the size of the investment and the consequences of a dam failure or operational problems, it was considered that the lowest weighting that could be reasonably given to functionality is 40%. Increasing or decreasing the weighting for environment versus functionality by 10% does not change the overall ranking or order of the alternates (i.e. Site 7b/Low C is the preferred option in all cases, followed by Wilder Creek and then the Base Case), and the relative difference between alternates remained essentially the same when weightings were changed.

Figure 12-7

Matrices Results - Sensitivity

Variation of Totals based on Percentage Split of Environment/Functionality



12.3.2 Weighting Favouring the Moberly River

For the Wilder Creek alternate, the main difference is that this alternate does not flood the lower part of the Moberly River, although there would be some terrestrial impacts in the Moberly catchment mainly due to transmission.

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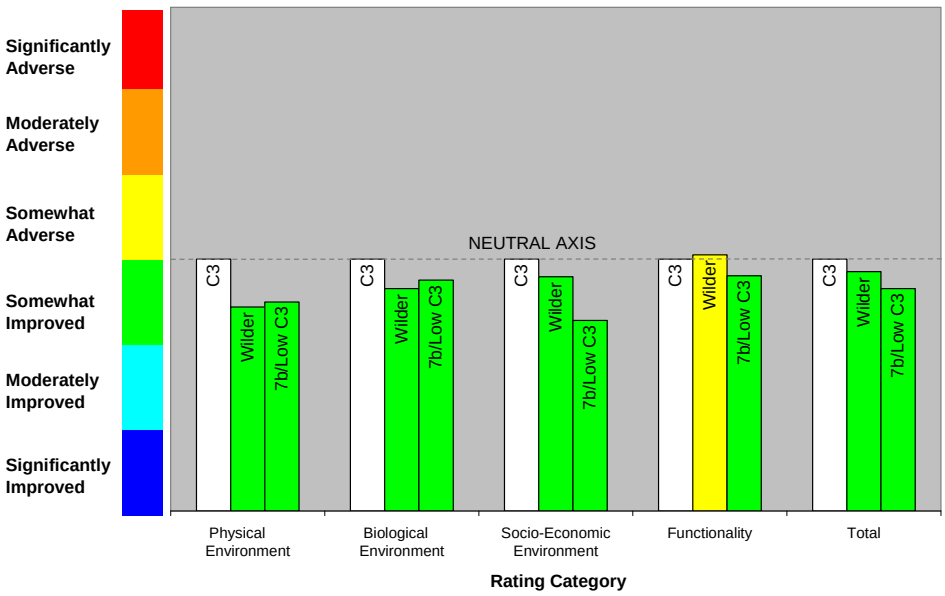
Therefore, the question would be how much more one would have to value the Moberly River to make a difference in the outcome.

Figure 12-8 shows the results of the sensitivity of increasing the weighting of the Moberly River to 50% relative to the other fish bearing courses, i.e. the Moberly River is valued the same as the Peace River and all other tributary rivers and creeks combined.

Figure 12-8

Matrices Results - Sensitivity #1

Moberly River Favoured 50% Relative to the Other Fish-Bearing Water Courses



Comparing the Biological Environment plot noted above to the 'Total' in Figure 12-4, one can see that increasing the weighting for the Moberly River improved the rating for Wilder Creek, such that it was rated higher than Site 7b/Low C or the Base Case. However, when combined with all other environmental and engineering factors, the ranking or order of alternates does not change (i.e. 'Total' in this plot compared to '50/50' plot in Figure 12-7), and the difference between the alternates is essentially the same.

Figure 12-9 shows the results of the sensitivity of increasing the weighting of the Moberly River to 100% relative to the other fish bearing watercourses, i.e. all other tributary rivers and creeks combined are assumed to have no value.

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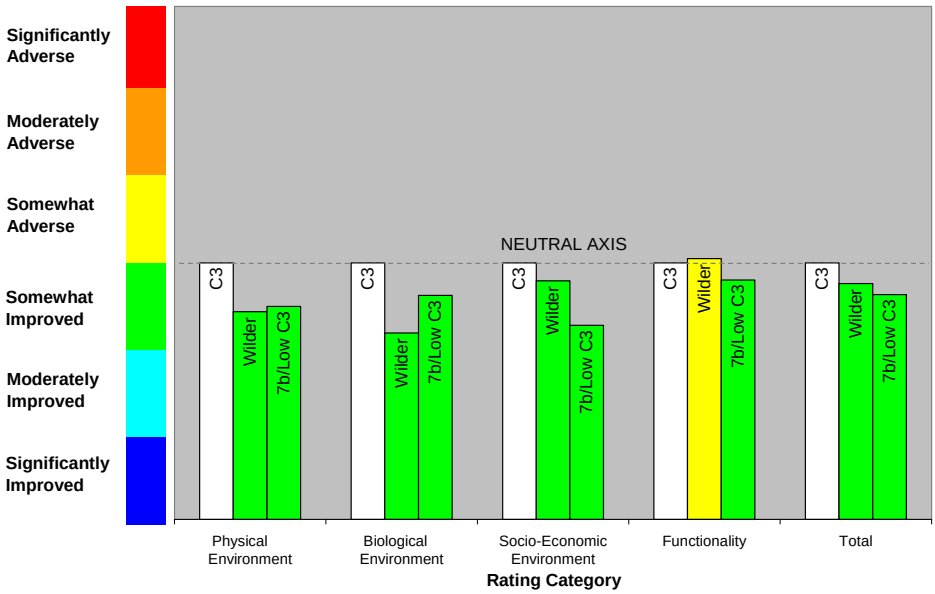
Figure 12-9

Matrices Results - Sensitivity #2

Moberly River Favoured 100% Relative to the Other Fish-Bearing Water Courses



Further increases to the value of Moberly River continue to improve the Wilder Creek rating in the Biological Environment category compared to Site 7B/Low C and the Base Case. However, as with the prior analysis, the additional weighting does not change the ranking or order of alternates; although Wilder Creek is rated slightly better (i.e. comparing 'Total' plots from Figures 12-8 and 12-9).

Figure 12-10 shows the results of the sensitivity of increasing the weighting of the Moberly River to 100% relative to the other fish bearing watercourses and the aquatics sub-accounts given 100% weighting relative to terrestrial, i.e. terrestrial impacts have no value.

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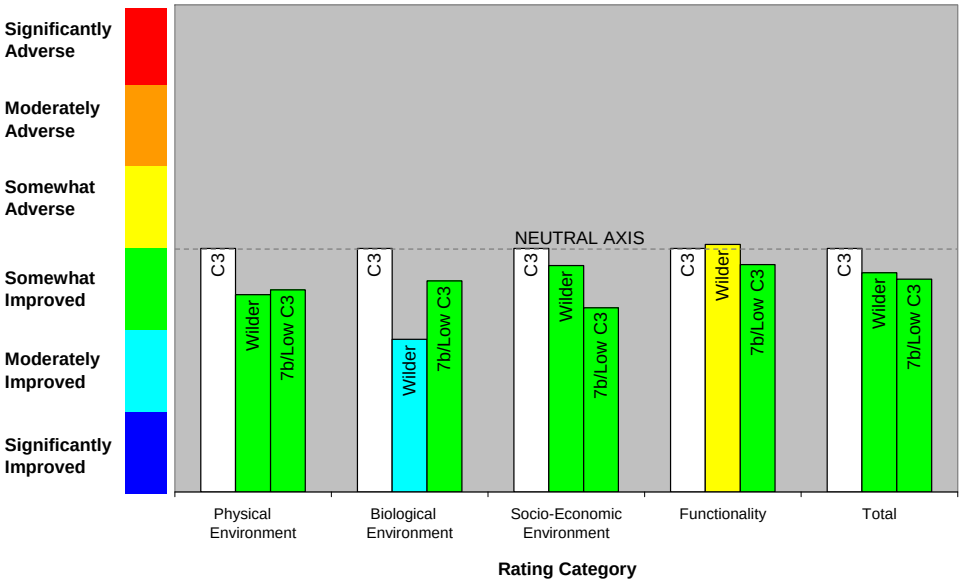
Figure 12-10

Matrices Results - Sensitivity #3

Moberly River Favoured 100% Relative to the Other Fish-Bearing Water Courses
& Aquatics Sub-Accounts Given 100% Weighting Relative to Terrestrial



This extreme valuation of the Moberly River aquatic resources to the exclusion of all other watercourses (i.e. Peace River and all tributaries) and all terrestrial values continues to improve the Wilder Creek Biological Environment rating relative to the other alternates (i.e. Wilder Creek now 'Moderately Improved' compared to Site 7b/Low C and the Base Case). However, even under this extreme valuation scenario, the ranking/order of the alternates does not change, although the Wilder Creek option is slightly improved over the previous scenario.

12.3.3 Weightings Favouring Flooding Less Land

For the two dam cascade, (Site 7b/Low C3) the main difference is that this alternate floods less land (particularly agricultural land and Watson Slough) between Site C and Site 7b. Therefore, the question would be how much more one would have to value the land and the socio-economic factors to make a difference in the outcome.

Figure 12-11 shows the results of the sensitivity of increasing the weighting of Watson Slough and valley bottom agriculture. Riparian habitat, islands, and shoreline vegetation community value were given higher weightings (biological account), and agricultural land was weighted 50% of overall land value (socio-economic).

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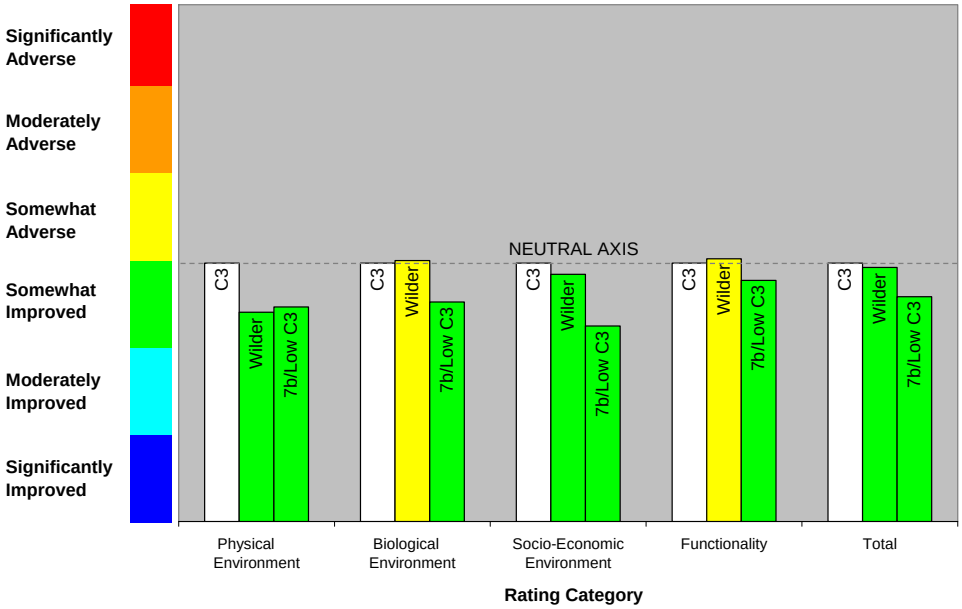
Figure 12-11

Matrices Results - Sensitivity #4

Value of Watson Slough and Valley Bottom Agriculture Weighted Highly



Comparing the Socio-economic Environment plot in the figure above to the 'Total' in Figure 12-5 indicates that the ranking/order of the alternates is not affected by this change, and the increased weighting of those factors results in no apparent difference between the alternates.

12.3.4 Summary

Figure 12-12 summarizes the results of the sensitivity analyses.

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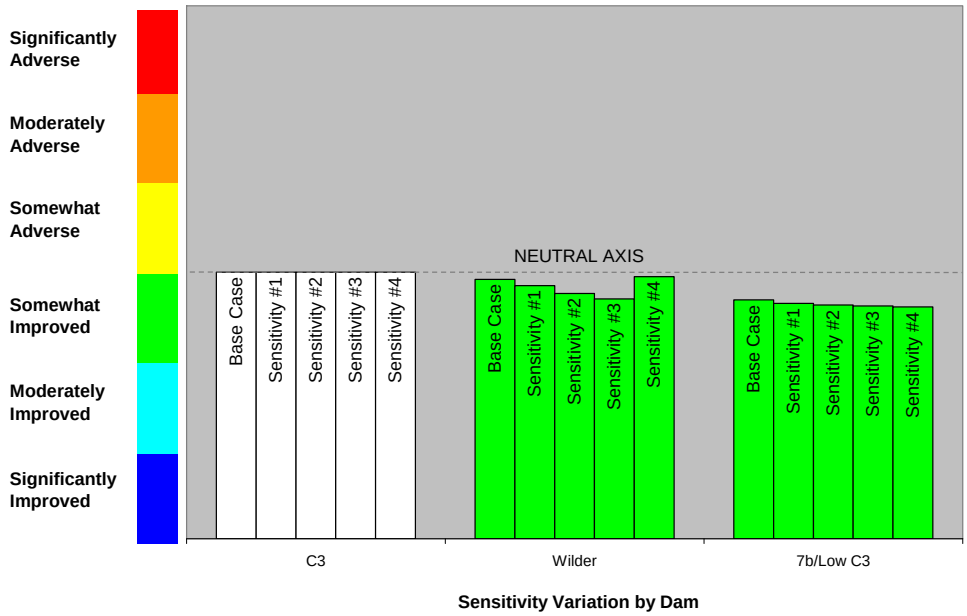
Figure 12-12

Matrices Results - Sensitivity #1 to #4 Summary



Sensitivity #1 which assigns an equivalent weight to the Moberly River aquatic resources as the Peace River and all other tributaries, and Sensitivities #2 and #3 which give no weight to aquatic resources other than the Moberly River (including the total exclusion of terrestrial values in Sensitivity #3) are unreasonable given the size and importance of the Peace River and other tributaries, including the Halfway River which provides important habitat for blue-listed bull trout as well as other species. While other tributary streams (i.e. Wilder Creek, Cache Creek, Farrell Creek, Lynx Creek and Maurice Creek) are less important, it is unreasonable to give them no value. However, the results of these three sensitivities demonstrate that the conclusion is not sensitive to the weighting applied to the aquatic resources of the Moberly River.

Sensitivity #4 demonstrates that the conclusion is not sensitive to the weighting applied to the terrestrial and agricultural resources.

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13. SUMMARY AND CONCLUSIONS

13.1 Summary

This study evaluated the following alternates for developing the hydroelectric potential of the Peace River between Peace Canyon Dam and Site C:

- the Site C Base Case;
- a single dam located upstream of the Moberly River at the more favourable of axes C1 and C2;
- a single dam located at Wilder Creek approximately 11.5 km upstream of Site C;
- two dams with a 15 m lower dam at axis C3 and a 15 m high dam located 66 km upstream;
- a cascade of three equal height dams;
- a cascade of four equal height dams; and
- a cascade of seven dams.

Layouts were developed so that key facility characteristics including the physical footprint and energy cost ratio could be defined for each alternate.

A multi-attribute decision making framework was used to assess the relative differences between:

- the impacts of each alternate and the Site C Base Case on the physical, biological and socio-economic environments based on the footprint information; and
- the functionality of each alternate and the Site C Base Case, including dam safety factors and life cycle factors.

Summary rankings and weightings for the physical, biological and socio-economic environments and functionality were plotted against energy cost ratio for each alternate.

Four of the alternates, namely a dam at axis C1/C2 and the three, four and seven dam cascades were found to be dominated alternates and therefore were screened out from further analysis. The ranking of the non-dominated alternates relative to the Site C Base Case were:

1. Site C Base Case, with an energy cost ratio of 1.00;

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2. Wilder Creek, with an energy cost ratio of 1.38; and

3. the two dam cascade with an energy cost ratio of 1.55.

As of May 2007, the early-stage conceptual estimate for Site C is between $5.0 billion and $6.6 billion in nominal dollars[2.9]. Therefore, each 0.1 increase in the energy cost ratio represents in the order of $500 million to $660 million loss of value. Construction of the project at Wilder Creek rather than Site C would result in a 38% increase in energy cost representing a loss in value of $1.9 billion to $2.5 billion.

A series of sensitivity analyses were performed on the three non-dominated alternates to determine whether changing the weightings would materially change the rankings.

It was found that the following changes to the weightings would not change the outcome:

1. Weighting environment at 60% and functionality at 40%, which given the nature of the project, the size of the investment and the consequences of a dam failure or operational problems, was considered that the lowest weighting that could be reasonably given to functionality.

2. Weighting the aquatic resources of the Moberly River at 100% with no weight given to the aquatic resources of the other tributaries, which would be unreasonable given the size and importance of the Halfway River which provides habitat for blue-listed bull trout as well as other species.

3. Giving riparian habitat, islands, and shorelines a higher weighting in the biological account and weighting agricultural land at 50% of the overall land value in the socio-economic account.

13.2 Conclusions

The consultants that undertook this alternates study conclude that:

- there are no environmental factors that would eliminate an alternate;

- the relative differences in environmental impacts and functionality between alternates are small; and

- in their opinion, the small relative differences in benefits between the alternates do not justify the significantly greater costs.

In the opinion of the three organizations, the multi-attribute assessment has confirmed that Site C is the preferred site.

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FIGURES

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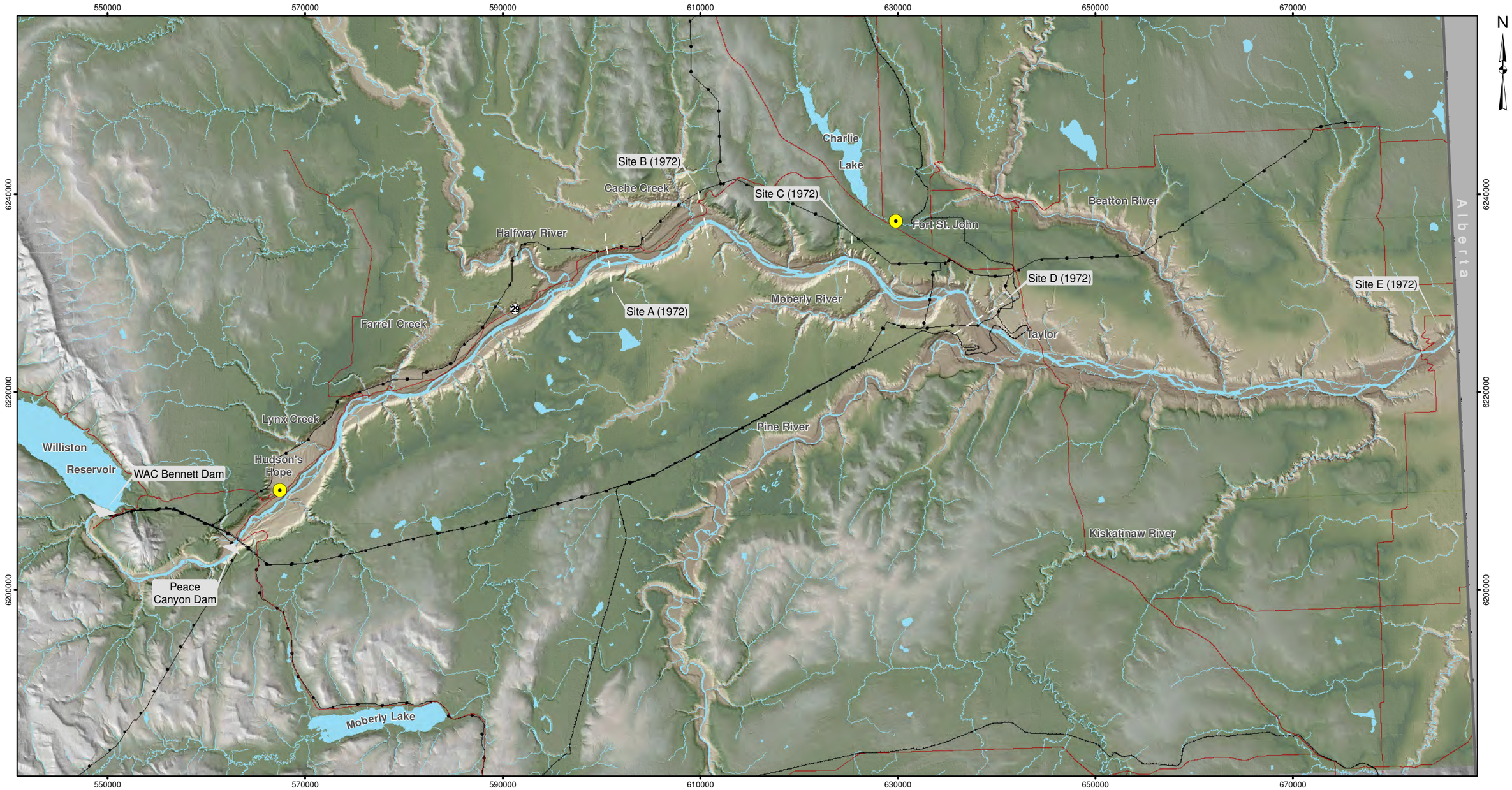

FIGURE: 2-1

Legend

- Existing highway 29
- Existing BCH transmission lines
- Railway
- Dam location

Scale 1:385,000 0 20km

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Source Documents:
Peace River Area Power Development Studies Between Site 1 and Alberta Border Feasibility Study (1972)

Klohn Crippen Berger
SNC·LAVALIN

BC hydro

1972 Feasibility Study
Dam Sites

DATE	OCT, 2009	DWG NO		R 0

P:\P\P05032 A02 Site C - 2006 to 2008 Eng Studies\400 Drawings\GIS_data\MXD\Evaluation_of_alternatives\Alternatives_EA_Hatch\Tiles\Examples\11x17\1972_Feas_Dam_Sites.mxd

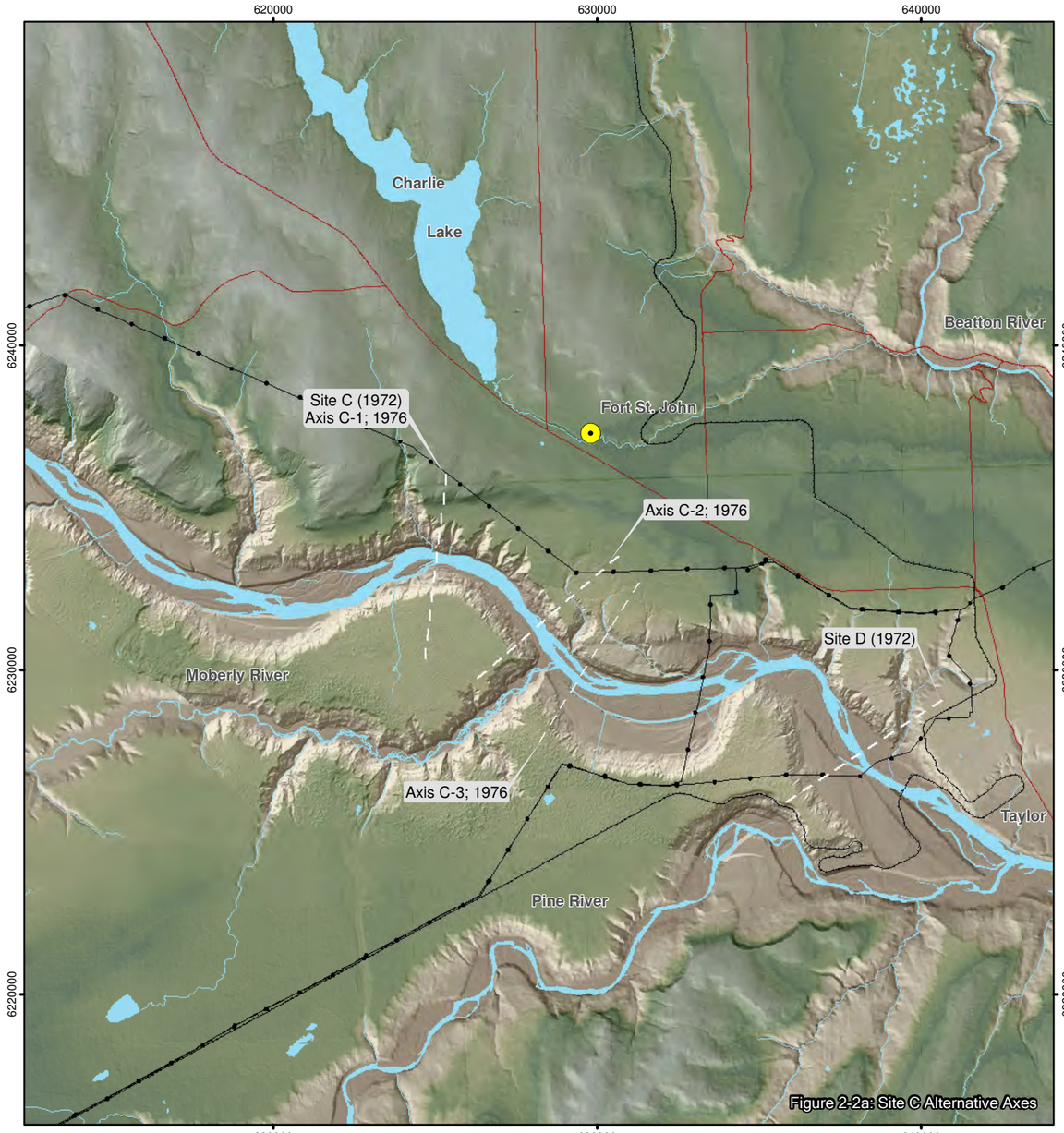

Figure 2-2a: Site C Alternative Axes

Scale 1:170,000

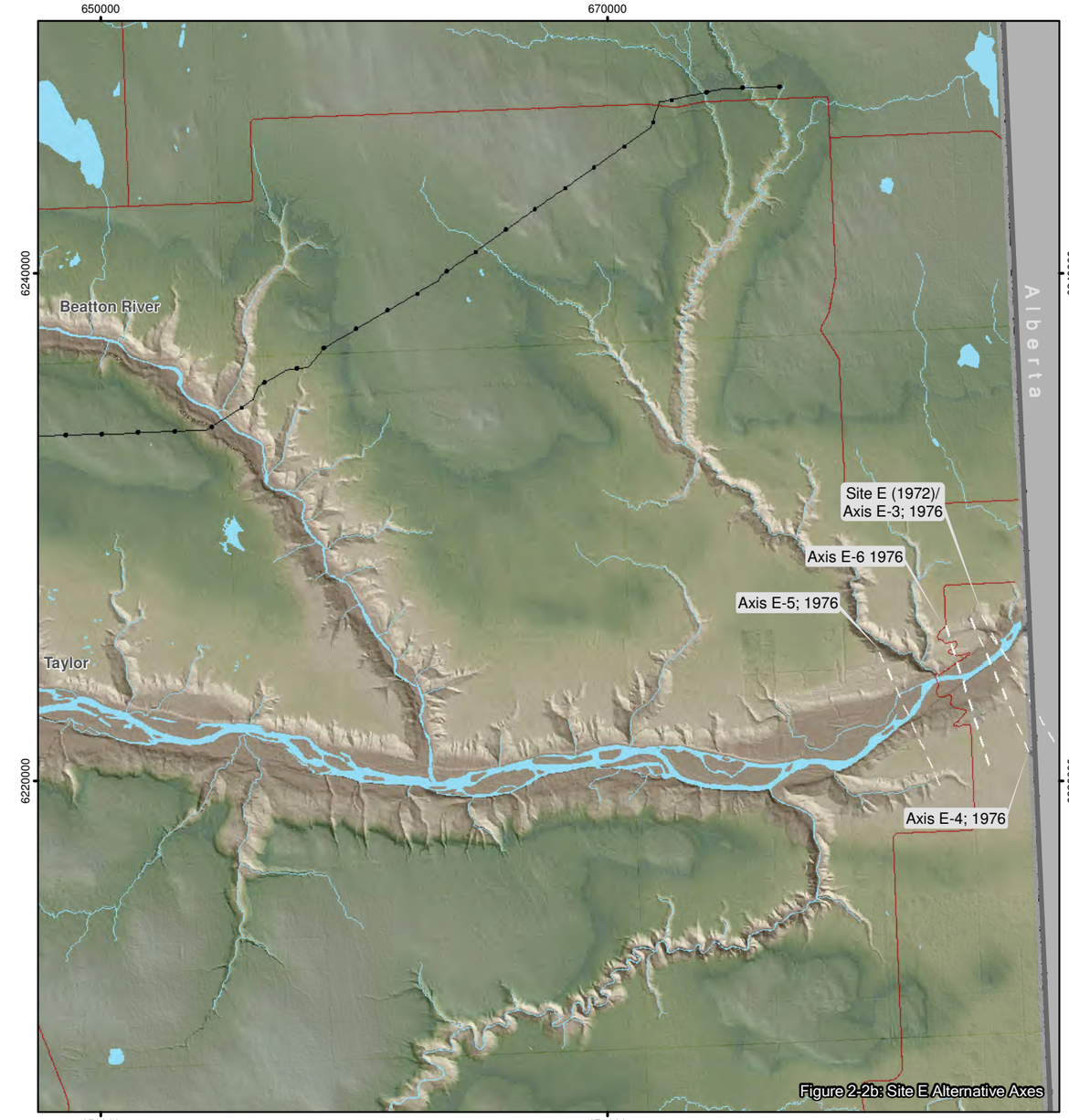

Figure 2-2b: Site E Alternative Axes

Scale 1:215,000

FIGURE: 2-2 a & b

Legend

- Existing highway 29
- Existing BCH transmission lines
- Railway
- Dam location

0 10km

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Source Documents:
1. Peace River Area Power Development Studies Between Site 1 and Alberta Border Feasibility Study (1972)
2. Peace river Sites C and E Feasibility Study (1976)

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1976 Feasibility Study
Site C & E Alternate Axes

DATE	OCT, 2009	DWG NO		R 0

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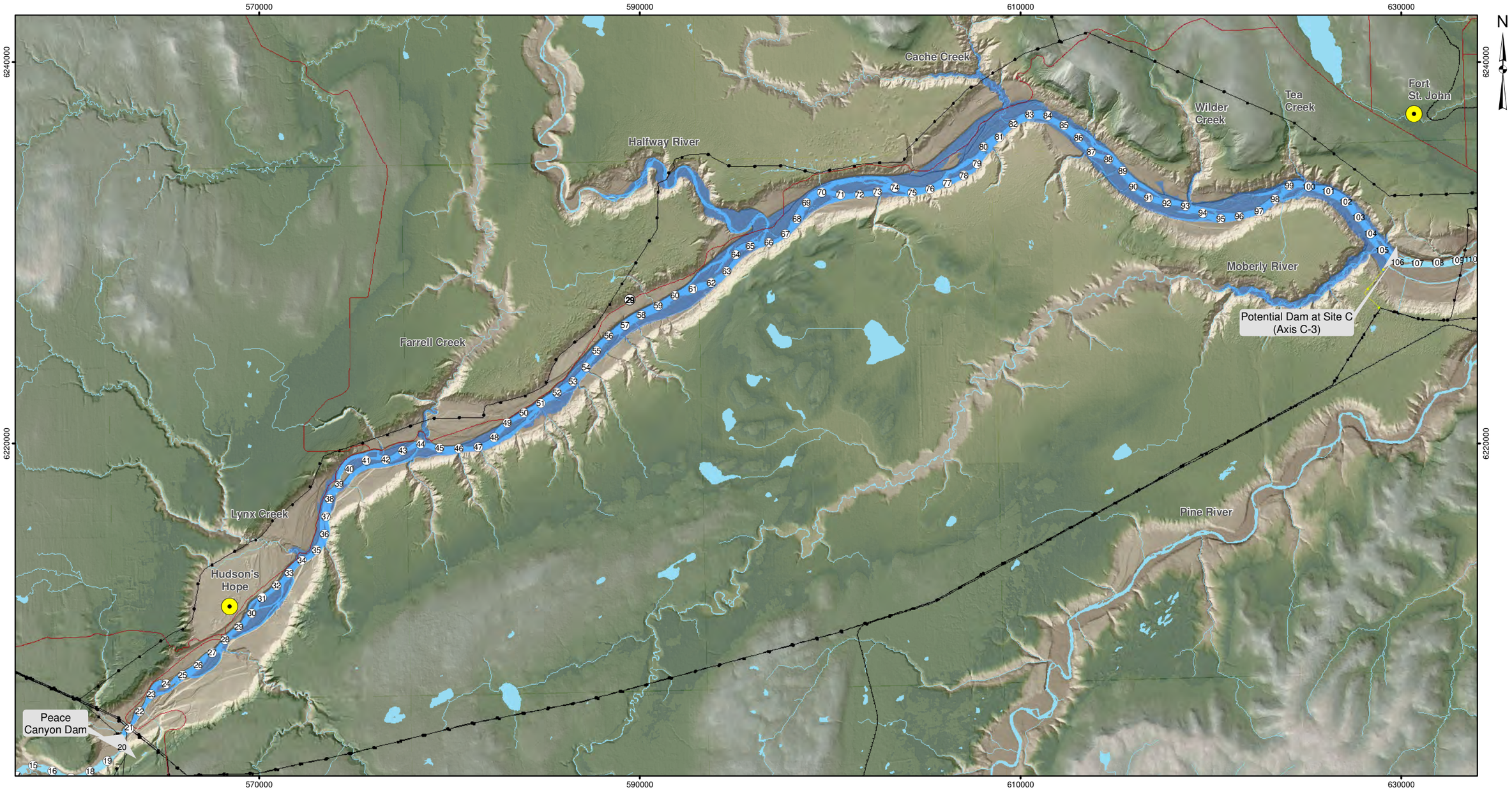

FIGURE: 2-3

Normal Reservoir Levels:
Dam Site C = 461.8m, reservoir surface area = 9,313.6 ha
Peace River area = 3,130.5 ha
Incremental flooded area = 6,183.1 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Existing Peace River
- Potential flooded area (El. 461.8m)
- Dam location
- River marker (see note 4)

Scale: 1:200,000 0 10km

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

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Location Map
Site C (Axis C-3)

DATE	OCT, 2009	DWG NO		R 0

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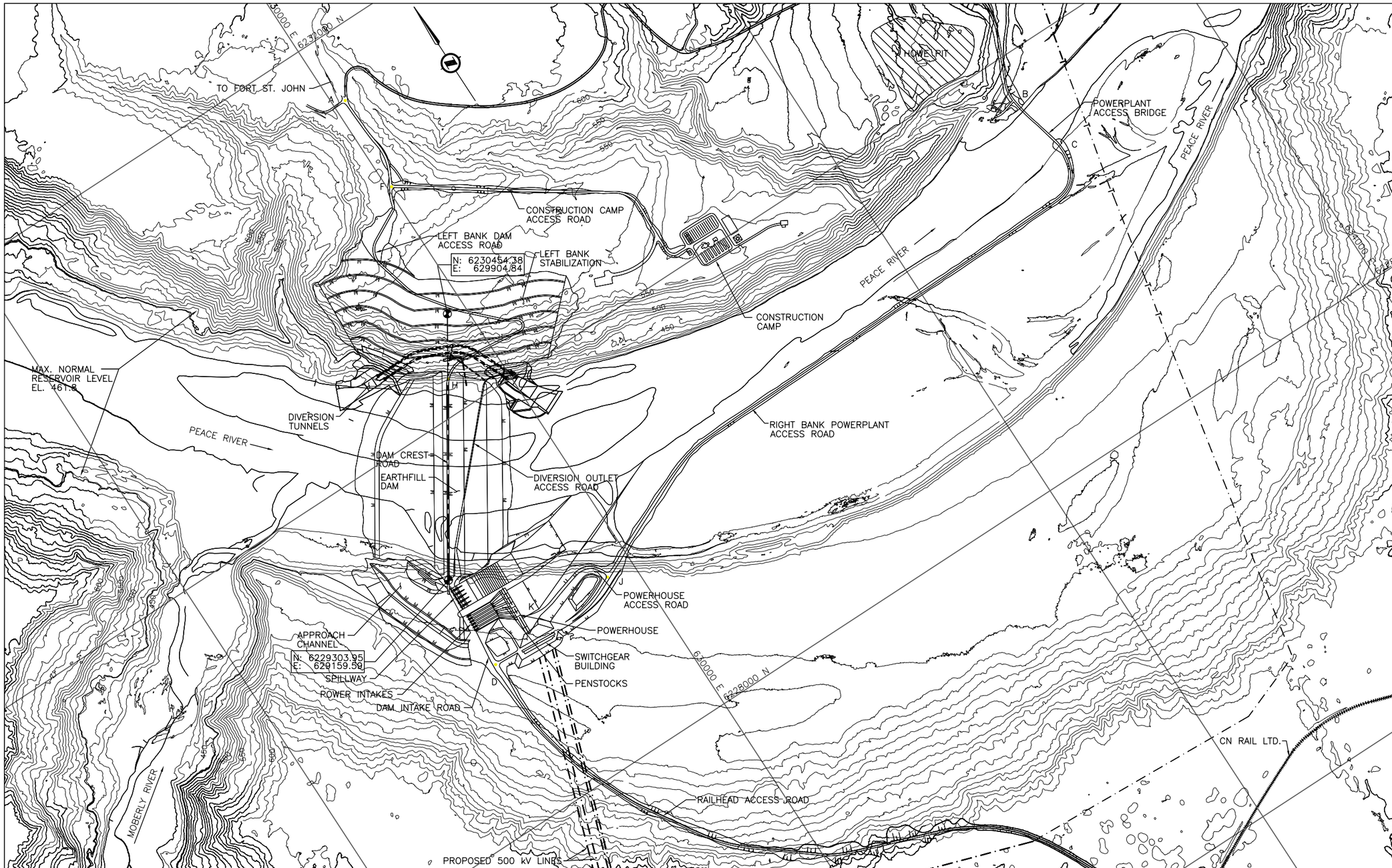

NOTE:

1. FIGURE IS BASED ON FIGURE 4 (DWG.1016–C14–D2658) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003. NOTE THAT COORDINATES HAVE BEEN UPDATED TO NAD83.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMMETRY SERVICES.

PLAN
SCALE 1:10000

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Klohn Crippen Berger

BChydro ENGINEERING

PEACE RIVER SITE C PROJECT

SITE C
1981 GENERAL ARRANGEMENT

DSGN		AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.
INDEP CHK		
DFTG	YK (SLI)	
DFTG CHK		
REPORT NO.		
PROJ. NO.	017348	

DATE	MAY 2009	FIG NO	FIGURE 2-4
DWN	YK	DWG NO	1016-C14-D3254
		R	

NOT TO BE REPRODUCED WITHOUT THE PERMISSION OF BC HYDRO

D

K:\P05032 A02 Site C – 2006 to 2008 Eng Studies\400 Drawings\Task 23 – Alternates Study\Figure 2.4 – General Arrangement.dwg
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2009/10/09 – 2:42pm

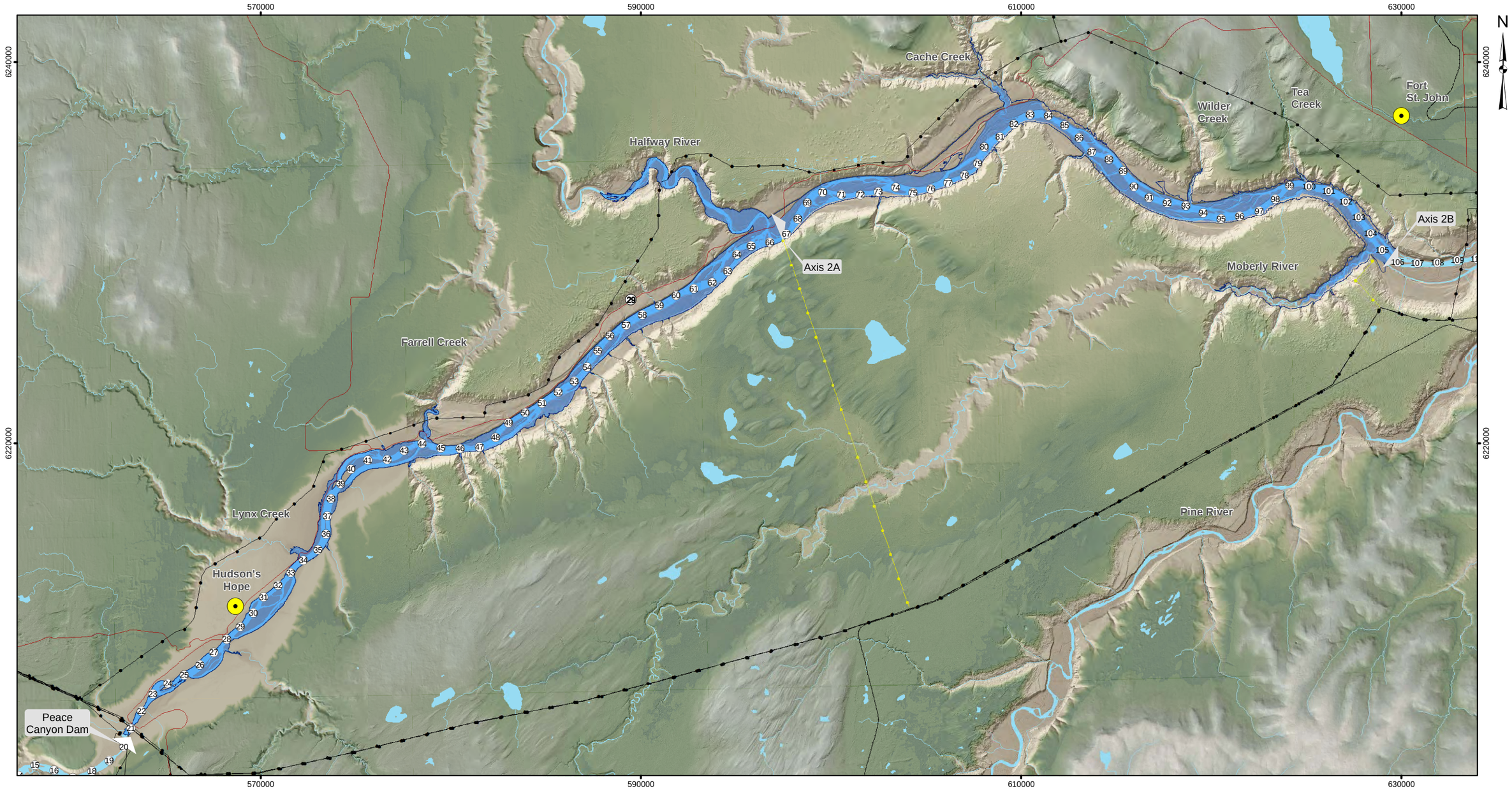

FIGURE: 3-1

Normal Reservoir Levels:
Dam 2a = 461.8m, reservoir surface area = 4,340.9 ha
Peace River area = 1,693.9 ha
Incremental flooded area = 2,647.0 ha
Dam 2b = 437.0m, reservoir surface area = 3,733.8 ha
Peace River area = 1,404.4 ha
Incremental flooded area = 2,329.4 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Source Document:
Cursory Evaluation of Cascade Option (November, 2002)

Scale: 1:200,000 0 10km

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Location Map
2 Dam Cascade

DATE May 29, 2012 | DWG NO | R 1

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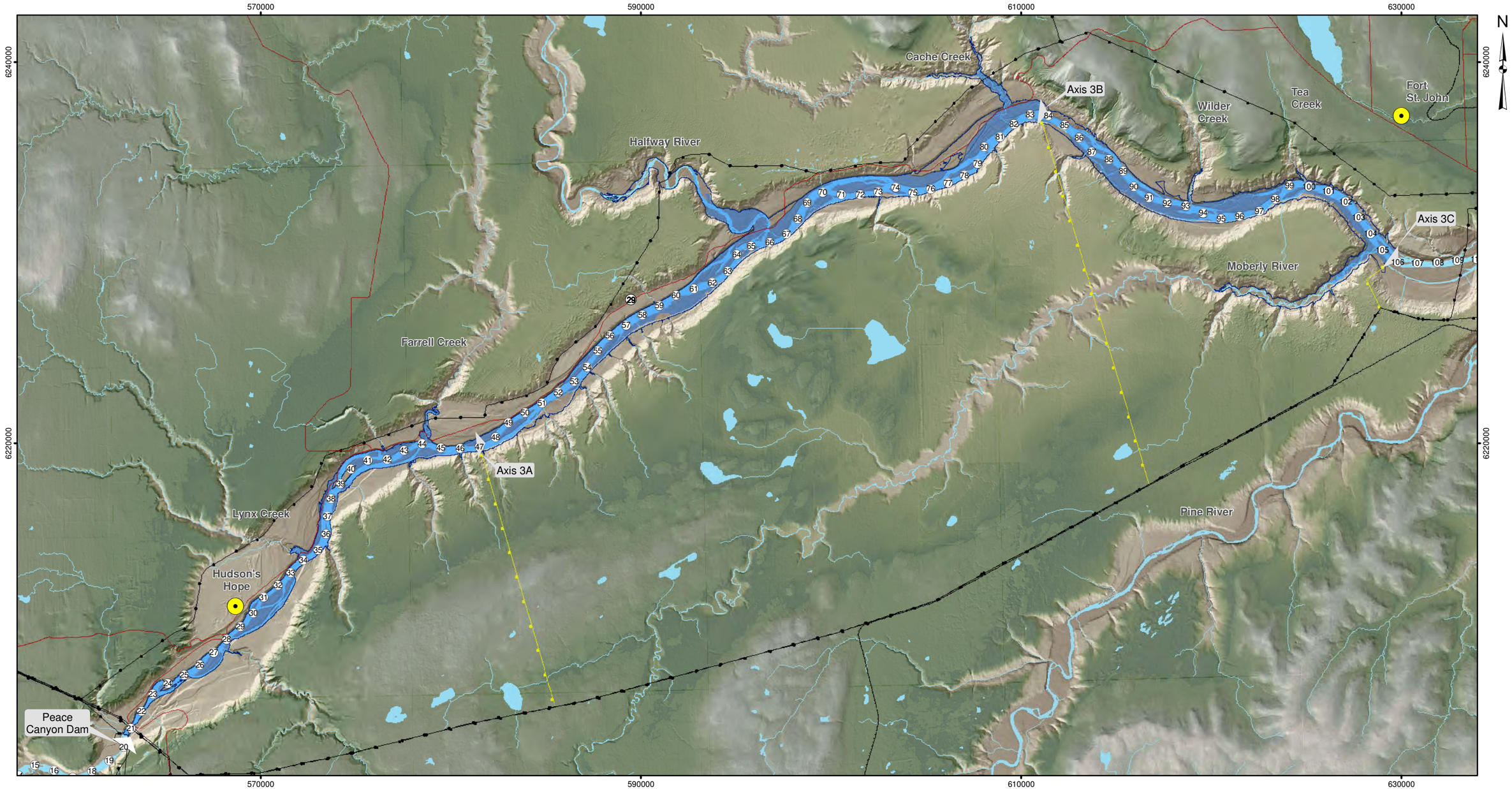

FIGURE: 3-2

Normal Reservoir Levels:

Dam 3a = 461.8m, reservoir surface area = 1,817.11 ha
Peace River area = 870.4 ha
Incremental flooded area = 957.0 ha

Dam 3b = 445.3m, reservoir surface area = 3,579.8 ha
Peace River area = 1,335.2 ha
Incremental flooded area = 2,244.6 ha

Dam 3c = 428.7m, reservoir surface area = 1,975.5 ha
Peace River area = 815.1 ha
Incremental flooded area = 1,160.4 ha

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)

Source Document:
Cursory Evaluation of Cascade Option (November, 2002)

Scale: 1:200,000 0 10km

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Location Map
3 Dam Cascade

DATE	OCT, 2009	DWG NO		R 0

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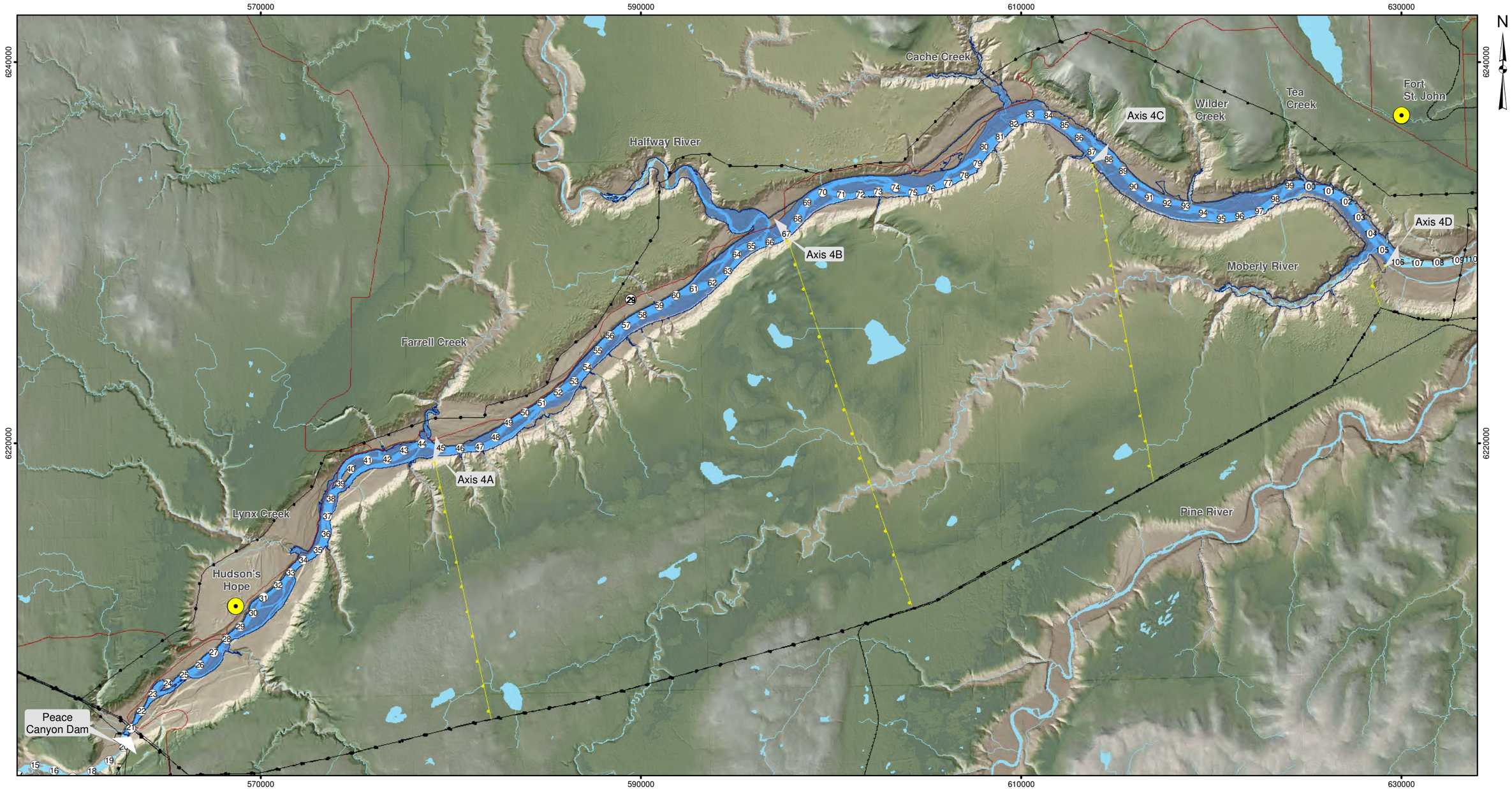

FIGURE: 3-3

Normal Reservoir Levels:

Dam 4a = 461.8m, reservoir surface area = 1,698.3 ha
Peace River area = 793.9 ha
Incremental flooded area = 904.4 ha

Dam 4b = 449.4m, reservoir surface area = 2,178.8 ha
Peace River area = 844.5 ha
Incremental flooded ara = 1,334.3 ha

Dam 4c = 437m, reservoir surface area = 1,858.2 ha
Peace River area = 703.0 ha
Incremental flooded area = 1,155.2

Dam 4d = 424.6m, reservoir surface area = 1,644.4 ha
Peace River area = 680.6 ha
Incremental flooded area = 963.8 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- ① km marker (see note 4)

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Source Document:
Cursory Evaluation of Cascade Option (November, 2002)

Scale: 1:200,000 0 10km

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Location Map
4 Dam Cascade

DATE OCT, 2009 | DWG NO | R 0

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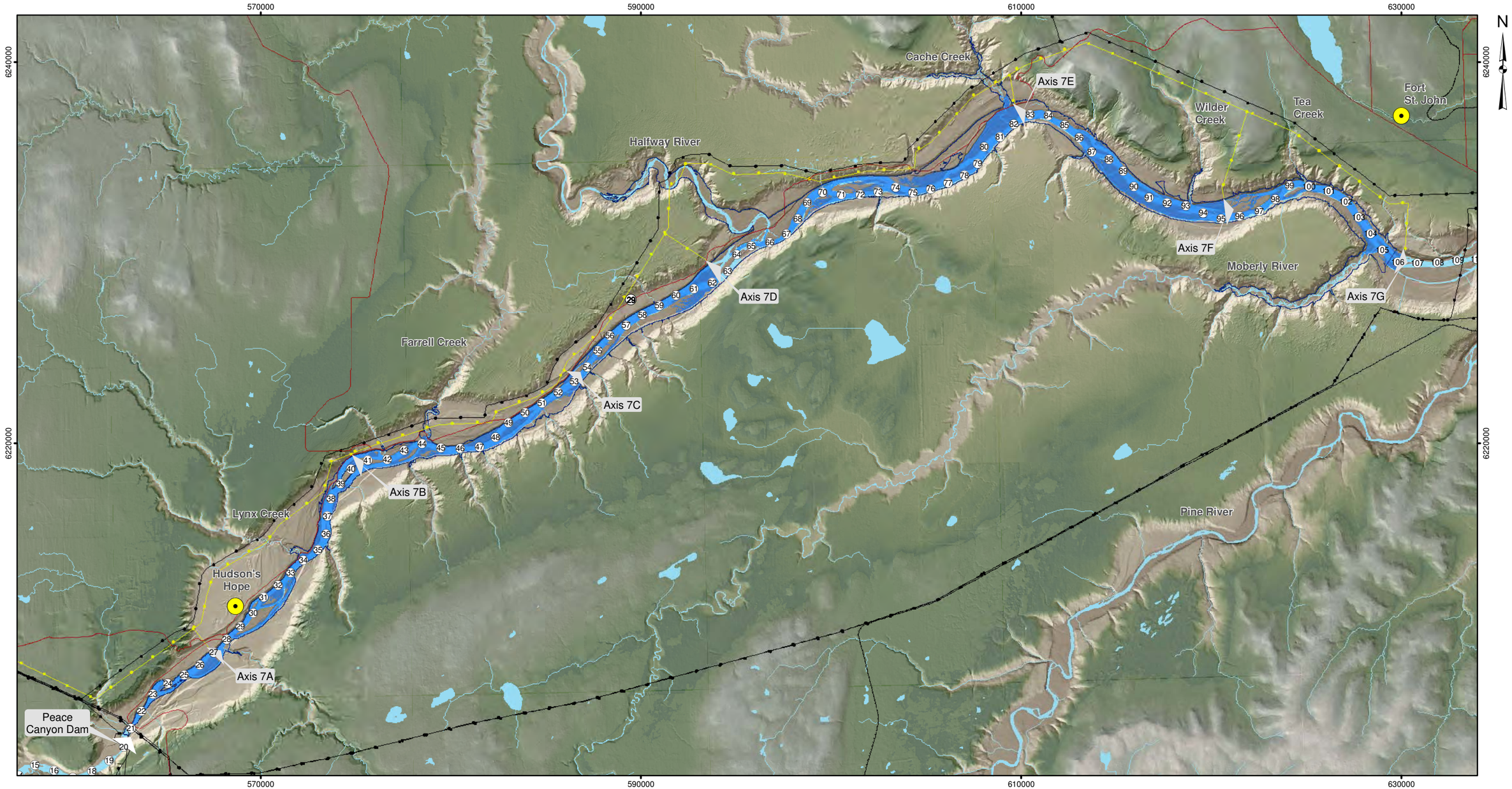

Normal Reservoir Levels:

Dam 7a = 460.0m, reservoir surface area = 268.3 ha
Peace River area = 182.4 ha
Incremental flooded area = 85.9 ha

Dam 7b = 454.1m, reservoir surface area = 721 ha
Peace River area = 435.6 ha
Incremental flooded area = 285.4 ha

Dam 7c = 446.2m, reservoir surface area = 783.2 ha
Peace River area = 449.0 ha
Incremental flooded area = 334.2 ha

Dam 7d = 438.2m, reservoir surface area = 541.3 ha
Peace River area = 304.2 ha
Incremental flooded area = 237.1 ha

Dam 7e = 431.0m, reservoir surface area = 1,226.7ha
Peace River area = 609.1 ha
Incremental flooded area = 617.6 ha

Dam 7f = 425.0m, reservoir surface area = 992.2 ha
Peace River area = 449.6 ha
Incremental flooded area = 542.6 ha

Dam 7g = 417.0m, reservoir surface area = 633.0 ha
Peace River area = 380.3 ha
Incremental flooded area = 252.7 ha

Source Document:
Prefeasability Study for a Cascade of Low Consequence Structures as an Alternative to Site C (2006)

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- ① River marker (see note 4)

FIGURE: 3-4

Scale: 1:200,000 0 10km

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Location Map
7 Dam Cascade

DATE OCT, 2009 | DWG NO | R 0

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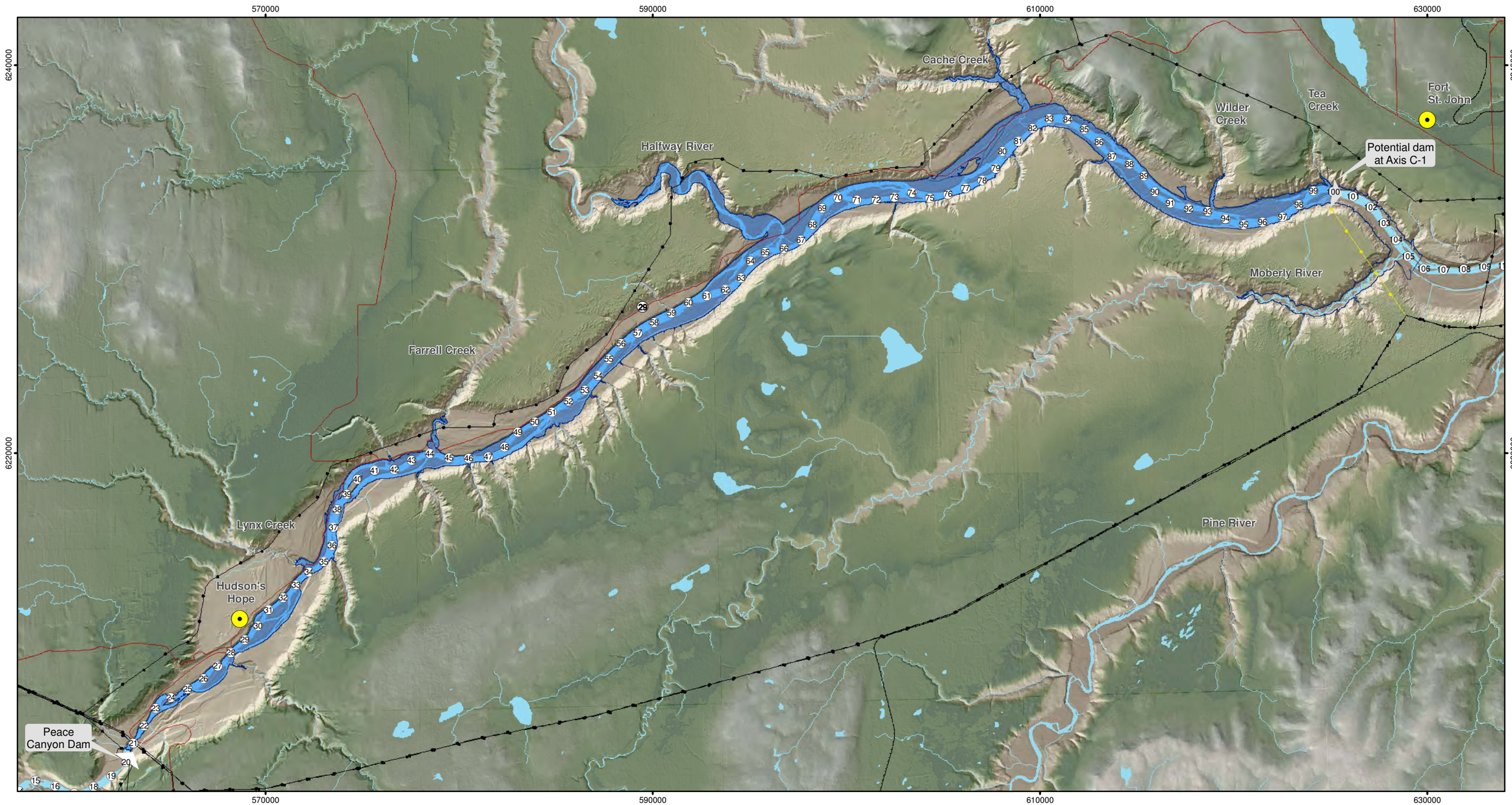

FIGURE: 3-5

Normal Reservoir Levels:
Dam Site C-1 = 461.8m, reservoir surface area = 8,320.9 ha
Peace River area = 2,846.2 ha
Incremental flooded area = 5474.7 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)

Source Document:
Review of Upstream Axis - Peace River Development Site C Project (2006)

Scale: 1:200,000 0 10km

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

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Location Map
Single Dam at Axis C-1

DATE	OCT, 2009	DWG NO		R 0

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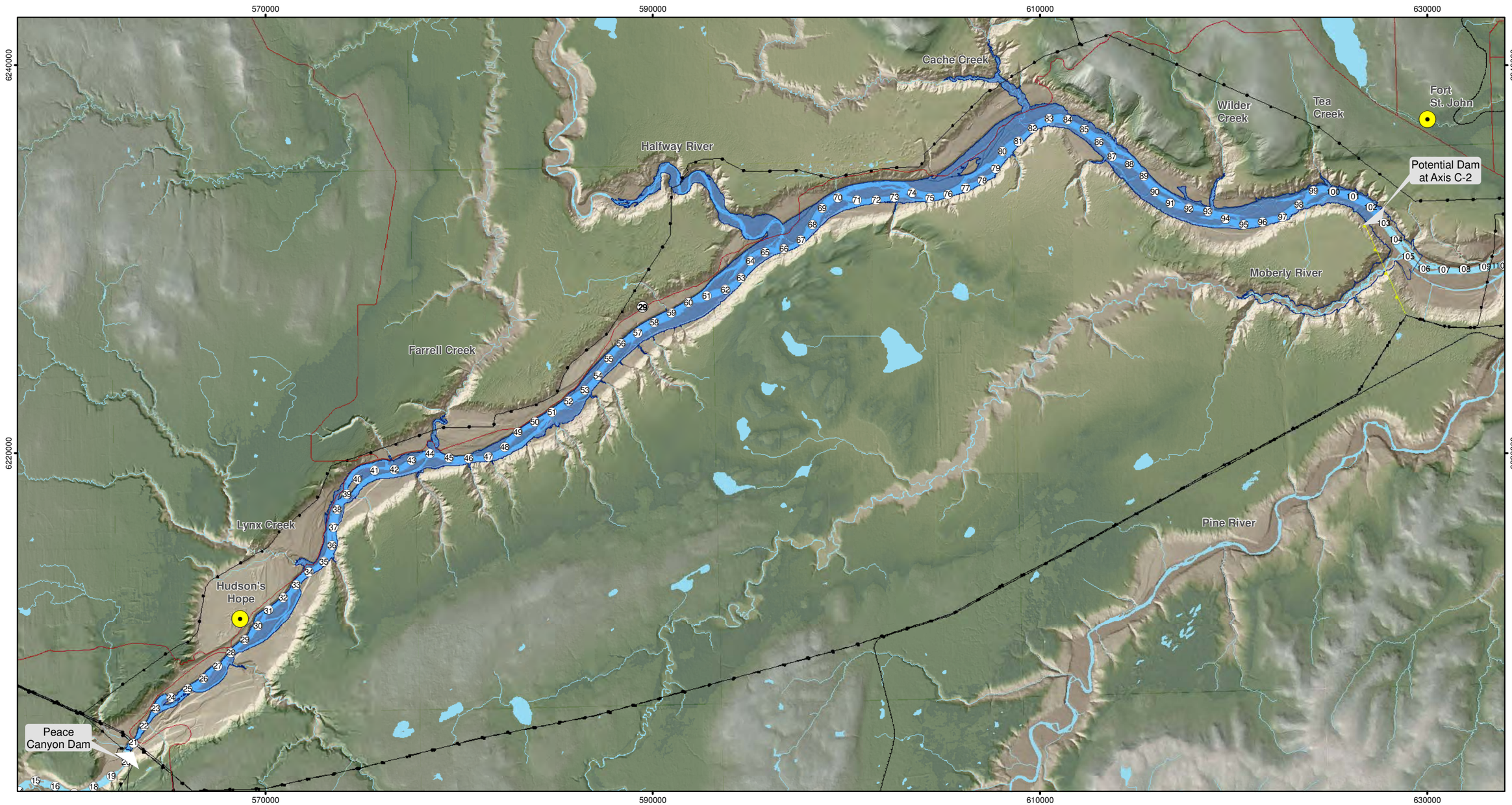

FIGURE: 3-6

Normal Reservoir Levels:
Dam Site C-2 = 461.8m, reservoir surface area = 8,568.4 ha
Peace River area = 2,949.3 ha
Incremental flooded area = 5,619.1 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)

Source Document:
Review of Upstream Axis - Peace River Development Site C Project (2006)

Scale: 1:200,000 0 10km

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

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Location Map
Single Dam at Axis C-2

DATE	OCT, 2009	DWG NO		R 0

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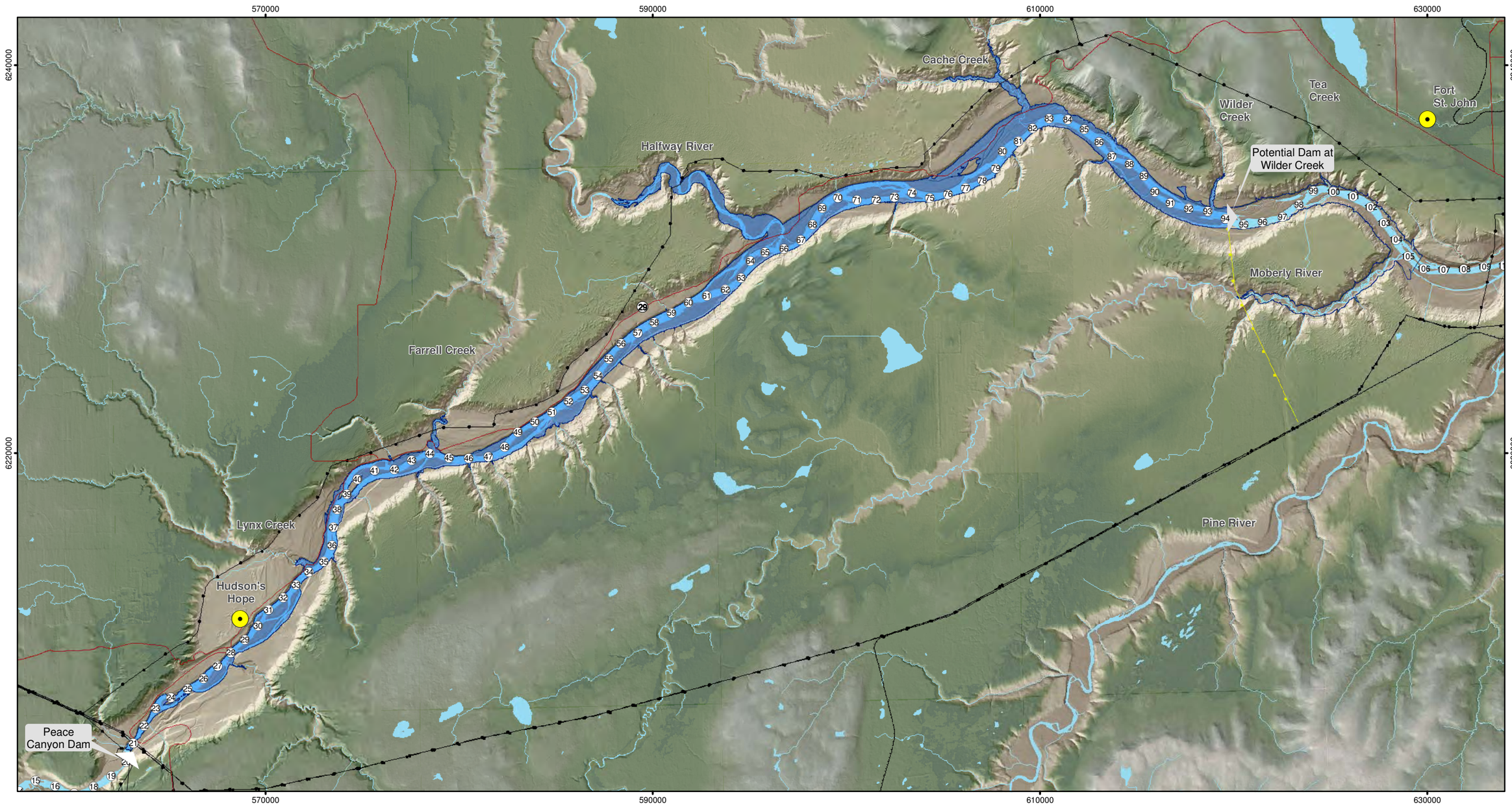

FIGURE: 4-1

Normal Reservoir Levels:
Dam Site Wilder Creek = 461.8m, reservoir surface area =7,677.7 ha
Peace River area = 2,645.9 ha
Incremental flooded area = 5,031.8 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Scale: 1:200,000 0 10km

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Location Map
Single Dam at Wilder Creek

DATE OCT, 2009 | DWG NO | R 0

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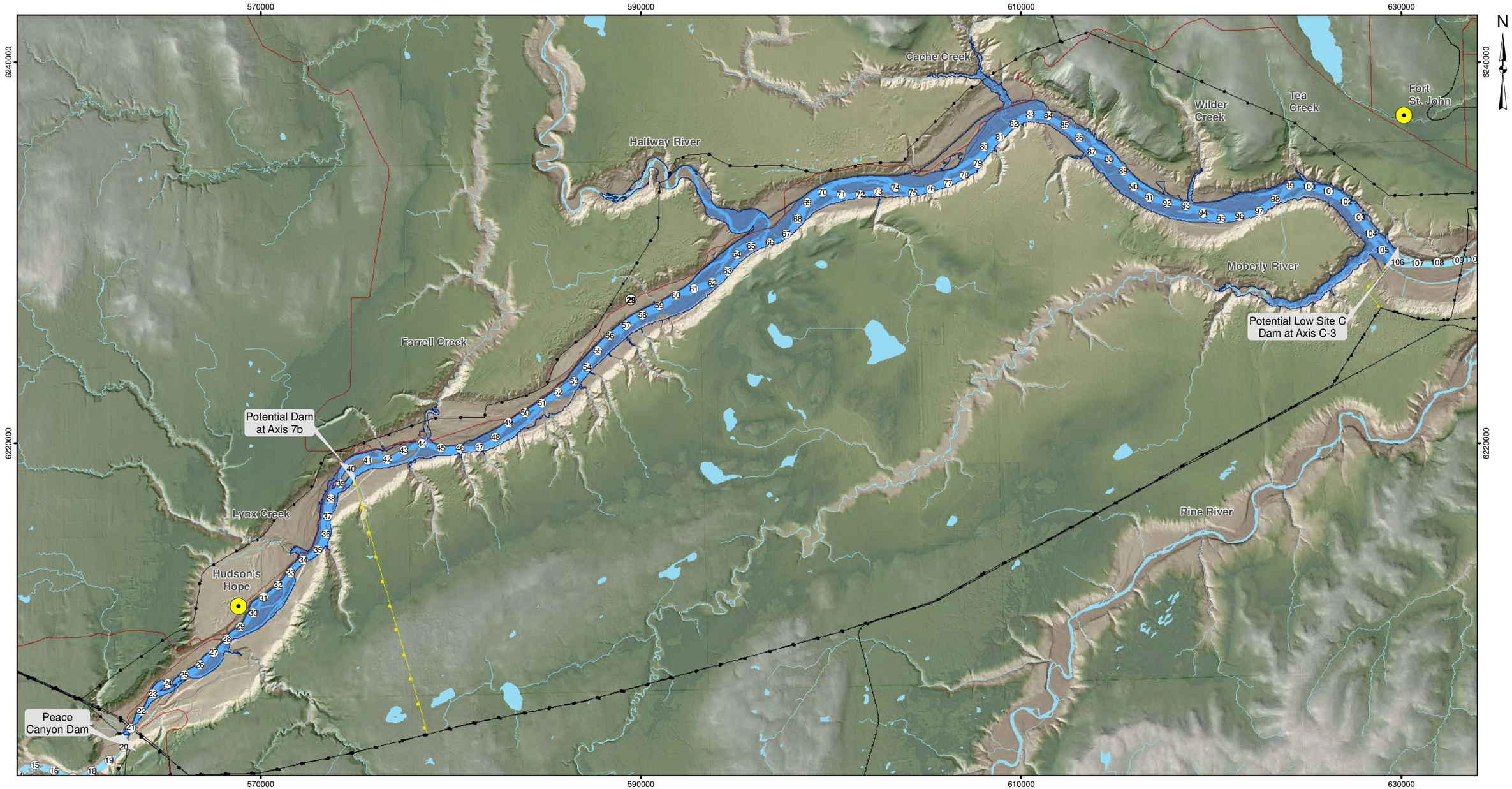

FIGURE: 4-2

Normal Reservoir Levels:
Low Site C = 446.7m, reservoir surface area = 6,478.2 ha
Peace River area = 2,432.8 ha
Incremental flooded area = 4,045.4 ha
Dam at 7b = 461.8m, reservoir surface area = 1,190.5 ha
Peace River area = 607.2 ha
Incremental flooded area = 583.3 ha

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Scale: 1:200,000 0 10km

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Location Map
Dams at Site 7b and C-3

DATE	OCT, 2009	DWG NO		R 0

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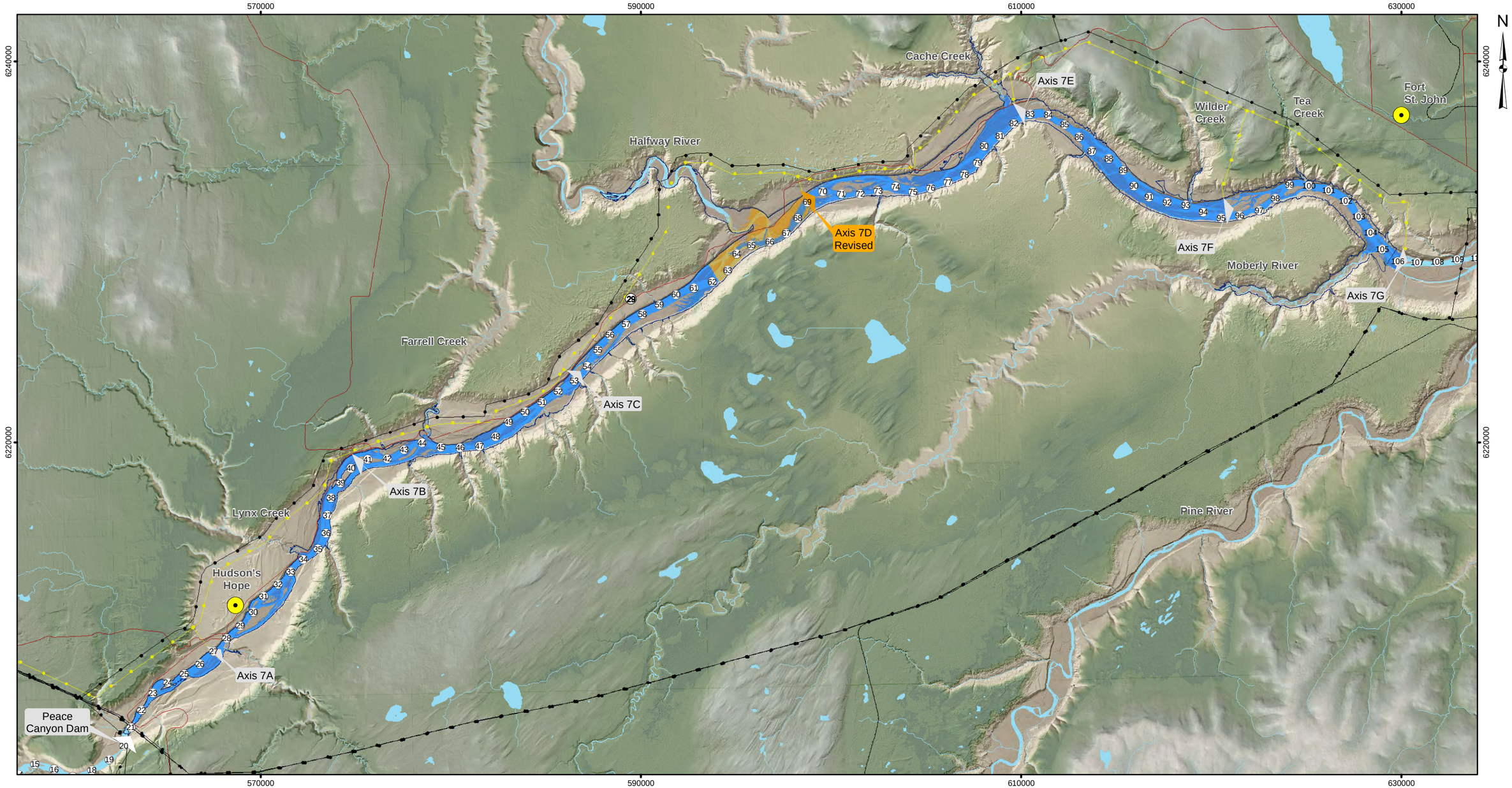

Normal Reservoir Levels:

Dam 7a = 460.0m, reservoir surface area = 268.3 ha
Peace River area = 182.4 ha
Incremental flooded area = 85.9 ha

Dam 7b = 454.1m, reservoir surface area = 721 ha
Peace River area = 435.6 ha
Incremental flooded area = 285.4 ha

Dam 7c = 446.2m, reservoir surface area = 783.2 ha
Peace River area = 449.0 ha
Incremental flooded area = 334.2 ha

Dam 7d = 438.2m, reservoir surface area = 541.3 ha
Peace River area = 304.2 ha
Incremental flooded area = 237.1 ha

Revised Dam 7d = 438.2m, reservoir surface area = 1,186.7 ha
Peace River area = 560.9 ha
Incremental flooded area = 625.8 ha

Dam 7e = 431.0m, reservoir surface area = 1,226.7ha
Peace River area = 609.1 ha
Incremental flooded area = 617.6 ha

Revised Dam 7e = 431.0m, reservoir surface area = 1,073.0 ha
Peace River area = 462.5 ha
Incremental flooded area = 610.5 ha

Dam 7f = 425.0m, reservoir surface area = 992.2 ha
Peace River area = 449.6 ha
Incremental flooded area = 542.6 ha

Dam 7g = 417.0m, reservoir surface area = 633.0 ha
Peace River area = 380.3 ha
Incremental flooded area = 252.7 ha

MAP NOTES:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Data Sources: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
4. River Markers are nominal kilometer chainages downstream of W.A.C. Bennett Dam.

Legend

- Existing highway 29
- Existing BCH transmission lines
- Potential transmission line interconnect
- Railway
- Dam location
- Existing Peace River
- Potential flooded area
- Potential flooded area for Site C (El. 461.8m)
- River marker (see note 4)
- Additional potentially flooded area 7d revised
- Dam 7D revised

Source Document:
Prefeasability Study for a Cascade of Low Consequence Structures as an Alternative to Site C (2006)

FIGURE: 4-3

Scale: 1:200,000 0 10km

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Location Map
7 Dam Cascade
7d Location Revised

DATE May 29, 2012 | DWG NO | R 1

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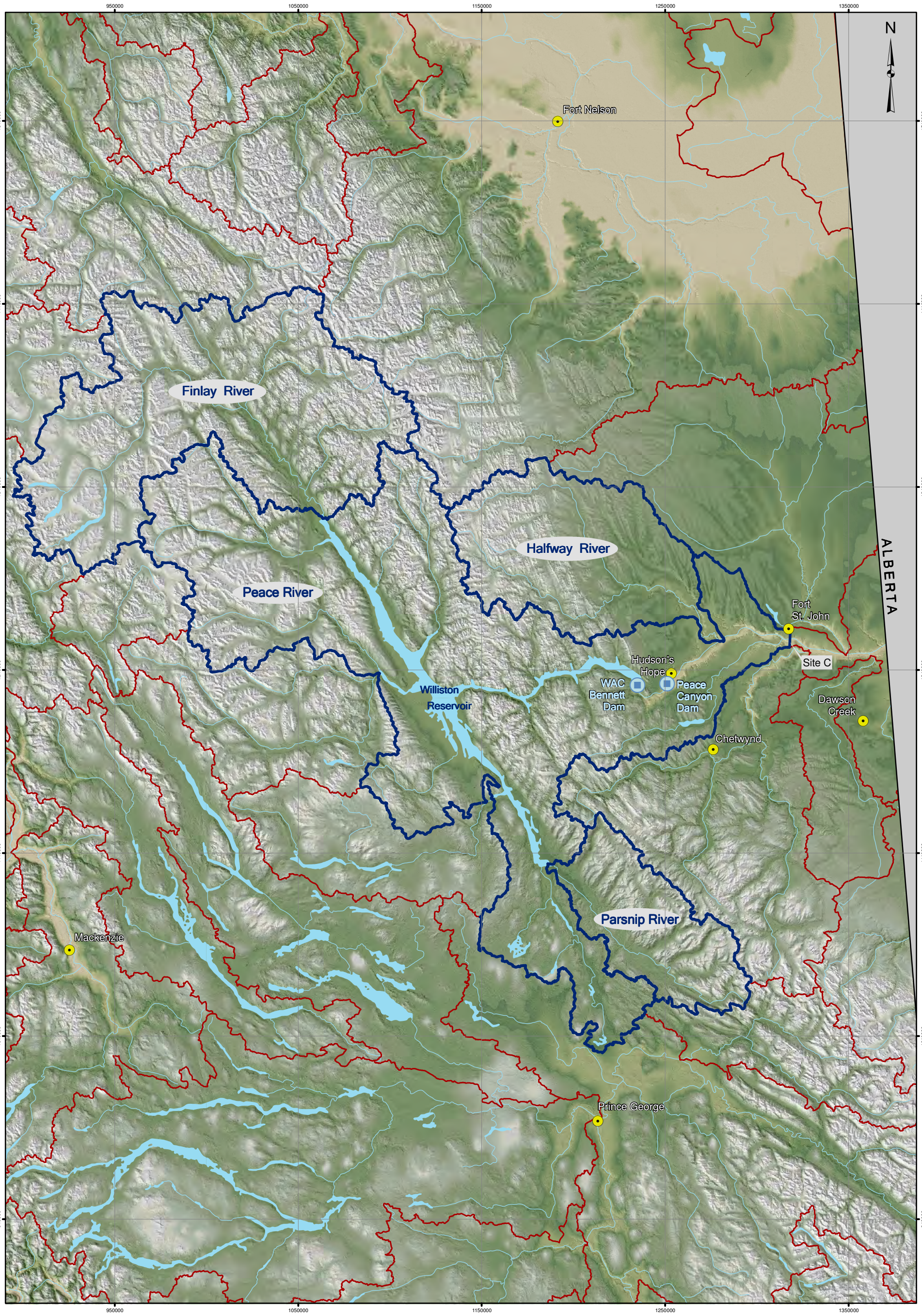

Legend:

- Site C Regional drainage basins
- Watershed
- Town

Notes:
1. Datum: NAD83
2. Projection: BC ALBERS
3. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks

Figure: 6-1

Scale: 1:200,000 0 125 km

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Williston & Site C Drainage Areas

DATE	OCT, 2009	µ	DWG NO	R X

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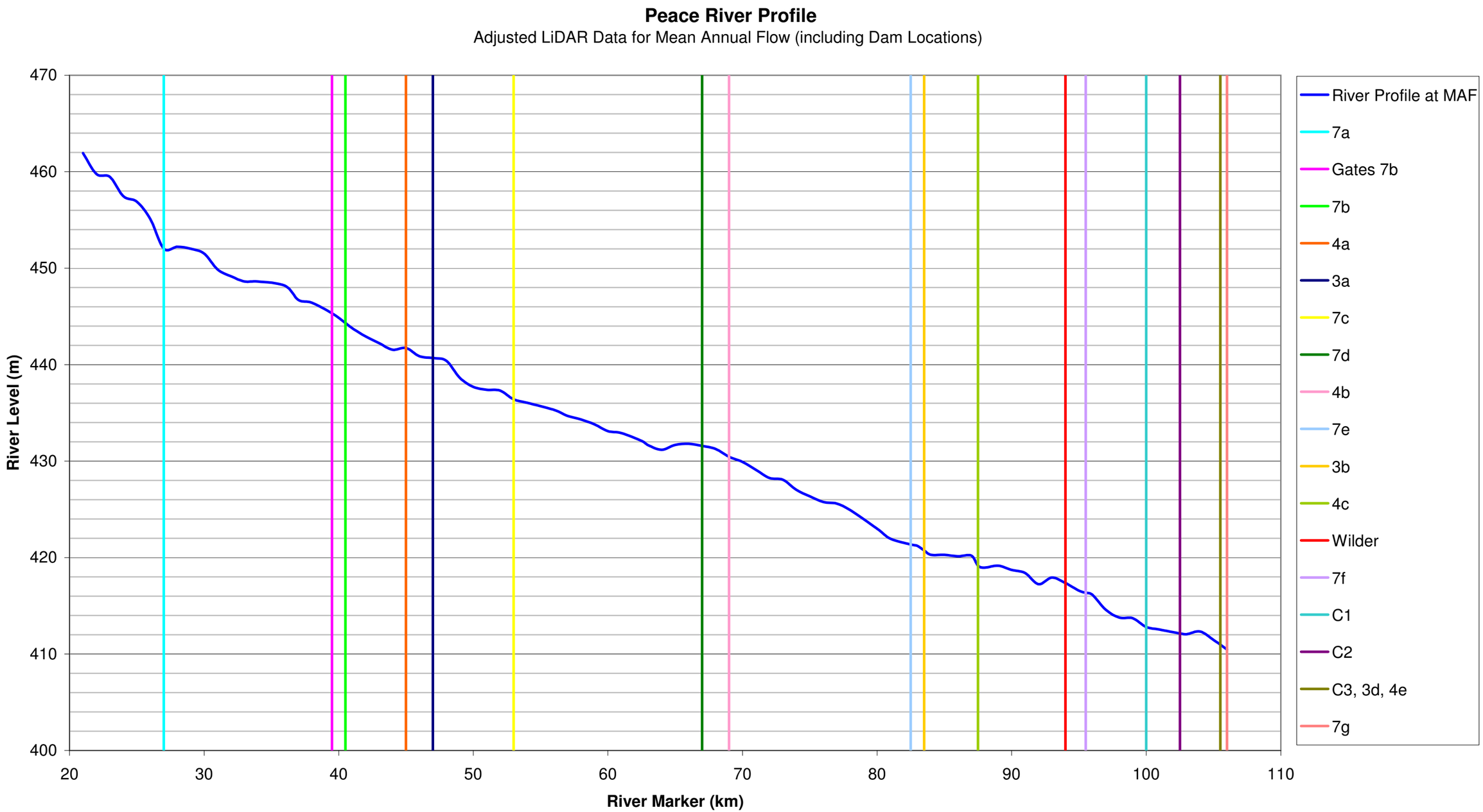
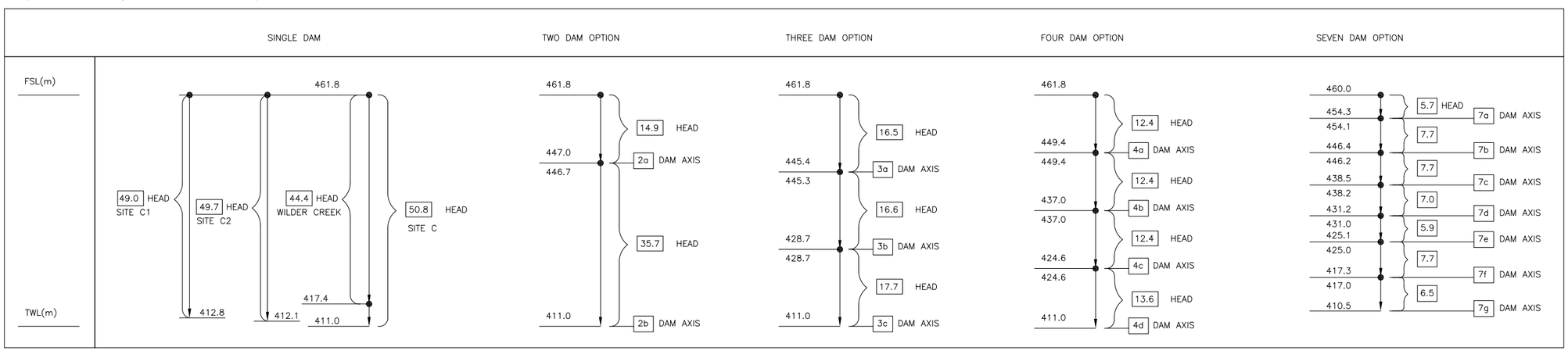

Peace River Profile
Adjusted LiDAR Data for Mean Annual Flow (including Dam Locations)
River Level (m)
470
460
450
440
430
420
410
400
20
30
40
50
60
70
80
90
100
110
River Marker (km)
River Profile at MAF
7a
Gates 7b
7b
4a
3a
7c
7d
4b
7e
3b
4c
Wilder
7f
C1
C2
C3, 3d, 4e
7g

Figure 6-2



NOTES:

1. HEADS INDICATED ARE GROSS HEAD AT MEAN ANNUAL FLOW WITH ALLOWANCE FOR BACKWATER EFFECTS.
2. TAILWATER LEVELS ARE AT MEAN ANNUAL FLOW.

SCALE 1:1000
10 0 10 20 30 40 50m

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DSGN	XXXXXX
INDEP CHK	XXXXXX
DFTG	ICN
DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	XXXXXX

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

ESTIMATED GROSS HEADS FOR DAM OPTIONS

DATE

FIG NO FIGURE 6-3

DWN

DWG NO

R

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X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\Site C – Low Head\\Development Locations Plan.dwg
Wednesday
2009/10/14 – 3:00pm

PLAN
1:12500

NOTE:

1. FIGURE IS BASED ON FIGURE 4 (DWG.1016–C14–D2658) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003. NOTE THAT COORDINATES HAVE BEEN UPDATED TO NAD83.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMMETRY SERVICES.

LEGEND:

(L#) RELOCATION AREAS

DRAFT

SNC·LAVALIN
Klohn Crippen Berger

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

SITE C
GENERAL ARRANGEMENT

DSGN	
INDEP CHK	
DFTG	YK (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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DATE MAY 2009	FIG NO FIGURE 10-1	
DWN YK	DWG NO	R

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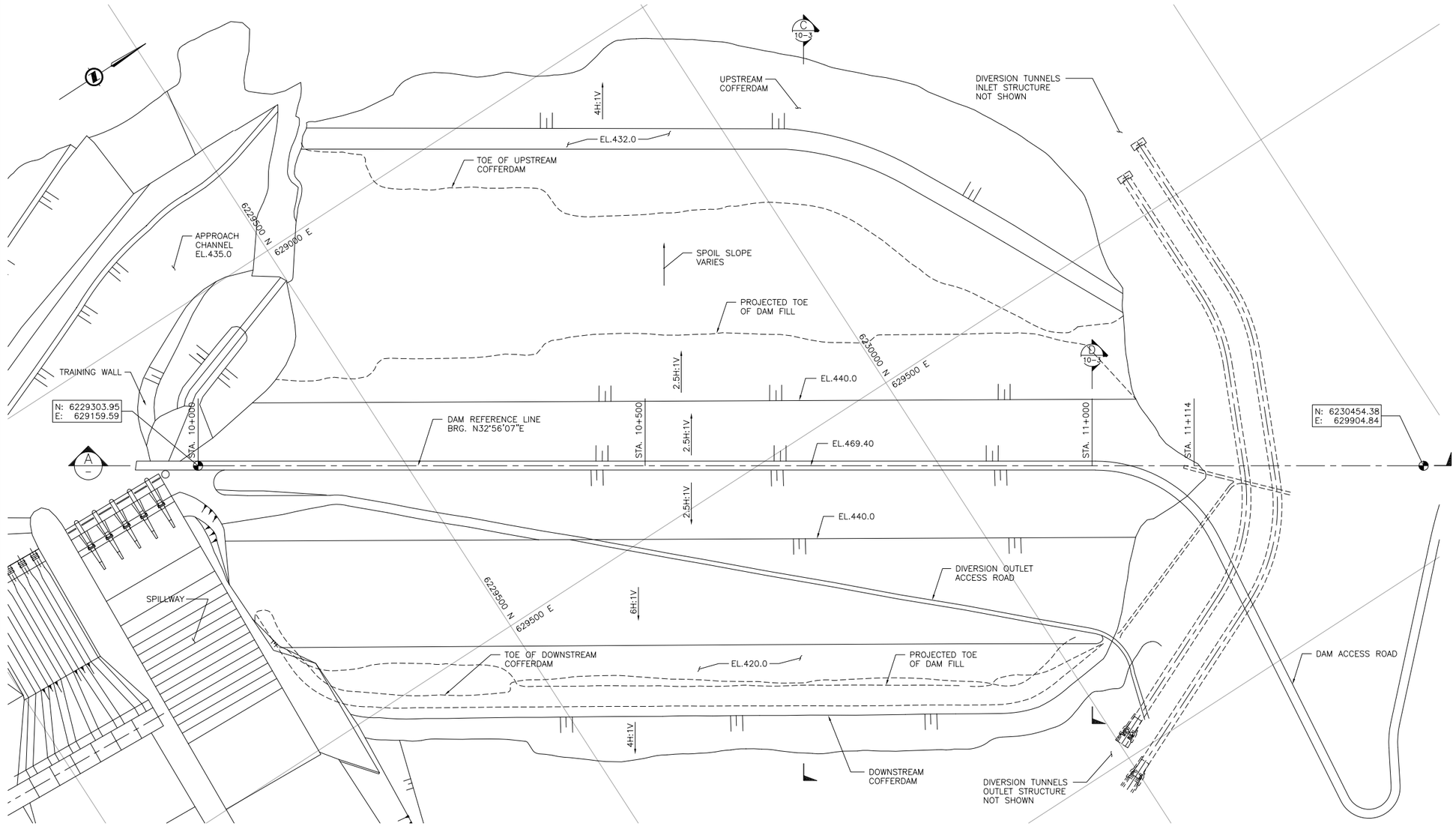
X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\FIGURE 10–1.dwg
Wed, 7 Oct 2009 – 9:29am
2009/10/08

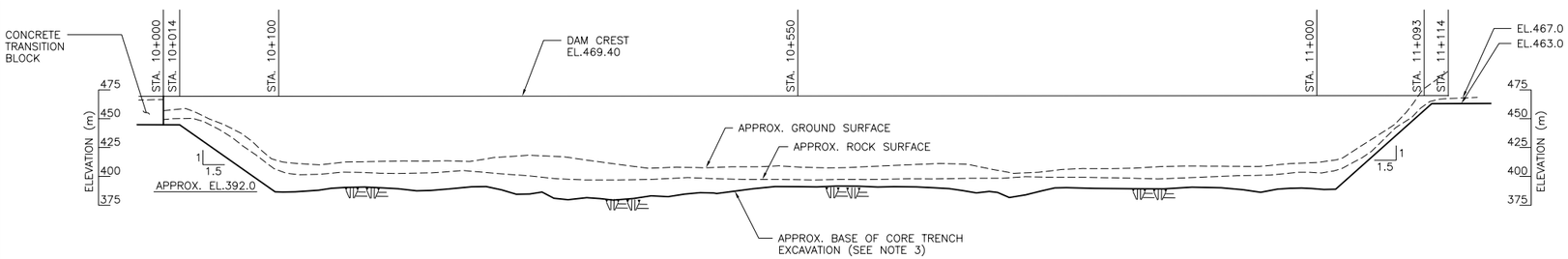


PLAN
1:2500

NOTES:

1. FIGURE IS BASED ON FIGURE 15 (DWG.1016–C14–D2669) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003. NOTE THAT COORDINATES HAVE BEEN UPDATED TO NAD83.
2. SECTION A BASED ON DWG.1006–C14–D1910 FOR THE GROUND AND SURFACE CONTOURS, BC HYDRO REPORT EP8 DATED SEPTEMBER 1986.

DRAFT



SECTION A
1:2500

0 100m

SNC·LAVALIN
Klohn Crippen Berger

DSGN	
INDEP CHK	
DFTG	YK (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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PEACE RIVER SITE C PROJECT

SITE C
EARTHFILL DAM
PLAN & LONGITUDINAL SECTION

DATE	MAY 2009
FIG NO	FIGURE 10-2
DWN	YK
DWG NO	
R	

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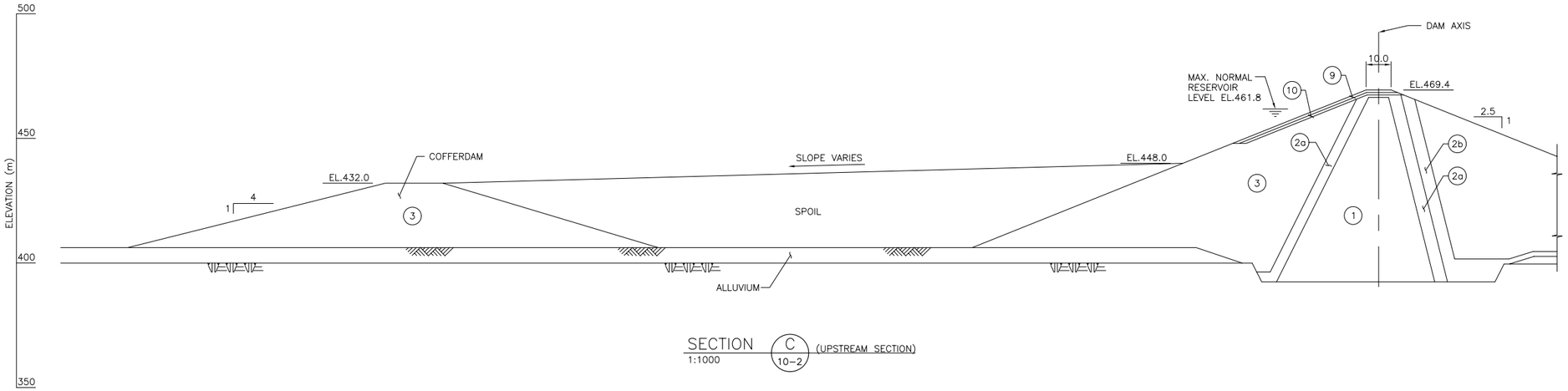
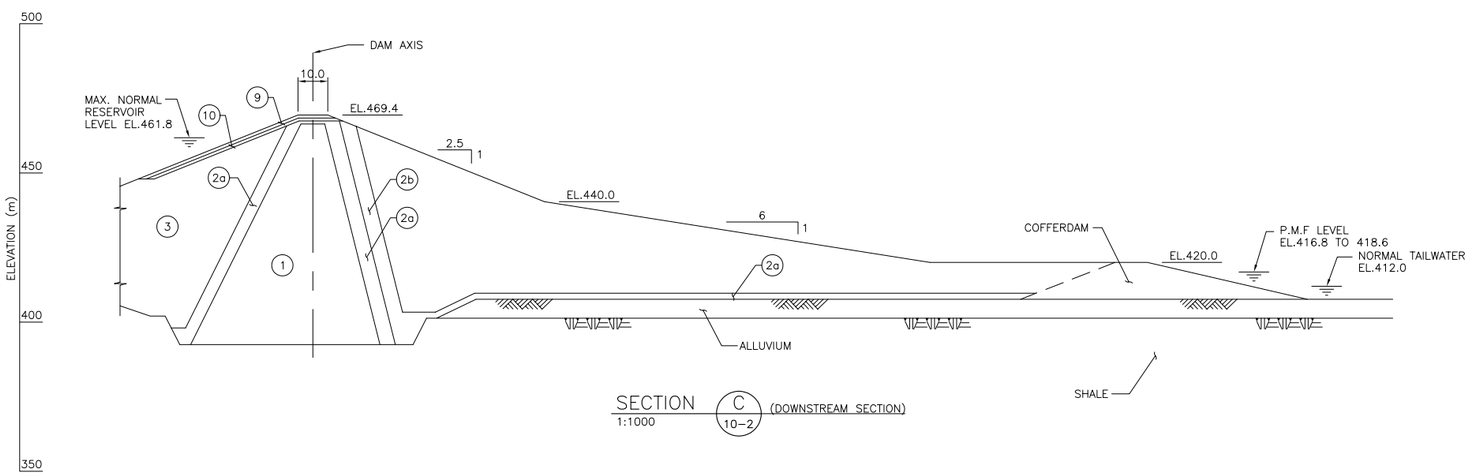
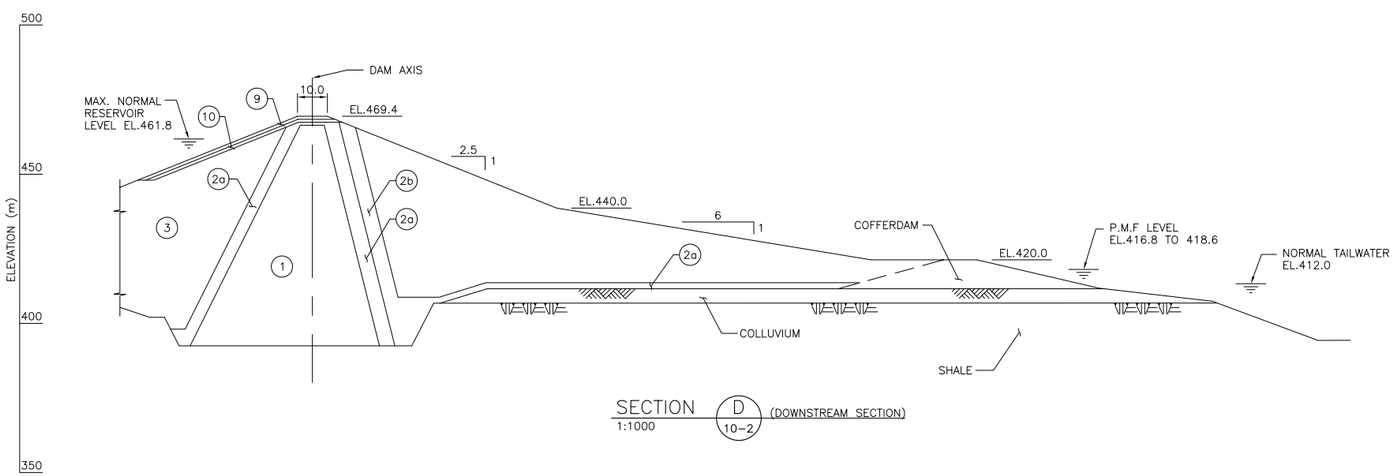
X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\FIGURE 10-2.dwg
Kim Kim – 2009/10/08 – 9:28am



SECTION C (10-2) (UPSTREAM SECTION)
1:1000



SECTION C (10-2) (DOWNSTREAM SECTION)
1:1000



SECTION D (10-2) (DOWNSTREAM SECTION)
1:1000

NOTES:

1. FIGURE IS BASED ON FIG.17 (DWG.1016-C14-D2671) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003.
2. FOR DETAILS OF CORE AND FILTER ZONES SEE DETAIL Z, FIGURE 10-2.
3. MODIFIED DAM SECTION USED TO MAXIMIZE SPOIL FILL.
4. SECTION C IS FROM FIG.14 (DWG.1016-C14-D2240) KLOHN-CRIPPEN REPORT KC40 DATED FEBRUARY 1990.
5. SECTION D IS FROM FIG.15 (DWG.1016-C14-D2254) KLOHN-CRIPPEN REPORT KC40 DATED FEBRUARY 1990.
6. RESERVOIR LEVELS ARE FROM THE PROJECT DATA TABLE KLOHN-CRIPPEN REPORT KC50 DATED JULY 1990.
7. TAILWATER VARIES FROM EL.416.8 TO EL.418.6 DEPENDING ON DEGRATION OF THE RIVER BED.

LEGEND:

ZONE	DESCRIPTION
1	COMPACTED IMPERVIOUS CORE
2a	FINE FILTER
2b	COARSE FILTER
3	SHELL
9	ROLLER COMPACTED CONCRETE (RCC)
10	RCC BEDDING

DRAFT

0 50m

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Klohn Crippen Berger

DSGN	
INDEP CHK	
DFTG	YK (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	

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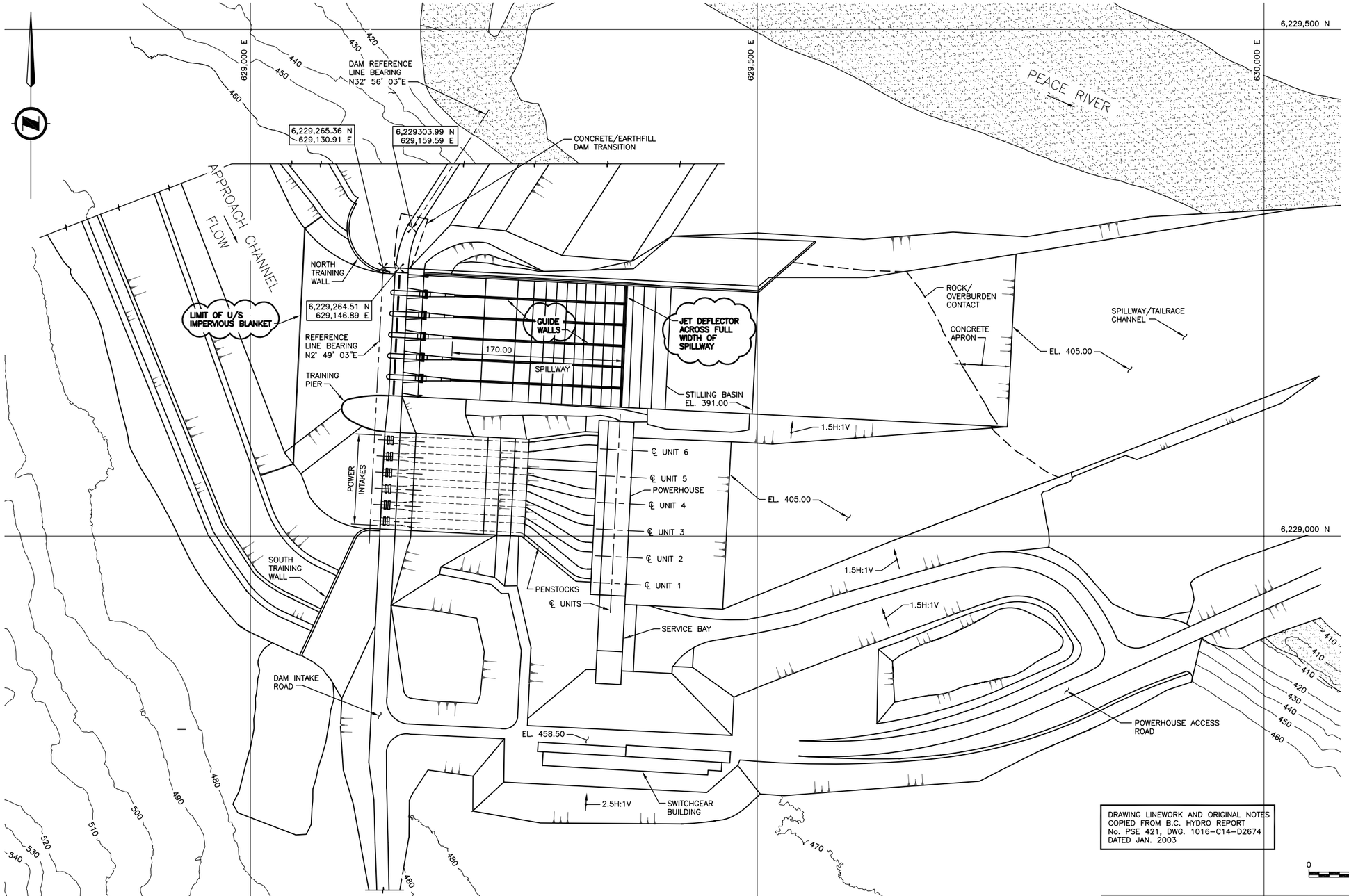
PEACE RIVER SITE C PROJECT

SITE C
EARTHFILL DAM
SECTIONS

DATE	FIG NO	
MAY 2009	FIGURE 10-3	
DWN YK	DWG NO	R

NOT TO BE REPRODUCED WITHOUT THE PERMISSION OF BC HYDRO

X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches-Drawings\Alternative Study\FIGURE 10-3.dwg
KLOHN-CRIPPEN
2009/10/08 – 9:28am



RIGHT BANK STRUCTURES – PLAN

SCALE 1:4000

ORIGINAL NOTES:

1. LAYOUT OF APPROACH CHANNEL, PENSTOCKS/POWER INTAKES AND SPILLWAY BASED ON KLOHN–CRIPPEN REPORT KC 50, DATED JULY 1990.
2. SLOPES BASED ON KLOHN–CRIPPEN REPORT KC 50, DATED JULY 1990.
3. SPILLWAY/TAILRACE CHANNEL ELEVATION BASED ON KLOHN–CRIPPEN REPORT KC 50, DATED JULY 1990.
4. ROAD LAYOUT & SWITCHGEAR BUILDING BASED ON DWG. No.1016–C14–D200, B.C. HYDRO STUDY DATED JULY 1984.
5. TOPOGRAPHY IS FROM B.C. HYDRO SURVEY AND PHOTOGRAMETRY DEPARTMENT (1989) DRAWINGS: 1016–C11–E1077, –E1078 AND 1016–C11–E1082, –E1083,

UPDATED NOTES:

1. GRID UPDATED TO NAD83.
2. TOPOGRAPHY UPDATED TO 2008 LIDAR SURVEY PROVIDED BY B.C. HYDRO PHOTOGRAMETRY SERVICES.
3. TOP OF EXCAVATION CUT LINES HAVE NOT BEEN UPDATED TO REFLECT INTERSECTION WITH UPDATED TOPOGRAPHY – ACTUAL CUT LINE INTERSECTION WITH CONTOURS MAY DIFFER.

DRAWING LINEWORK AND ORIGINAL NOTES COPIED FROM B.C. HYDRO REPORT No. PSE 421, DWG. 1016–C14–D2674 DATED JAN. 2003

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Klohn Crippen Berger

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PEACE RIVER SITE C PROJECT

SITE C
RIGHT BANK STRUCTURES - PLAN
GENERAL ARRANGEMENT

DSGN	
INDEF CHK	
DFTG	WN (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	

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DATE	FIG NO	
MAY 2009	FIGURE 10-4	
DWN WN	DWG NO 1016-C14-3282	R

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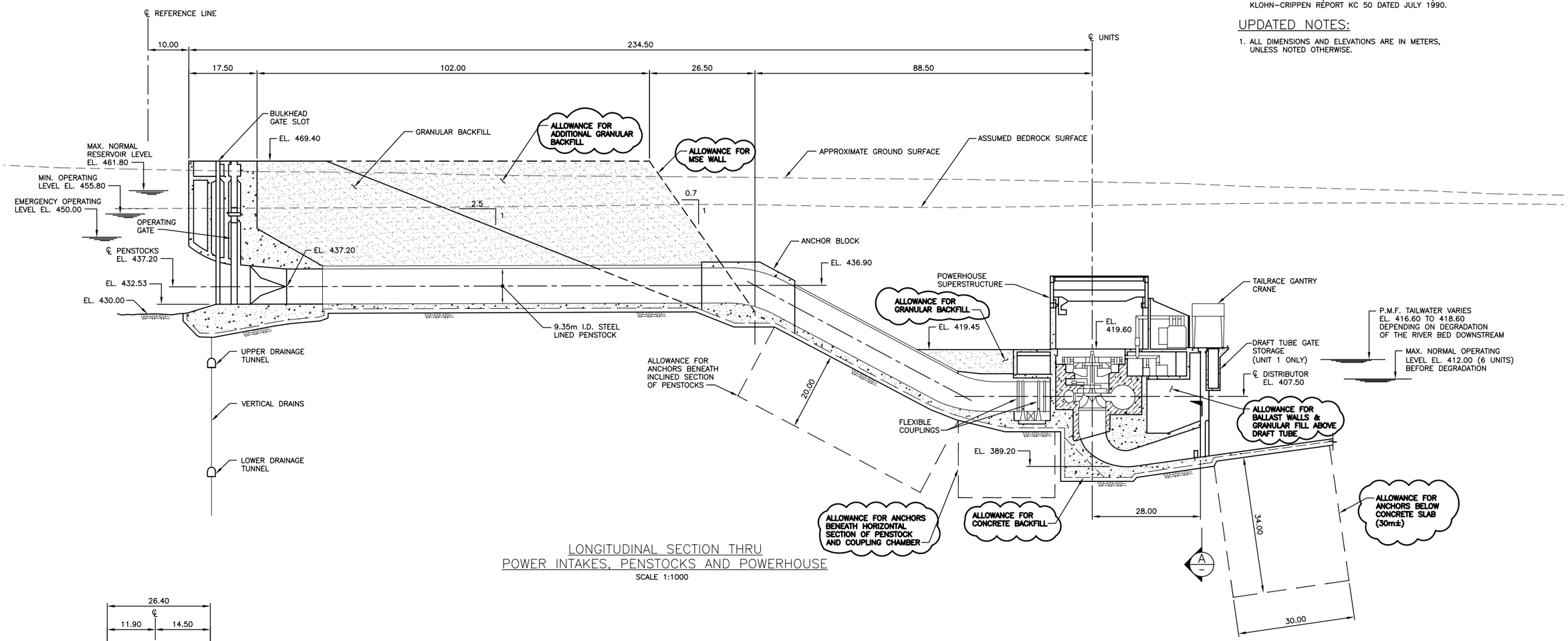
K:\P05032 A02 Site C – 2006 to 2008 Eng Studies\400 Drawings\Task 23 – Alternates Study\Figure 10–4.dwg
WN/KCBL
2009/10/09 – 2:44pm

ORIGINAL NOTES:

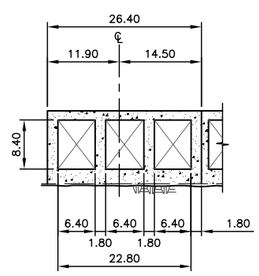
1. BASED ON FIG. 7 (DWG. No. 1016–C14–B2393) KLOHN–CRIPPEN REPORT KC 50 DATED JULY 1990.

UPDATED NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.



LONGITUDINAL SECTION THRU
POWER INTAKES, PENSTOCKS AND POWERHOUSE
SCALE 1:1000



SECTION A
1:1000

DRAWING LINEWORK AND ORIGINAL NOTES COPIED FROM B.C. HYDRO REPORT No. PSE 421, DWG. 1016–C14–D2674 DATED JAN. 2003

0 25m

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Klohn Crippen Berger

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PEACE RIVER SITE C PROJECT

SITE C
POWER INTAKES, PENSTOCKS AND POWERHOUSE SECTIONS

DSGN	
INDEP CHK	
DFTG	WN (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	

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DATE	MAY 2009	FIG NO	FIGURE 10-5
DWN	WN	DWG NO	1016-C14-D3288
		R	

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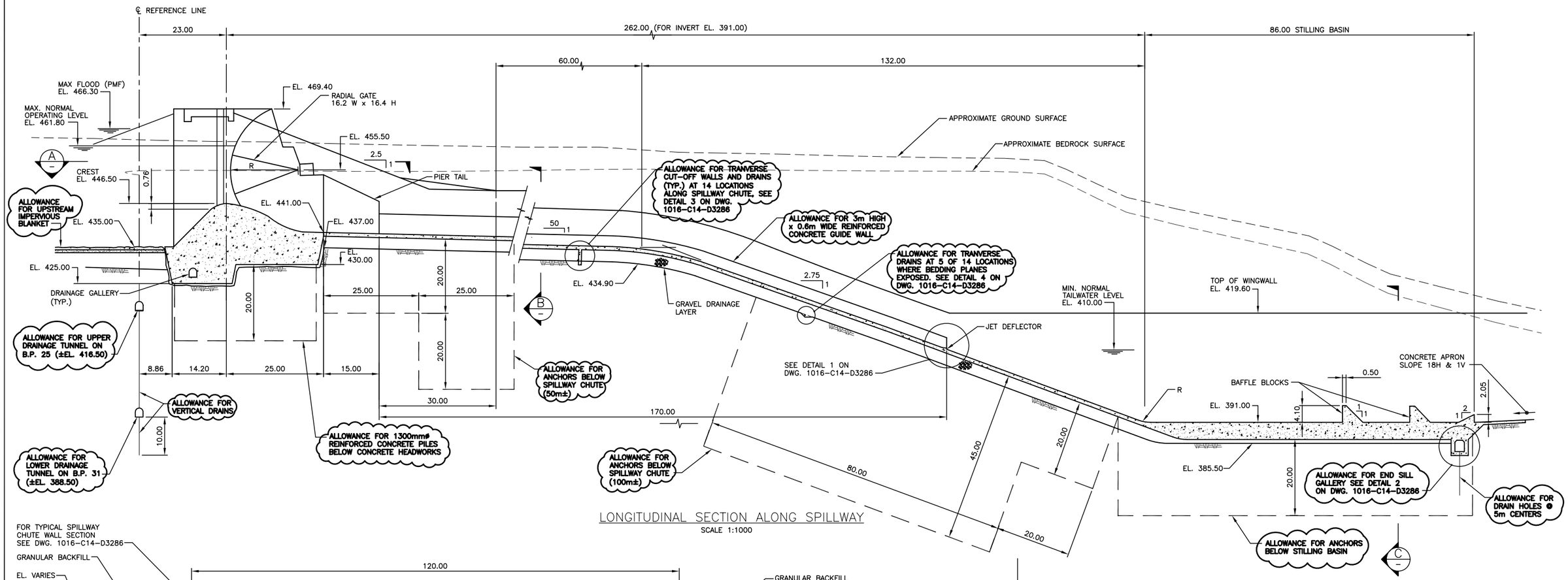
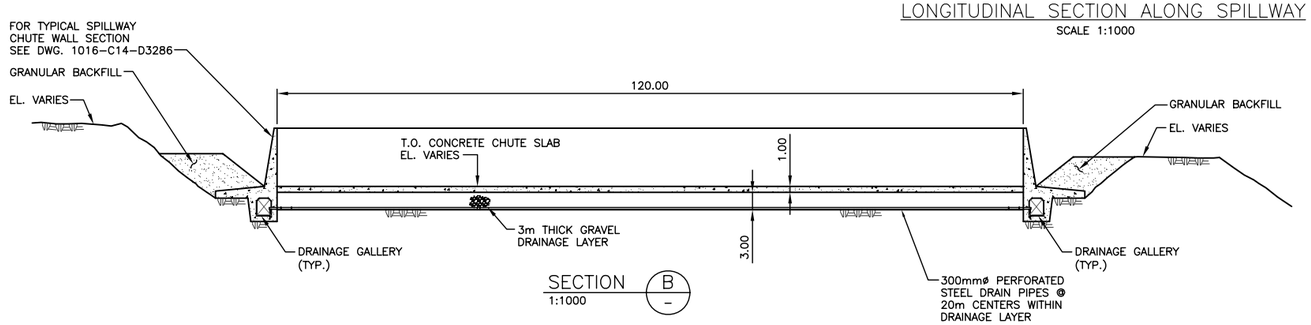
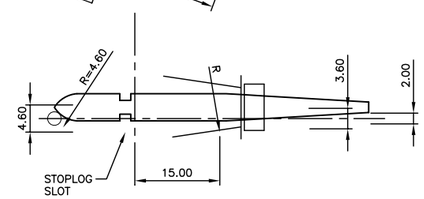
K:\P05032 A02 Site C – 2006 to 2008 Eng Studies\400 Drawings\Task 23 – Alternates Study\\Figure 10–5.dwg
WN/Wyn
2009/10/09 – 2:45pm



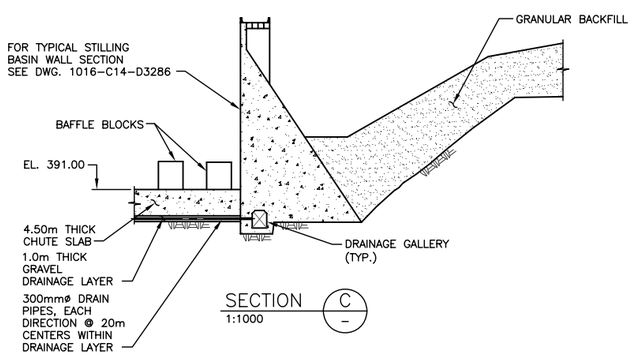
LONGITUDINAL SECTION ALONG SPILLWAY
SCALE 1:1000



SECTION B
1:1000



SECTION A
1:1000



SECTION C
1:1000

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.

0 25m

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Klohn Crippen Berger

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PEACE RIVER SITE C PROJECT

SITE C
SPILLWAY
SECTIONS

DSGN		AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.
INDEF CHK		
DFTG	WN (KCBL)	
DFTG CHK		
REPORT NO.		
PROJ. NO.		

DATE MAY 2009	FIG NO FIGURE 10-6	
DWN WN	DWG NO 1016-C14-D3285	R

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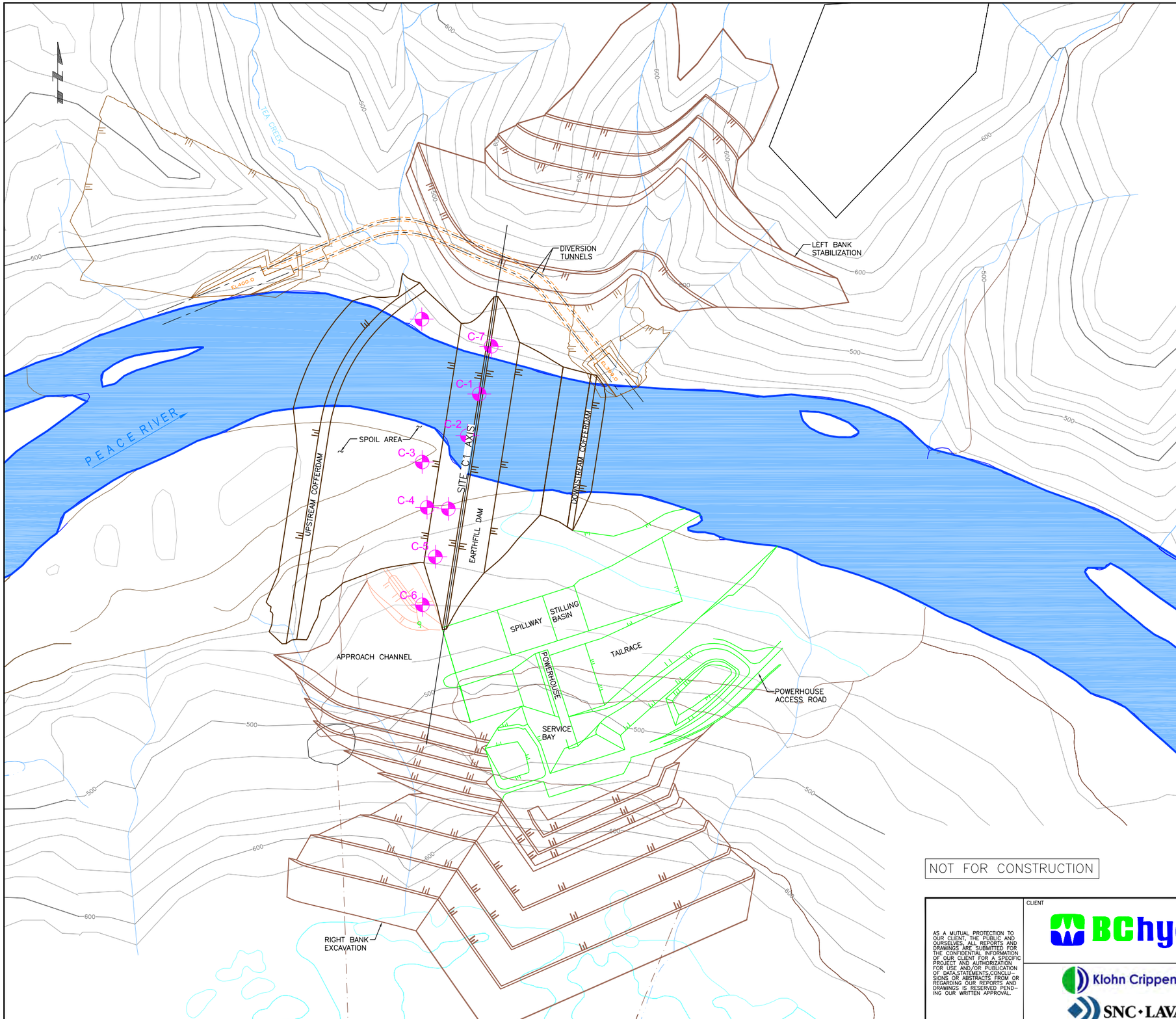
K:\P05032 A02 Site C - 2006 to 2008 Eng Studies\400 Drawings\Task 23 - Alternates Study\Figure 10-6.dwg
Mark Nelson
2009/10/09 - 2:46pm



NOTES:

1. DAM AND RIGHT BANK STRUCTURES COPIED FROM FIGURE 9, BC HYDRO REPORT No. PSE421, JANUARY 2003.

LEGEND:

DRILLHOLE

NOT FOR CONSTRUCTION

SCALE 0 1:5000 250m

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CLIENT: BC hydro

Klohn Crippen Berger

SNC·LAVALIN

PROJECT: **PEACE RIVER, SITE C PROJECT**
BRITISH COLUMBIA, CANADA

TITLE: AXIS C1 PLAN

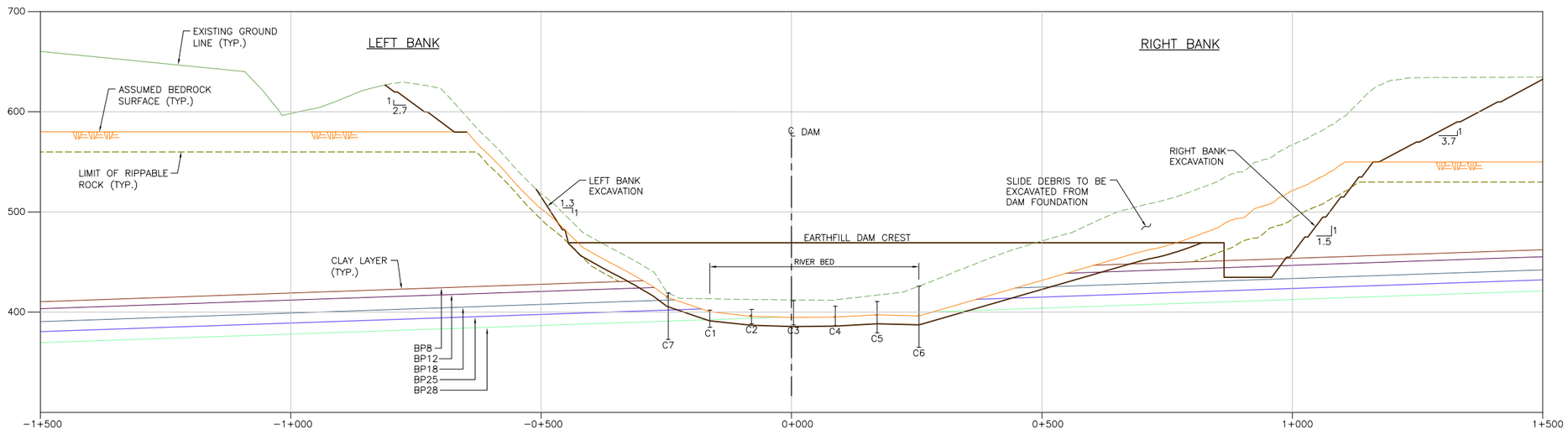
PROJECT No. P05032A02

FIG. No. FIGURE 10–7

KCR–BM

NOTES:

1. DAM AND RIGHT BANK STRUCTURES BASED ON FIGURE 9, BCH REPORT No. PSE421, JANUARY 2003.
2. BEDDING PLANES (BP) PROJECTED FROM SITE C.
3. IT IS ASSUMED THAT BEDROCK IS NOT RIPPABLE BELOW BP8.



SECTION ALONG DAM AXIS C1

NOT FOR CONSTRUCTION

SCALE
0 VERT. 1:2500 100m
0 HORIZ. 1:5000 250m

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CLIENT
BC hydro
Klohn Crippen Berger
SNC·LAVALIN

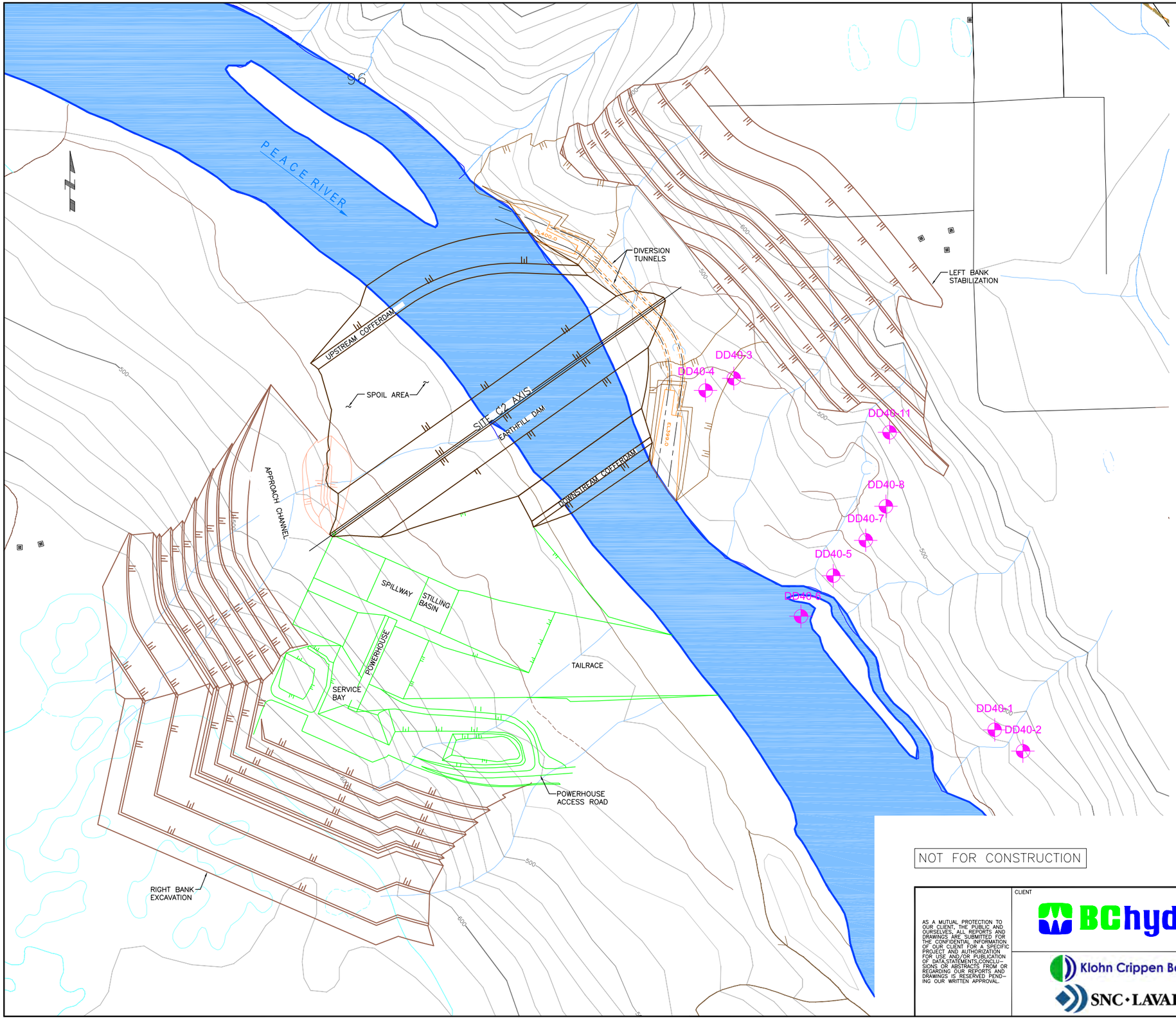
PROJECT
PEACE RIVER, SITE C PROJECT
BRITISH COLUMBIA, CANADA

TITLE
AXIS C1
SECTION

PROJECT No. P05032A02

FIG. No. FIGURE 10–8

KCR–BM



NOTES:

1. DAM AND RIGHT BANK STRUCTURES COPIED FROM FIGURE 9, BC HYDRO REPORT No. PSE421, JANUARY 2003.

LEGEND:

DRILLHOLE

NOT FOR CONSTRUCTION

SCALE 0 1:5000 250m

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CLIENT: BC hydro

Klohn Crippen Berger

SNC·LAVALIN

PROJECT: **PEACE RIVER, SITE C PROJECT**
BRITISH COLUMBIA, CANADA

TITLE: AXIS C2 PLAN

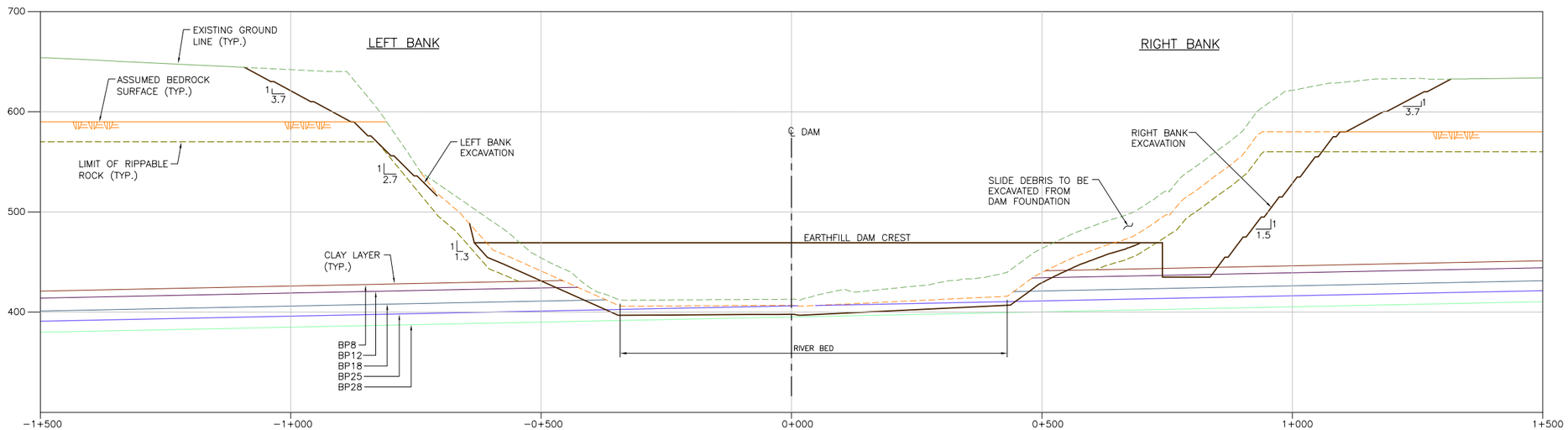
PROJECT No. P05032A02

FIG. No. FIGURE 10–9

KCR–BM

NOTES:

1. DAM AND RIGHT BANK STRUCTURES BASED ON FIGURE 9, BCH REPORT No. PSE421, JANUARY 2003.
2. BEDDING PLANES (BP) PROJECTED FROM SITE C.
3. IT IS ASSUMED THAT BEDROCK IS NOT RIPPABLE BELOW BP8.



SECTION ALONG DAM AXIS C2

NOT FOR CONSTRUCTION

SCALE
0 VERT. 1:2500 100m
0 HORIZ. 1:5000 250m

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CLIENT
BC hydro
Klohn Crippen Berger
SNC·LAVALIN

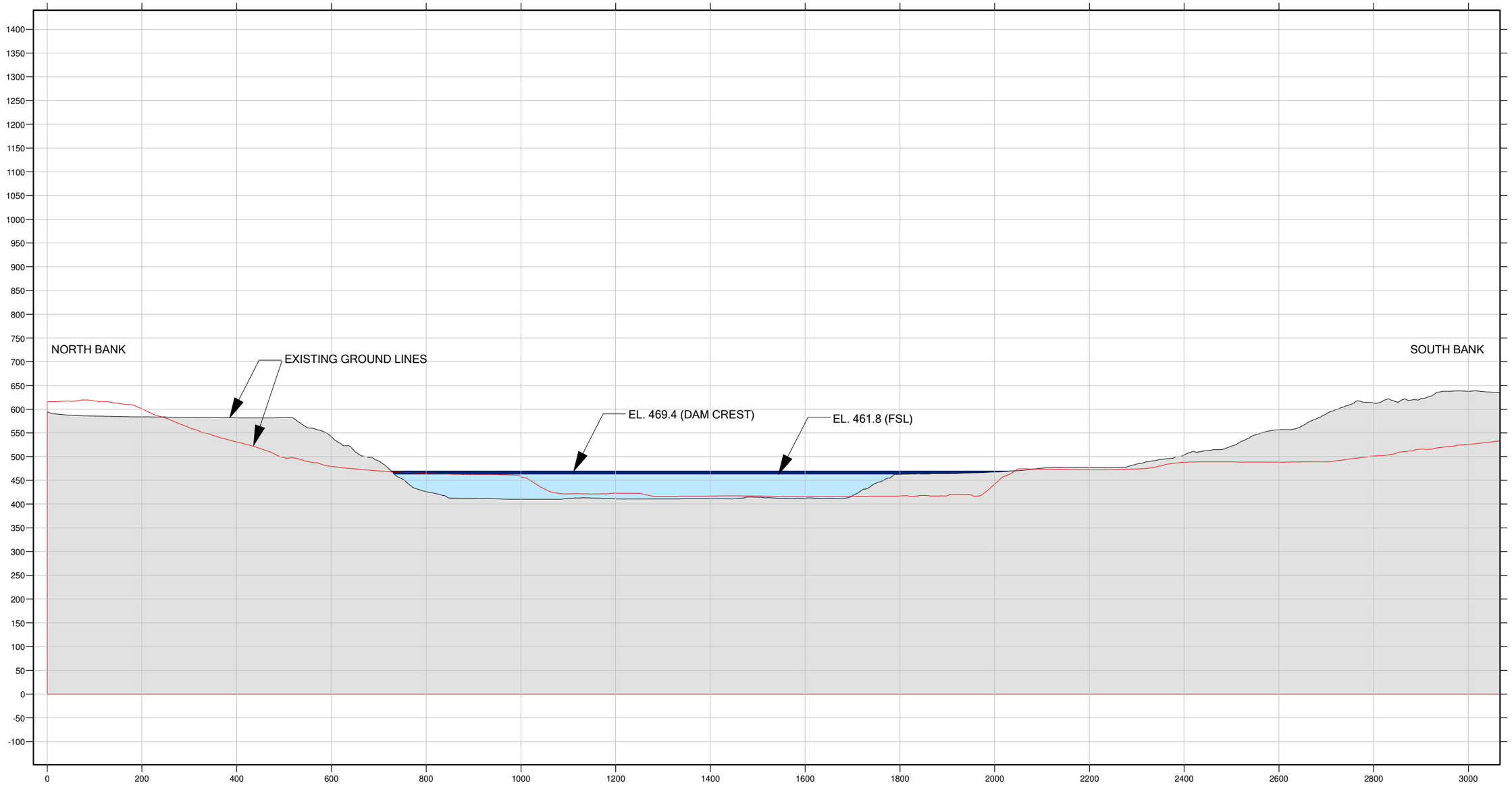
PROJECT
PEACE RIVER, SITE C PROJECT
BRITISH COLUMBIA, CANADA

TITLE
AXIS C2
SECTION

PROJECT No. P05032A02

FIG. No. FIGURE 10–10

KCR–BM



Peace River Cross-Valley Profile (looking downstream)
Scale 1:8,500

FIGURE: 10-11

Legend

Site C Cross-Valley Profile

Wilder Creek Site Cross-Valley Profile

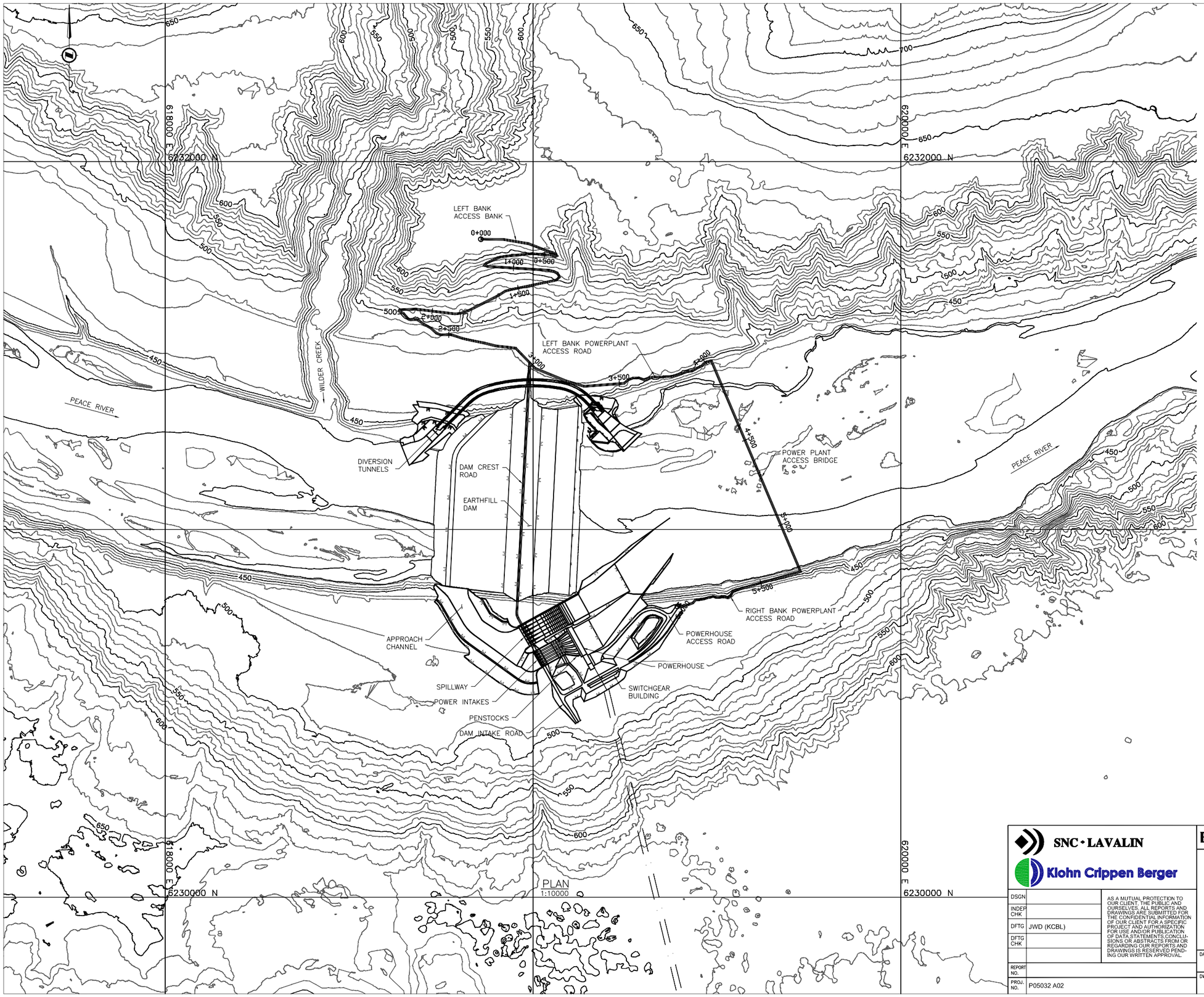
Klohn Crippen Berger
SNC·LAVALIN

BC hydro

Comparison of Valley Cross-Sections

DATE	OCT, 2009	DWG NO		R 0

P:\PI\P05032 A02 Site C - 2006 to 2008 Eng Studies\400 Drawings\GIS_data\MXD\Evaluation_of_alternatives\Alternatives_EA_Hatch\Tiles\Examples\11x17\Valley_Cross_Section.mxd



NOTES:

1. LAYOUT OF DAM, DIVERSION TUNNEL AND RIGHT BANK STRUCTURES ADOPTED AND MODIFIED FROM FIGURE 4 PSE421 DATE JANUARY 2003.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMETRY SERVICES.
3. GRID COORDINATES HAVE BEEN UPDATED TO NAD 83.

DRAFT

0 1:10000 500m

SNC·LAVALIN

Klohn Crippen Berger

DSGN	
INDEP CHK	
DFTG	JWD (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	P05032 A02

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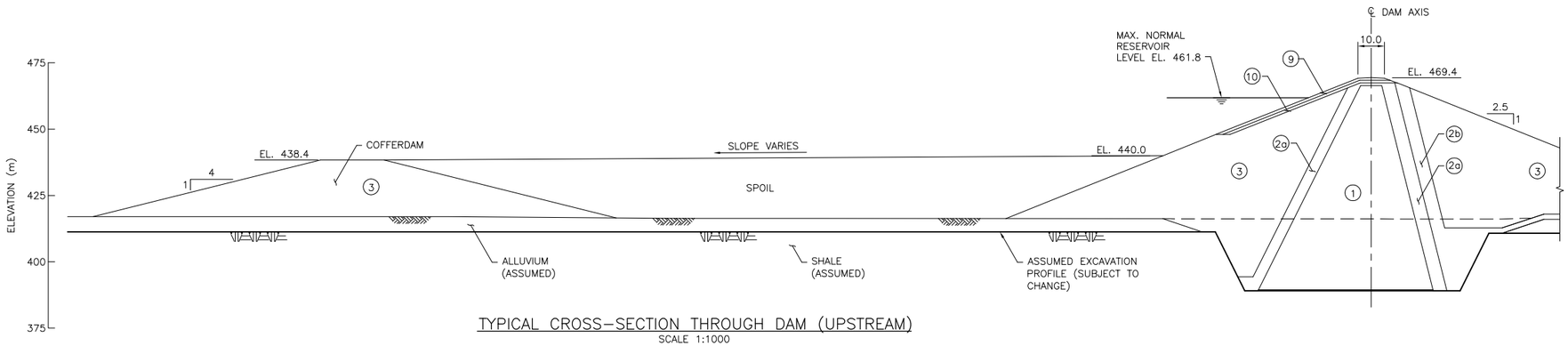
PEACE RIVER SITE C PROJECT

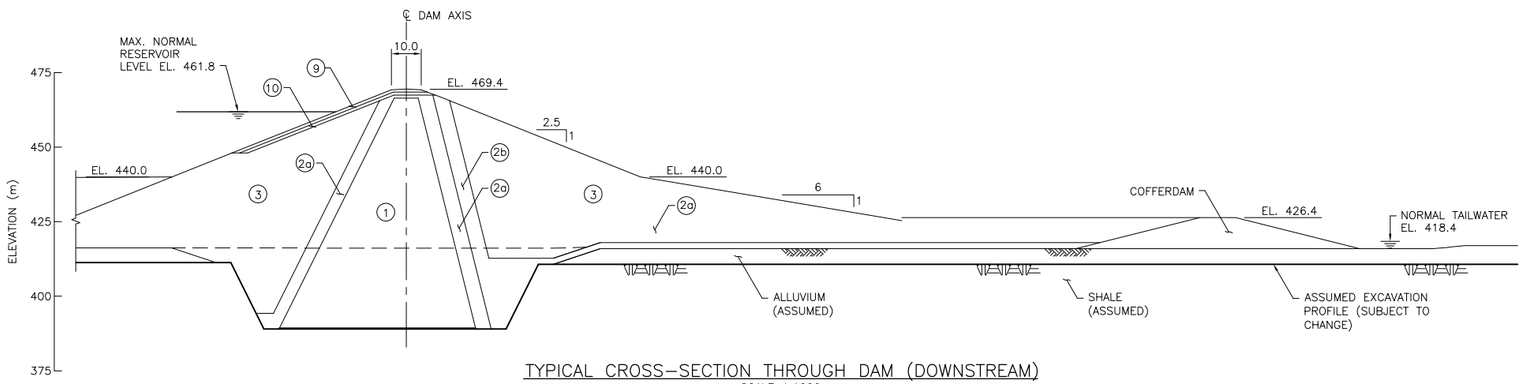
WILDER CREEK ALTERNATE GENERAL ARRANGEMENT

DATE	2009 SEPTEMBER	FIG NO	FIGURE 10-12
DWN	JWD	DWG NO	R



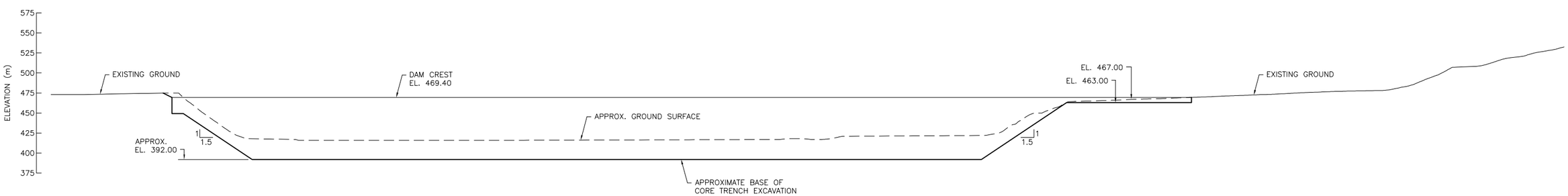
TYPICAL CROSS–SECTION THROUGH DAM (UPSTREAM)

SCALE 1:1000



TYPICAL CROSS–SECTION THROUGH DAM (DOWNSTREAM)

SCALE 1:1000



TYPICAL LONGITUDINAL SECTION THROUGH DAM

SCALE 1:2500

NOTE:

1. FIGURE IS APADTED FROM FIG. 17 (DWG. 1016–C14–D2671) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003.
2. CROSS SECTIONS ARE TYPICAL THROUGH CENTER OF DAM.
3. MODIFIED DAM SECTION USED TO MINIMIZE SOIL FILL.
4. SECTION IS ADAPTED FROM FIG. 14 (DWG. 1010–C14–D2240) KLOHN CRIPPEN REPORT KC40 DATED FEBRUARY 1990.
5. NORMAL TAILWATER ELEVATION IS ASSUMED TO BE NORMAL TAILWATER ELEVATION FROM FIG. 13 (DWG. 1016–C14–D2125) PLUS THE AVERAGE DIFFERENCE IN WATER SURFACE ELEVATION BETWEEN WILDER CREEK AND STIE C (6.4m). ELEVATION IS SUBJECT TO CONFIRMATION.

LEGEND:

ZONE	DESCRIPTION
1	COMPACTED IMPERVIOUS CORE
2a	FINE FILTER
2b	COARSE FILTER
3	SHELL
9	RIPRAP
10	RIPRAP BEDDING

DRAFT

0 1:2500 100m

0 1:1000 50m

SNC·LAVALIN

Klohn Crippen Berger

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

WILDER CREEK ALTERNATE
EARTHFILL DAM
TYPICAL SECTIONS

DSGN	
INDEP CHK	
DFTG	JWD (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	P05032 A02

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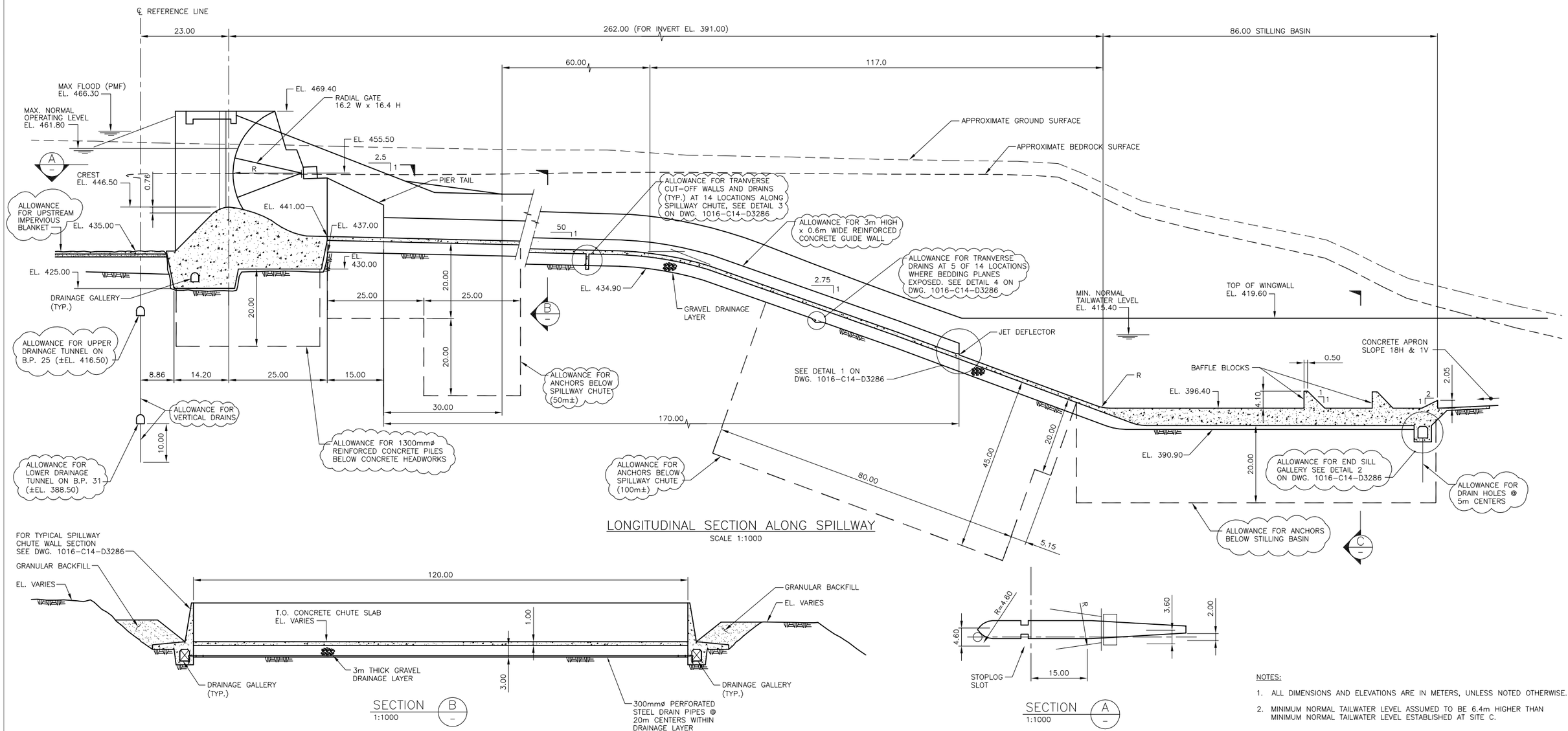
DATE 2009 SEPTEMBER	FIG NO FIGURE 10-13	
DWN JWD	DWG NO	R



LONGITUDINAL SECTION ALONG SPILLWAY

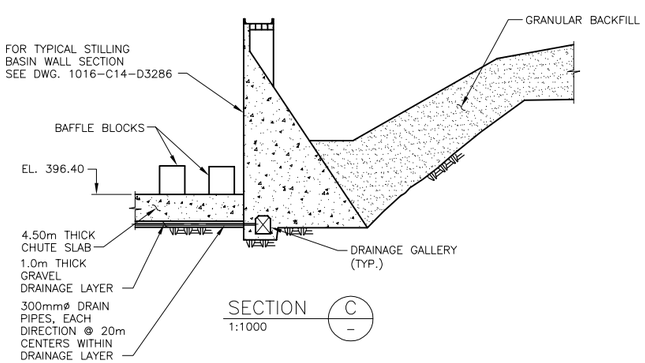
SCALE 1:1000

SECTION B

1:1000

SECTION A

1:1000



SECTION C

1:1000

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.
2. MINIMUM NORMAL TAILWATER LEVEL ASSUMED TO BE 6.4m HIGHER THAN MINIMUM NORMAL TAILWATER LEVEL ESTABLISHED AT SITE C.

0 1:1000 50m

SNC·LAVALIN

Klohn Crippen Berger

DSGN	
INDEP CHK	
DFTG	JWD (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	P05032 A02

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PEACE RIVER SITE C PROJECT

WILDER CREEK ALTERNATE
SPILLWAY
TYPICAL SECTION

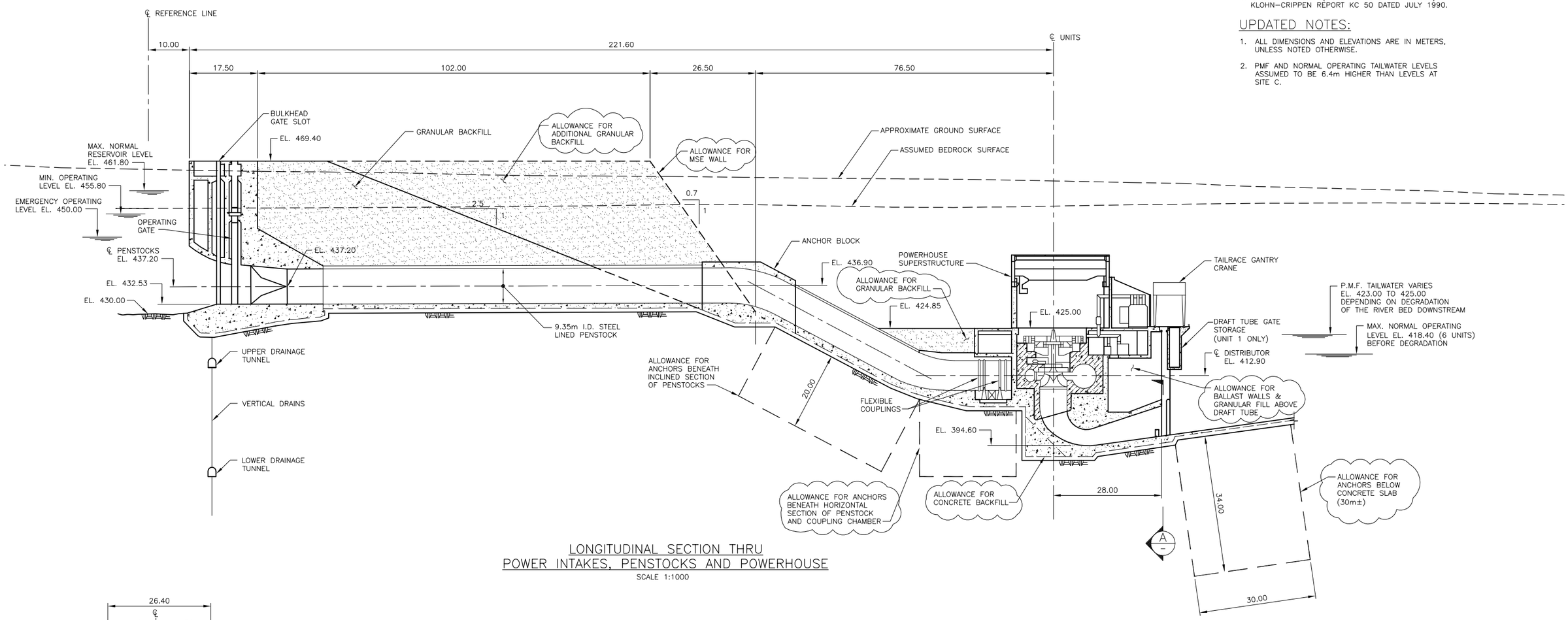
DATE	2009 SEPTEMBER	FIG NO	FIGURE 10-14
DWN	JWD	DWG NO	R

ORIGINAL NOTES:

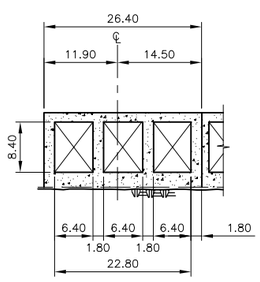
1. BASED ON FIG. 7 (DWG. No. 1016–C14–B2393) KLOHN–CRIPPEN REPORT KC 50 DATED JULY 1990.

UPDATED NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.
2. PMF AND NORMAL OPERATING TAILWATER LEVELS ASSUMED TO BE 6.4m HIGHER THAN LEVELS AT SITE C.



LONGITUDINAL SECTION THRU
POWER INTAKES, PENSTOCKS AND POWERHOUSE
SCALE 1:1000



SECTION A
1:1000

DRAWING LINEWORK AND ORIGINAL NOTES COPIED FROM DWG. 1016–C14–D2676 DATED JAN. 2003

0 1:1000 25m

SNC·LAVALIN
Klohn Crippen Berger

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

WILDER CREEK ALTERNATE
POWER INTAKES, PENSTOCKS AND POWERHOUSE
TYPICAL SECTION

DSGN	
INDEP CHK	
DFTG	JWD (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	P05032 A02

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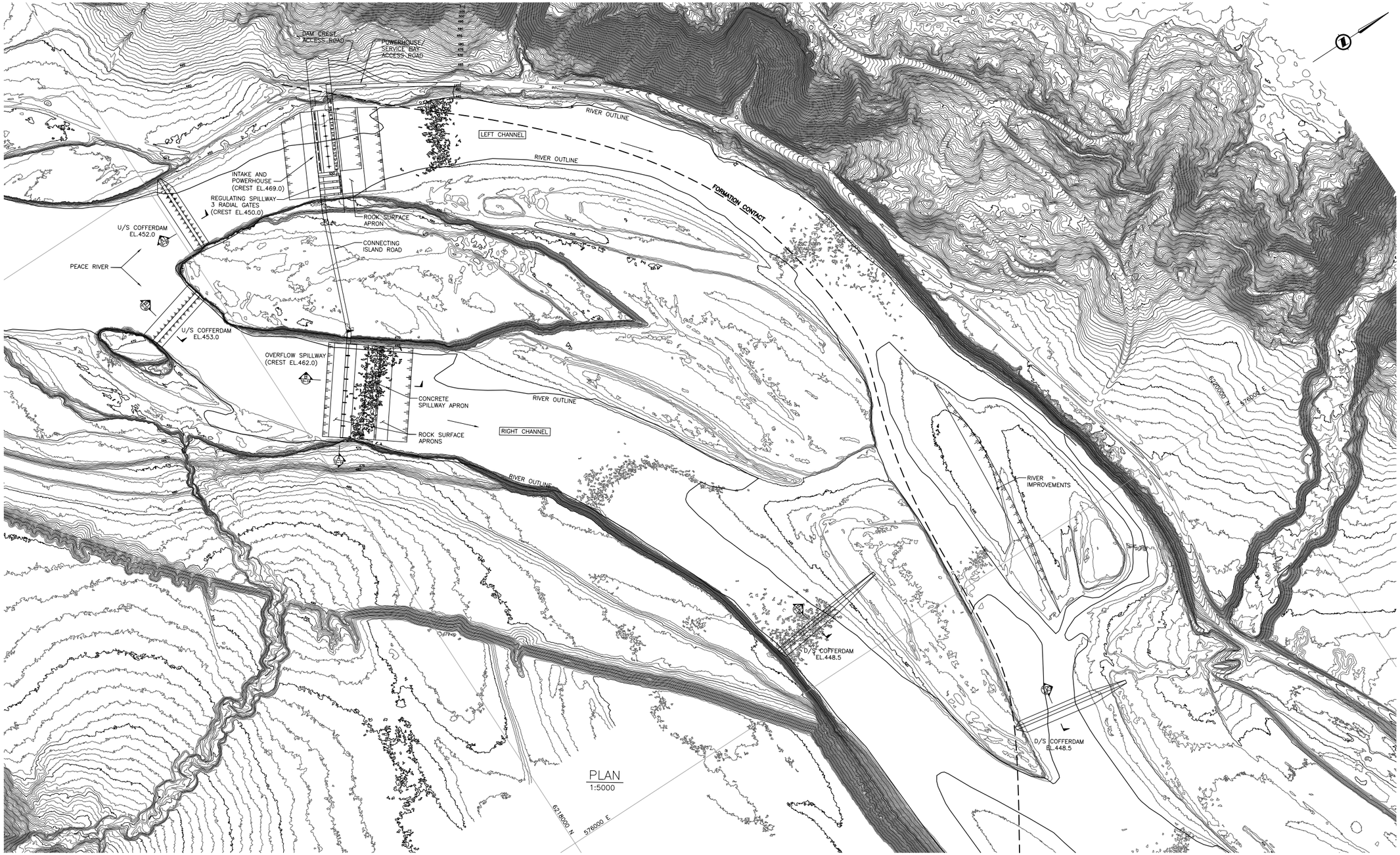
DATE	2009 SEPTEMBER	FIG NO	FIGURE 10-15
DWN	JWD	DWG NO	R



NOTES:

1. THE FORMATION CONTACT REPRESENTS THE ESTIMATED CONTACT LINE OF THE GATES SANDSTONE AND SHAFTSBURY SHALE.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMMETRY SERVICES.

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BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - SITE 7B
GENERAL ARRANGEMENT

DSGN	
INDEP CHK	
DFTG	RCP (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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DATE June 2009	FIG NO FIGURE 10-16	
DWN RCP	DWG NO	R

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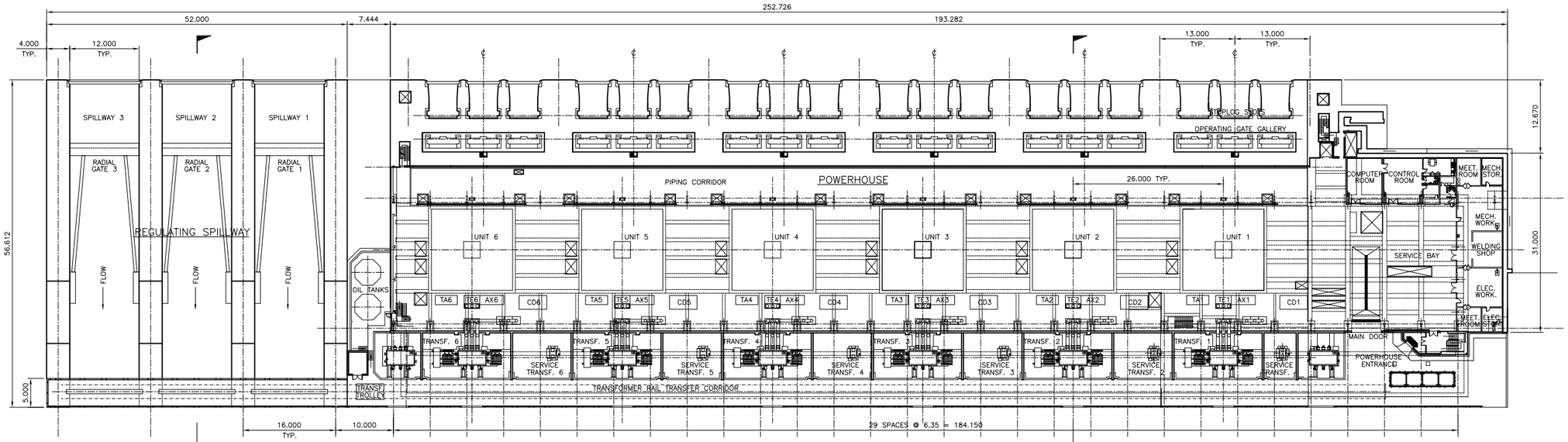
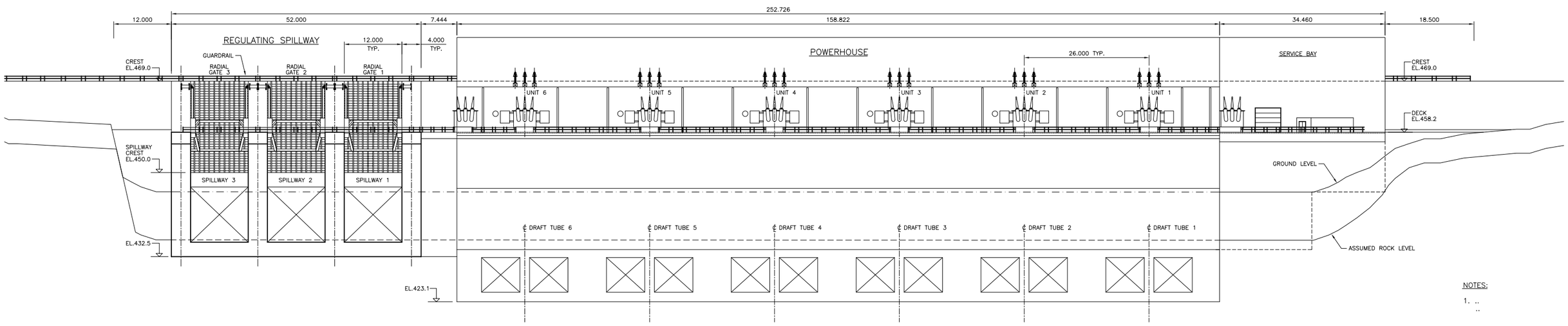
X:\017348 - Site C\41 - Civil Engineering\41DK - Sketches-Drawings\Alternative Study\FIGURE 10-16.dwg
Model Space
2009/10/08 - 9:27am



PLAN
1:400
LEFT CHANNEL
SPILLWAY AND POWERHOUSE



ELEVATION D
1:400
LEFT CHANNEL
SPILLWAY AND POWERHOUSE

NOTES:

1. ..
..

0 20m

DRAFT

SNC·LAVALIN

Klohn Crippen Berger

BChydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - SITE 7B
POWERHOUSE AND REGULATING SPILLWAY
PLAN

DSGN	
INDEP CHK	
DFTG	RCP (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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DATE JUNE 2009	FIG NO FIGURE 10-17	
DWN RCP	DWG NO	R

X:\017348 - Site C\41 - Civil Engineering\41DK - Sketches-Drawings\Alternative Study\FIGURE 10-17.dwg
2009/10/08 - 9:26am

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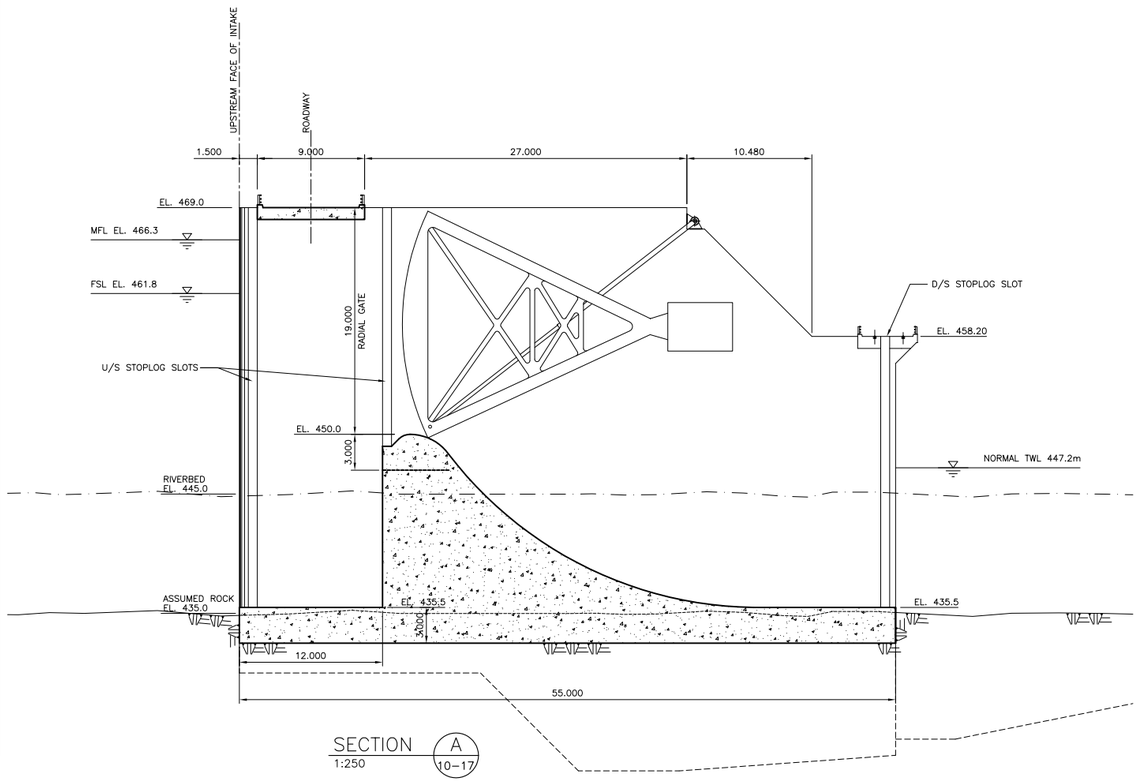
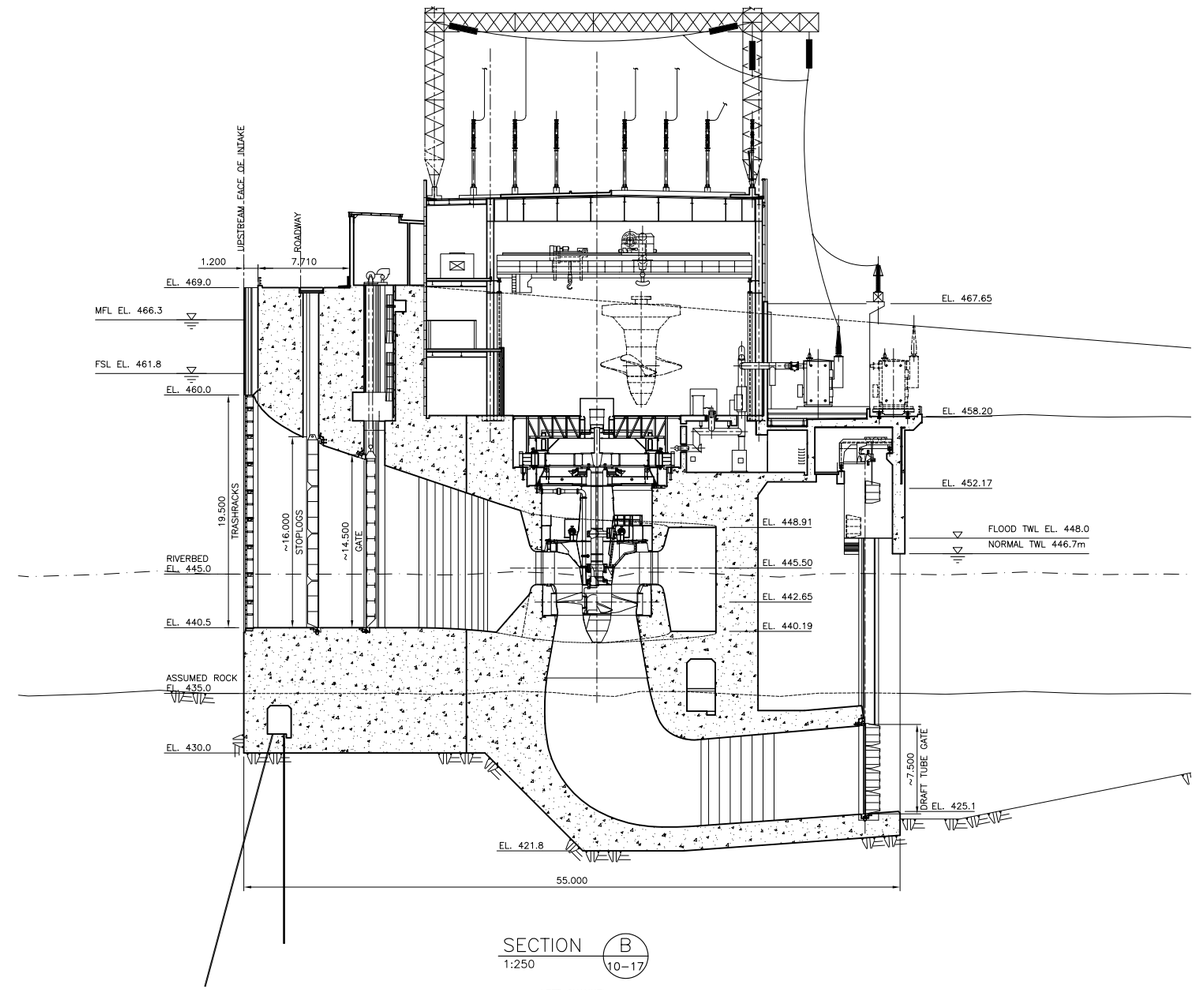


SECTION A 10–17
1:250

LEFT CHANNEL REGULATING SPILLWAY



SECTION B 10–17
1:250

LEFT CHANNEL
INTAKE AND POWERHOUSE

0 10m

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PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - SITE 7B
POWERHOUSE AND REGULATING SPILLWAY
SECTIONS

DSGN	
INDEP CHK	
DFTG	RCP (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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DATE JUNE 2009	FIG NO FIGURE 10-18	
DWN RCP	DWG NO	R

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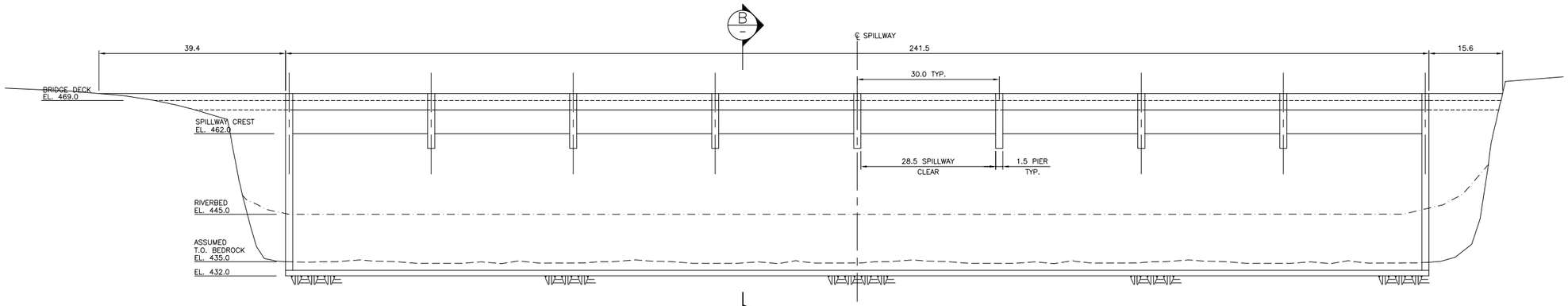
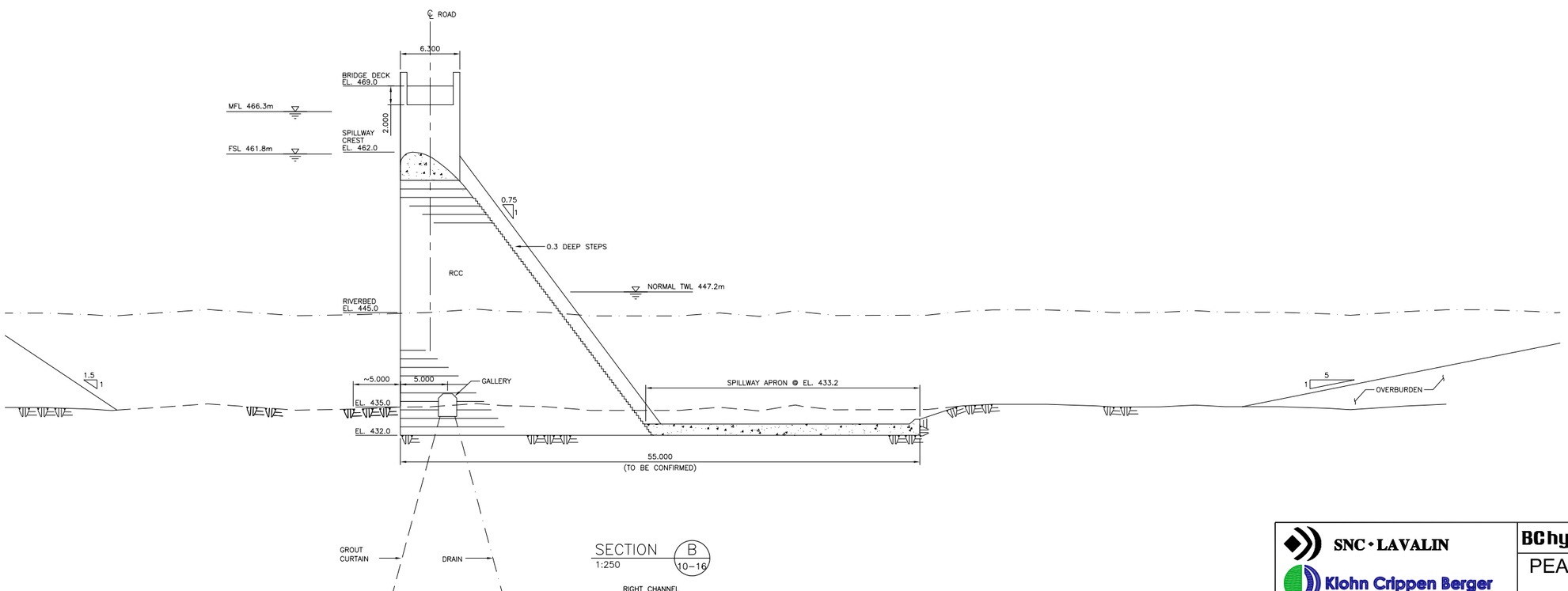
X:\017348 – Site C\41 – Civil Engineering\410K – Sketches-Drawings\Alternative Study\FIGURE 10-18.dwg
Kevin Chow
2009/10/08 – 9:25am



ELEVATION A
1:500 10–16

RIGHT CHANNEL
OVERFLOW SPILLWAY
(LOOKING UPSTREAM)



SECTION B
1:250 10–16

RIGHT CHANNEL
OVERFLOW SPILLWAY
(SPILL PORTION)

NOTES:

1. FOR LOCATION OF SECTIONS SEE FIGURE 16.
2. ELEVATION VARIES DEPENDING ON FINAL CONSTRUCTION SEQUENCE.

0 25m

0 10m

DRAFT

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Klohn Crippen Berger

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - SITE 7B
OVERFLOW SPILLWAY
ELEVATION AND SECTION

DSGN	
INDEP CHK	
DFTG	RCP (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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DATE	JUNE 2009
FIG NO	FIGURE 10-19
DWN	RCP
DWG NO	
R	

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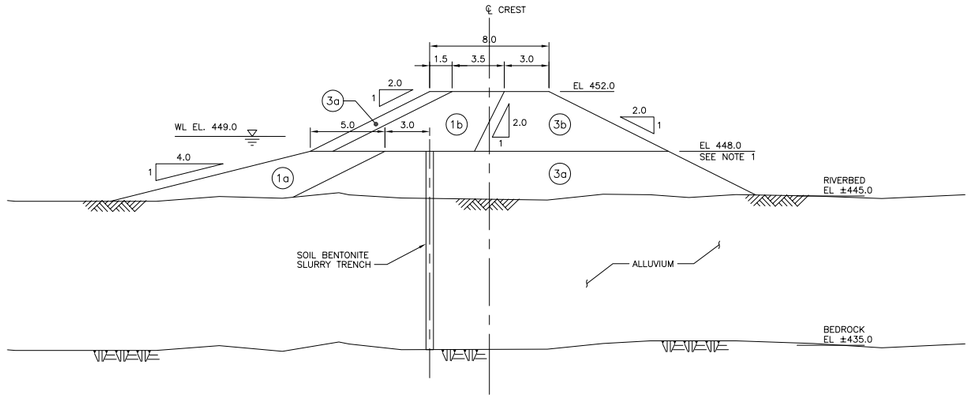
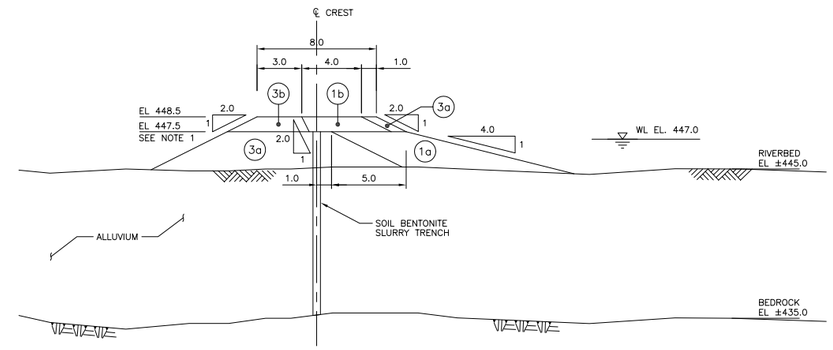
X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches-Drawings\Alternative Study\\FIGURE 10-19.dwg
KERRY, Ron
2009/10/08 – 9:24am



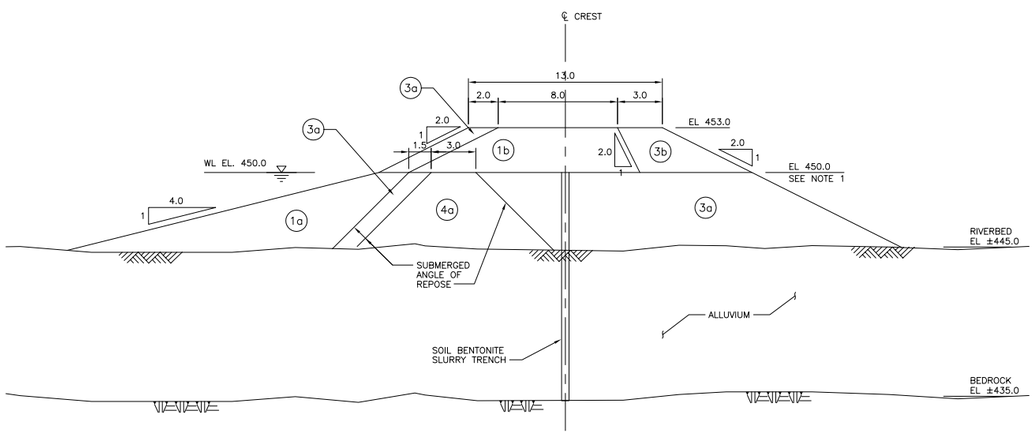
SECTION A1 (10–16)
1:200

LEFT CHANNEL
UPSTREAM COFFERDAM
STAGE 1 – CLOSURE



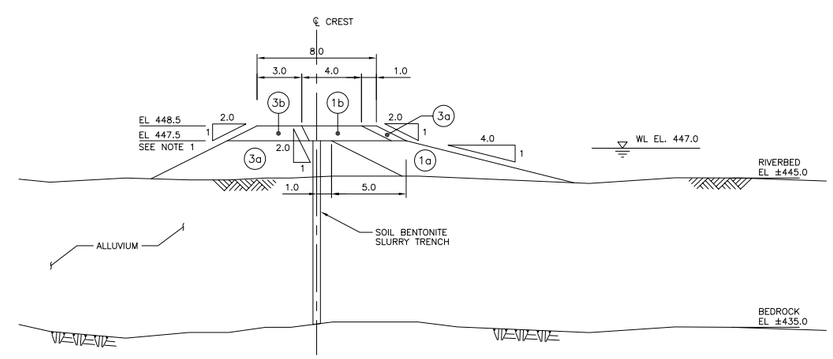
SECTION A2 (10–16)
1:200

LEFT CHANNEL
DOWNSTREAM COFFERDAM
STAGE 1 – CLOSURE



SECTION B1 (10–16)
1:200

RIGHT CHANNEL
UPSTREAM COFFERDAM
STAGE 2 – CLOSURE



SECTION B2 (10–16)
1:200

RIGHT CHANNEL
DOWNSTREAM COFFERDAM
STAGE 1 – CLOSURE

NOTES:

1. THE TOP LEVELS OF UNDERWATER CONSTRUCTION SHOWN ON THIS DRAWING ARE TENTATIVE. ACTUAL LEVELS SHALL DEPEND ON THE ENVISAGED WATER LEVELS DURING THE CONSTRUCTION OF THE COFFERDAMS.
2. FOR LOCATION OF SECTIONS SEE FIGURE 10–16.

LEGEND:

ZONE	DESCRIPTION
1a	DUMPED IMPERVIOUS FILL
1b	COMPACTED IMPERVIOUS FILL
3a	DUMPED GRANULAR FILL
3b	COMPACTED GRANULAR FILL
4a	DUMPED ROCK FILL

0 10m

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Klohn Crippen Berger

DSGN	
INDEP CHK	
DFTG	RCP (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - SITE 7B
UPSTREAM AND DOWNSTREAM COFFERDAMS
TYPICAL SECTIONS

DATE JUNE 2009	FIG NO FIGURE 10-20	
DWN RCP	DWG NO	R

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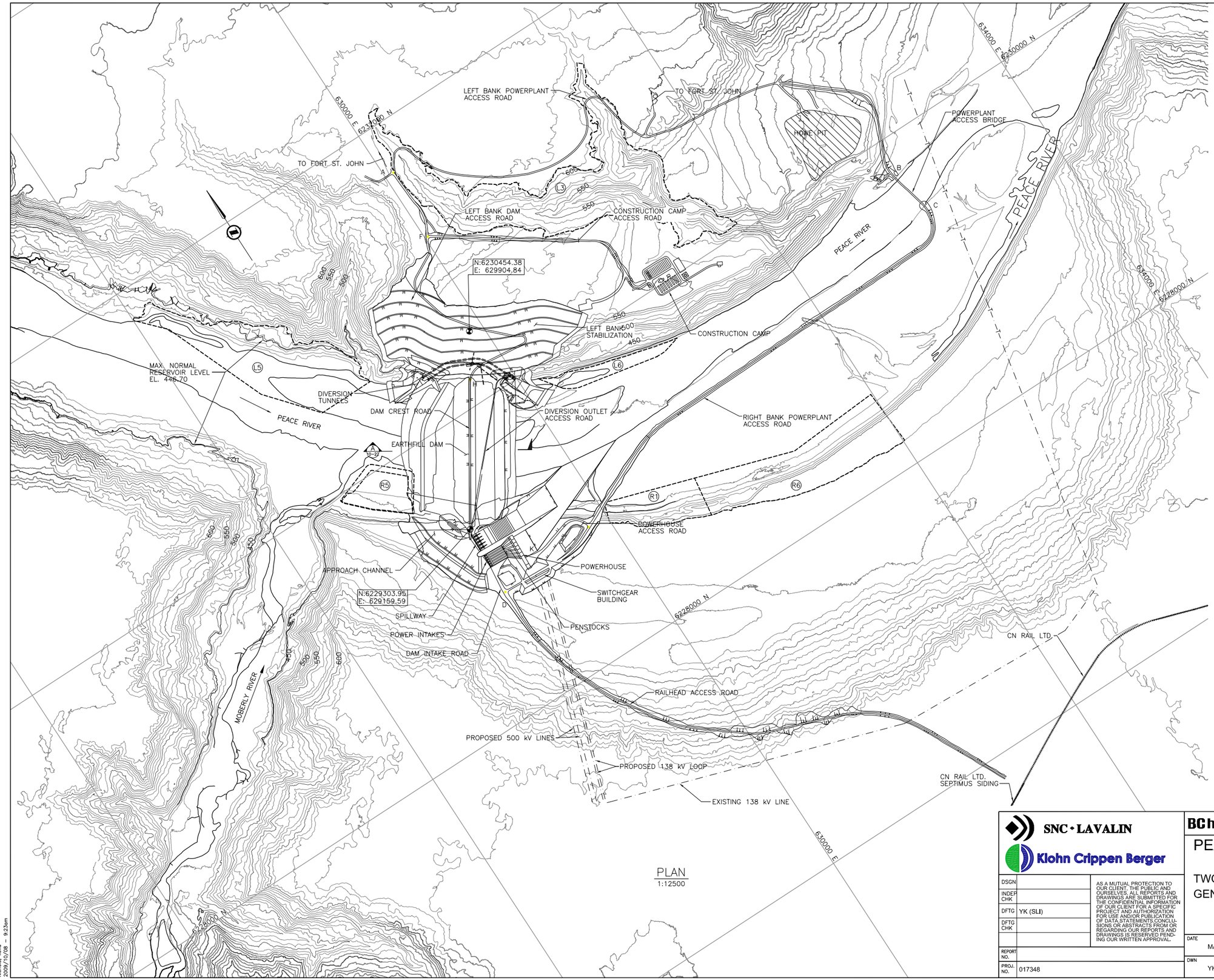
X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\\FIGURE 10-20.dwg
Kloehn, Ute
2009/10/08 – 9:24am



PLAN
1:12500

NOTES:

1. FIGURE IS BASED ON FIGURE 4 (DWG.1016– C14–D2658) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003. NOTE THAT COORDINATES HAVE BEEN UPDATED TO NAD83.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMMETRY SERVICES.

LEGEND:

(L#) RELOCATION AREAS

DRAFT

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Klohn Crippen Berger

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - LOW SITE C
GENERAL ARRANGEMENT

DSGN	
INDEP CHK	
DFTG	YK (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	017348

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DATE: MAY 2009
FIG NO: FIGURE 10-21
DWN: YK
DWG NO:
R

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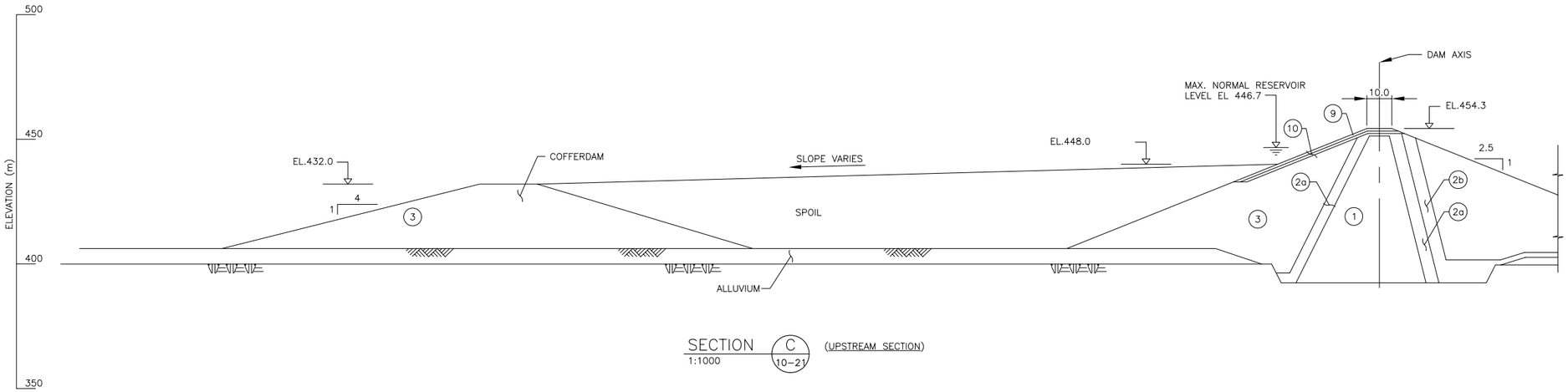
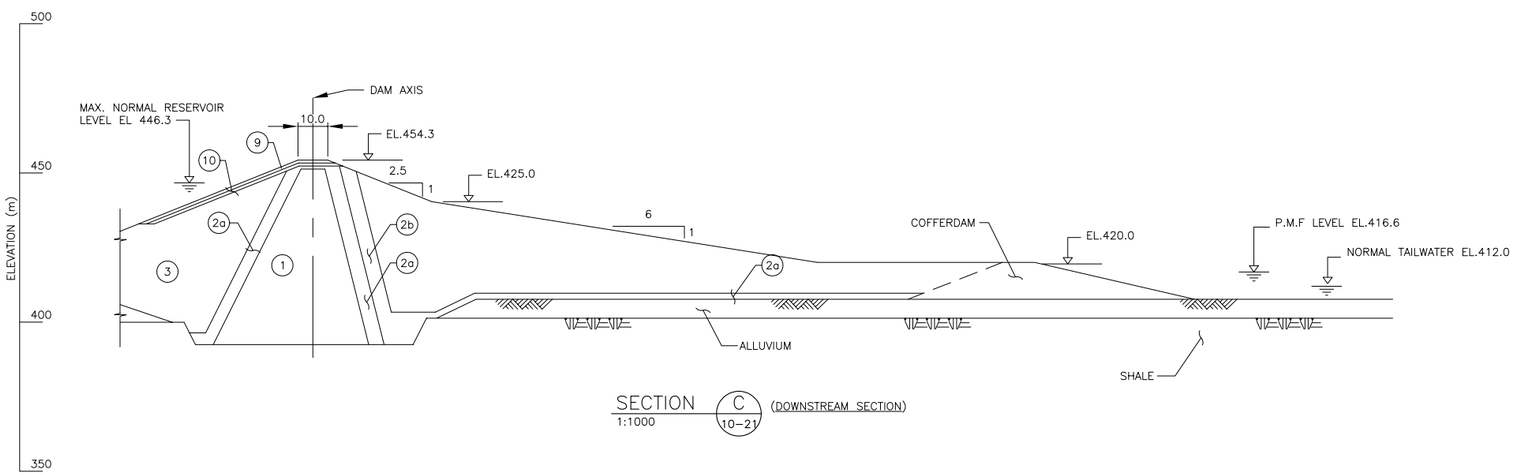
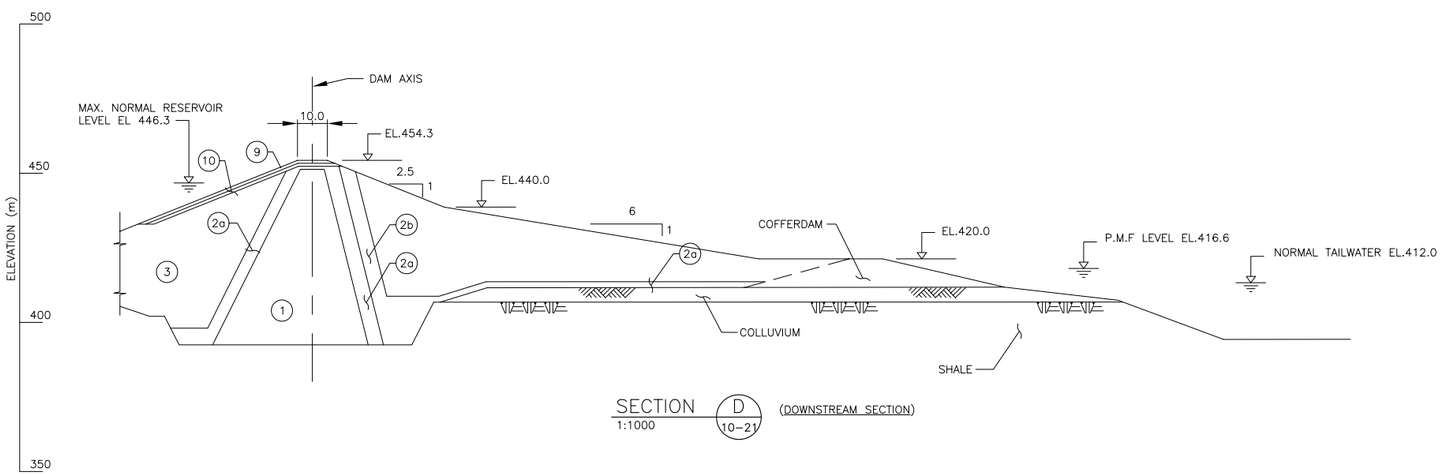
X:\017348 – Site C\41 – Civil Engineering\410K – Sketches–Drawings\Alternative Study\\FIGURE 10-21.dwg
Kelly Yang
2009/10/08 – 9:23am



SECTION C 10-21 (UPSTREAM SECTION)
1:1000



SECTION C 10-21 (DOWNSTREAM SECTION)
1:1000



SECTION D 10-21 (DOWNSTREAM SECTION)
1:1000

NOTES:

1. FIGURE IS BASED ON FIG.17 (DWG.1016-C14-D2671) FROM BC HYDRO REPORT PSE421 DATED JANUARY 2003.
2. FOR LOCATION OF SECTION SEE FIGURE 10-21.

LEGEND:

ZONE	DESCRIPTION
1	COMPACTED IMPERVIOUS CORE
2a	FINE FILTER
2b	COARSE FILTER
3	SHELL
9	ROLLER COMPACTED CONCRETE (RCC)
10	RCC BEDDING

DRAFT

0 50m

SNC·LAVALIN
Klohn Crippen Berger

BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - LOW SITE C
DAM SECTIONS

DSGN	
INDEP CHK	
DFTG	YK (SLI)
DFTG CHK	
REPORT NO.	
PROJ. NO.	

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DATE	MAY 2009
FIG NO	FIGURE 10-22
DWN	YK
DWG NO	
R	

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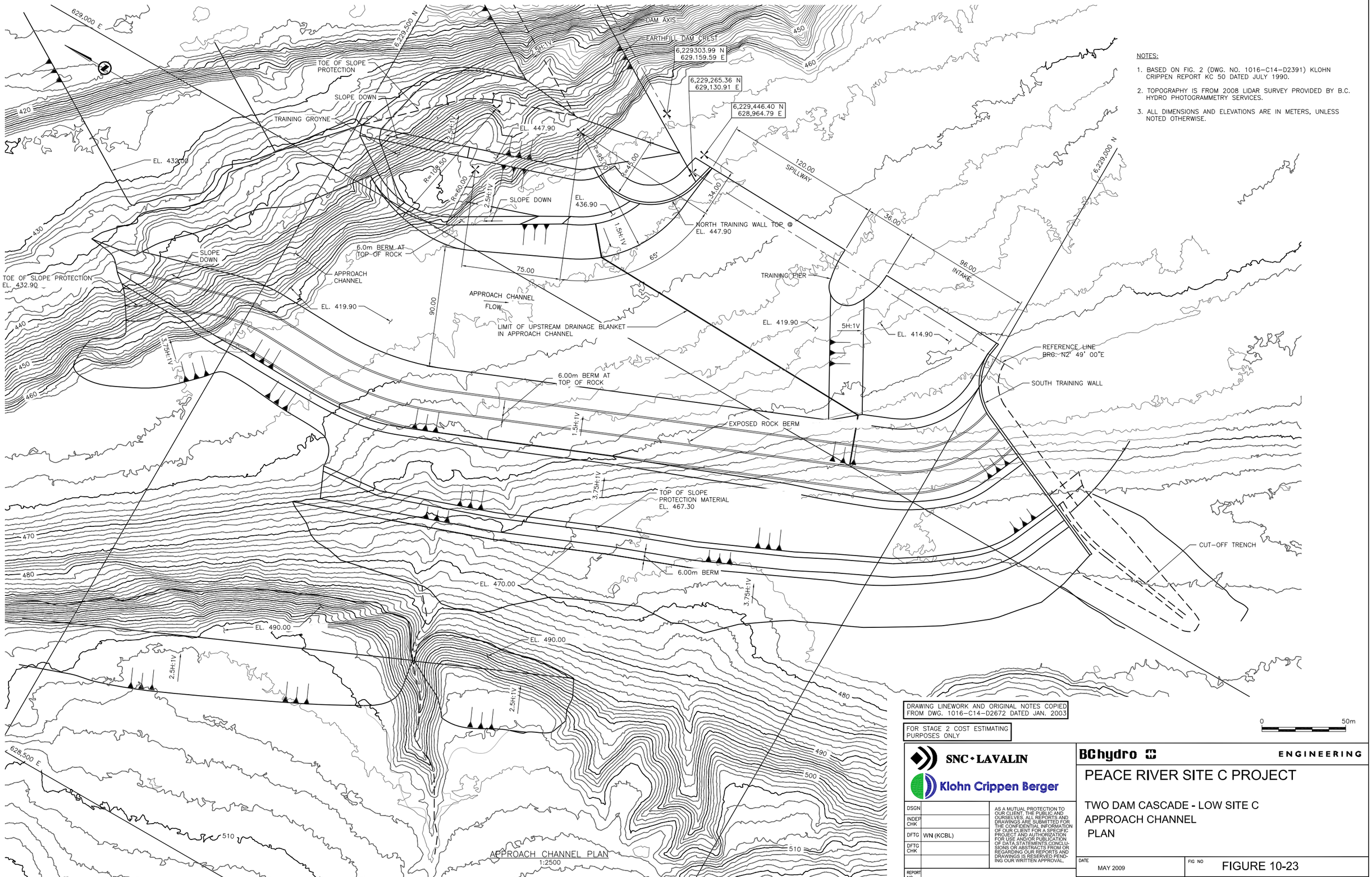
X:\07348 - Site C\41 - Civil Engineering\41DK - Sketches-Drawings\Alternative Study\\FIGURE 10-22.dwg
Kim Yoshida 2009/10/08 - 9:22am



APPROACH CHANNEL PLAN
1:2500

NOTES:

1. BASED ON FIG. 2 (DWG. NO. 1016–C14–D2391) KLOHN CRIPPEN REPORT KC 50 DATED JULY 1990.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY B.C. HYDRO PHOTOGRAMMETRY SERVICES.
3. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.

DRAWING LINEWORK AND ORIGINAL NOTES COPIED FROM DWG. 1016–C14–D2672 DATED JAN. 2003

FOR STAGE 2 COST ESTIMATING PURPOSES ONLY

SNC·LAVALIN
Klohn Crippen Berger

DSGN	
INDEP CHK	
DFTG	WN (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	

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BC hydro ENGINEERING

PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - LOW SITE C
APPROACH CHANNEL
PLAN

DATE	MAY 2009
FIG NO	FIGURE 10-23
DWN	WN
DWG NO	
R	

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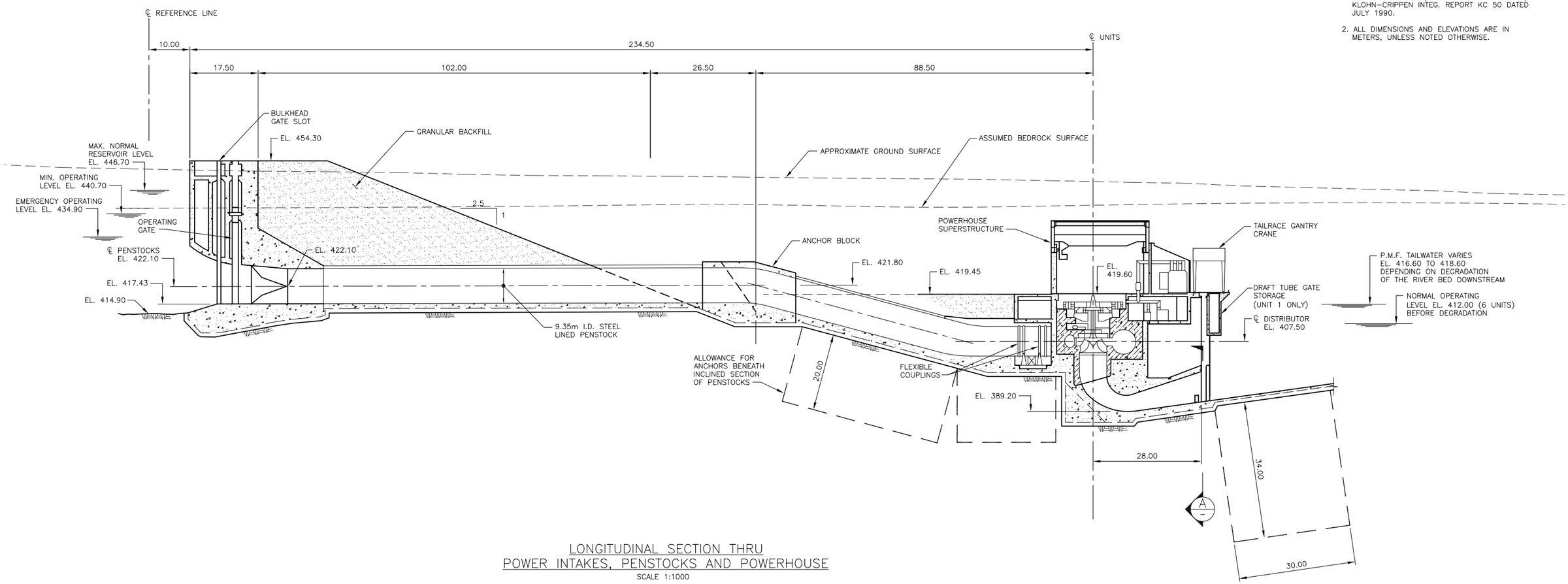
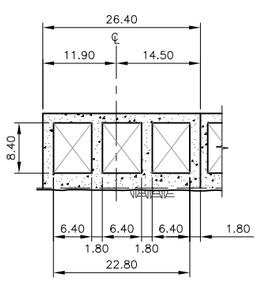
X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\FIGURE 10–23.DWG
Wed 2009/10/28 – 9:18am

NOTES:

1. BASED ON FIG. 7 (DWG. No.016–C14–B2393) KLOHN–CRIPPEN INTEG. REPORT KC 50 DATED JULY 1990.
2. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.



LONGITUDINAL SECTION THRU
POWER INTAKES, PENSTOCKS AND POWERHOUSE
SCALE 1:1000



SECTION A
1:1000

DRAWING LINEWORK AND ORIGINAL NOTES COPIED FROM DWG. 1016–C14–D2676 DATED JAN. 2003

0 25m

SNC·LAVALIN
Klohn Crippen Berger

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PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - LOW SITE C
POWERHOUSE SECTION

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INDEP CHK		
DFTG	WN (KCBL)	
DFTG CHK		
REPORT NO.		
PROJ. NO.		

DATE MAY 2009	FIG NO FIGURE 10-24	
DWN WN	DWG NO	R

X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\FIGURE 10–24.dwg
KWILSON.dwg
2009/10/08 – 9:17am

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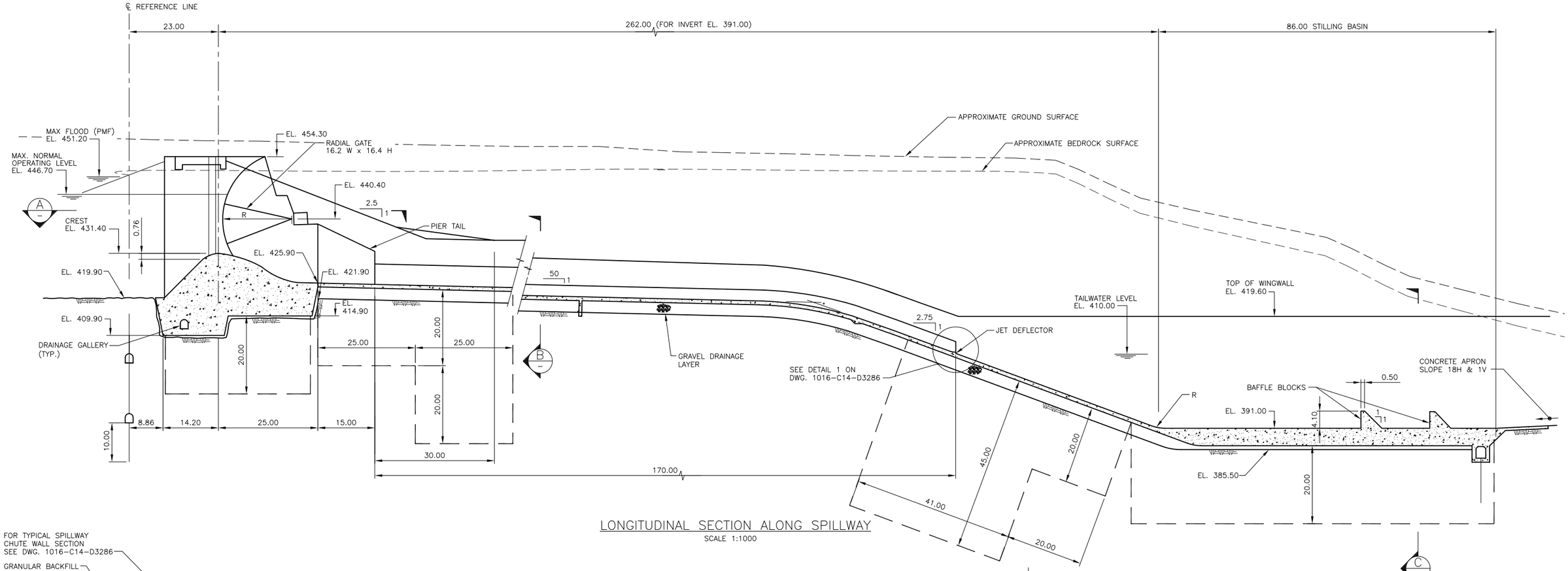
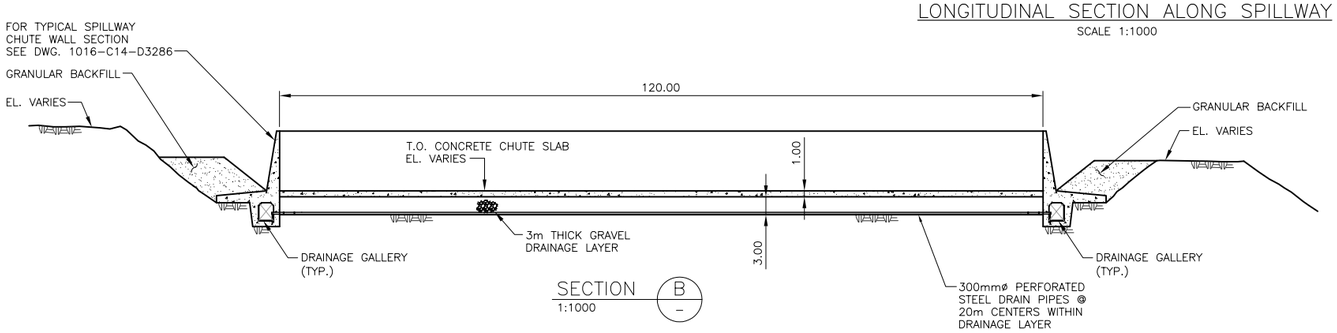
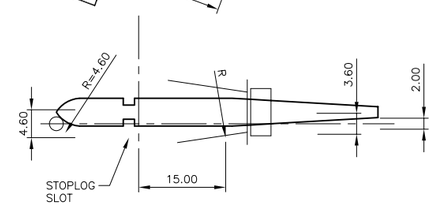


LONGITUDINAL SECTION ALONG SPILLWAY

SCALE 1:1000



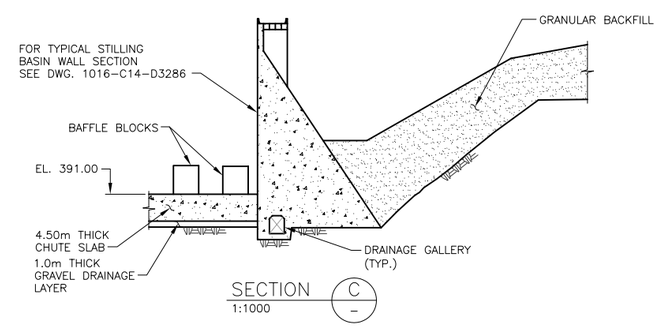
SECTION B
1:1000



SECTION A
1:1000

NOTES:

1. BASED ON FIGURE XX (DWG NO 1016-C14-BXXX) KLOHN CRIPPEN INTEG REPORT KC 50 DATED JULY 1990.
2. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.



SECTION C
1:1000

FOR STAGE 2 COST ESTIMATING PURPOSES ONLY

0 25m

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Klohn Crippen Berger

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DSGN	
INDEP CHK	
DFTG	WN (KCBL)
DFTG CHK	
REPORT NO.	
PROJ. NO.	

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PEACE RIVER SITE C PROJECT

TWO DAM CASCADE - LOW SITE C
SPILLWAY SECTIONS

DATE MAY 2009	FIG NO FIGURE 10-25	
DWN	DWG NO	R

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K:\017348 – Site C\41 – Civil Engineering\41DK – Sketches-Drawings\Alternative Study\FIGURE 10-25.dwg
WNGUYEN on 2009/10/08 – 9:16am

NOTES:

1. FIGURE IS BASED ON FIGURE 3 (DWG 1016–C14–B2694) FROM BC HYDRO REPORT E77 DATED NOVEMBER 2002.
2. THE COORDINATES HAVE BEEN UPDATED TO NAD 83.
3. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMMETRY SERVICES.

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DSGN	XXXXXX
INDEP CHK	XXXXXX
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DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	071348

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PEACE RIVER SITE C PROJECT

THREE DAM CASCADE
TYPICAL GENERAL ARRANGEMENT

DATE

DWN

FIG NO FIGURE 10-26

DWG NO

R

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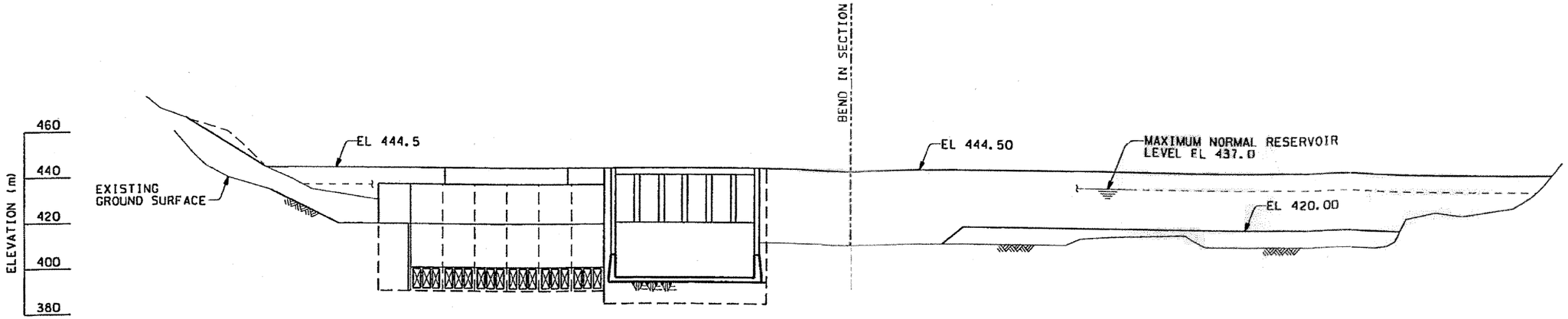
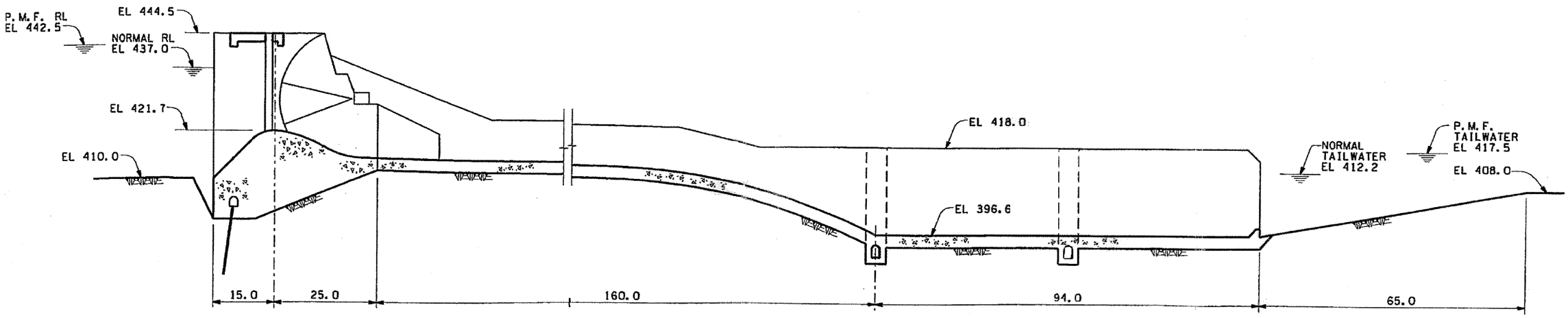
X:\071348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\FIGURE 10–26.dwg
Kevin Kim
2009/10/08 – 9:13am



DOWNSTREAM ELEVATION
HORIZONTAL SCALE B
VERTICAL SCALE C



SPILLWAY - LONGITUDINAL SECTION
SCALE A

NOTES:

1. FIGURE IS BASED ON FIGURE 4 (DWG. 1016-C14-B2695) FROM BC HYDRO REPORT E77 DATED NOVEMBER 2002.

SNC·LAVALIN
Klohn Crippen Berger

DSGN	XXXXXX
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DFTG	XXXXXX
DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	071348

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BChydro ENGINEERING

PEACE RIVER SITE C PROJECT

THREE DAM CASCADE
D/S ELEVATION AND SPILLWAY
LONGITUDINAL SECTION

DATE
FIG NO FIGURE 10-27
DWN
DWG NO
R

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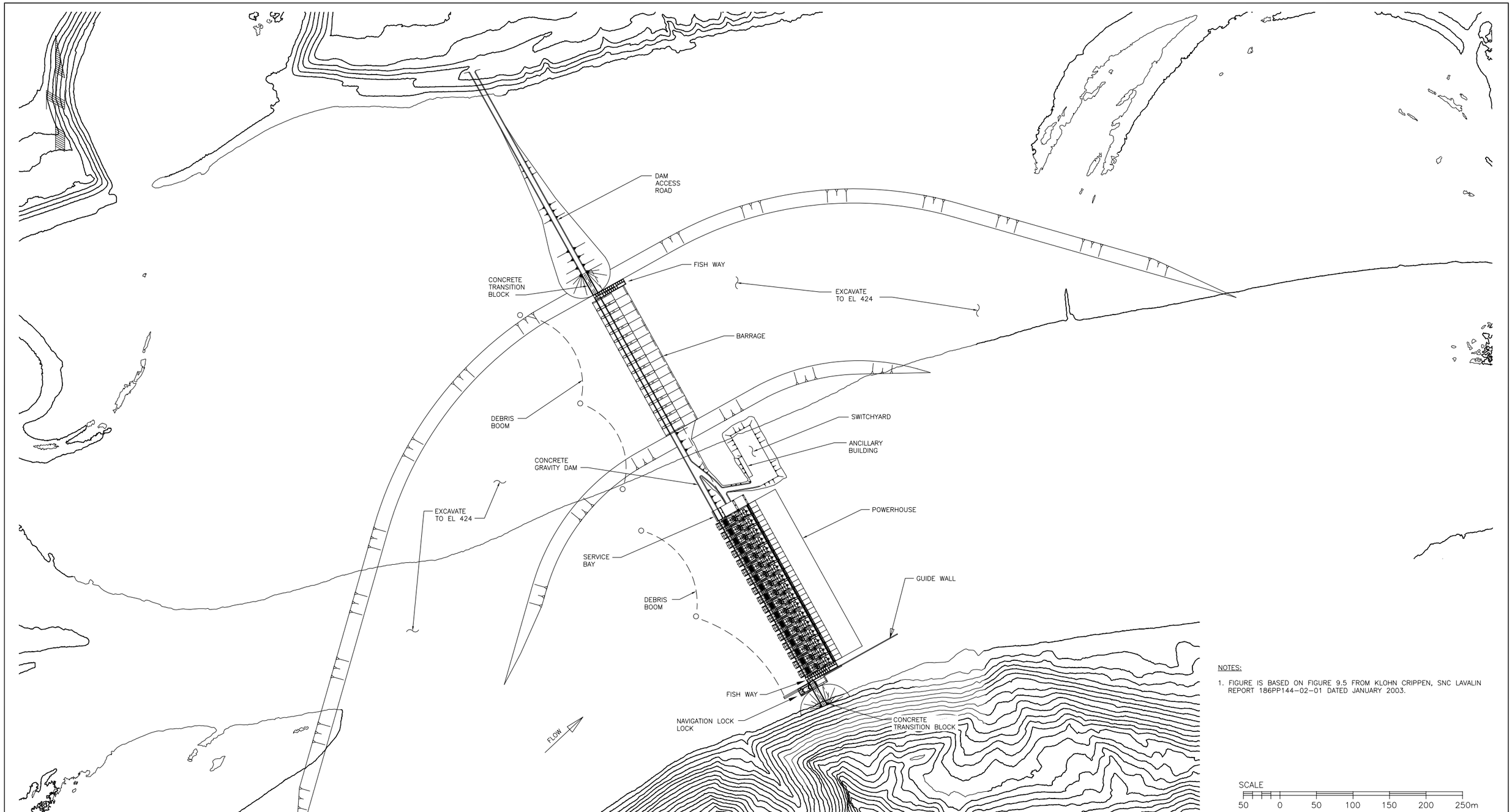
X:\071348 - Site C\41 - Civil Engineering\410K - Sketches-Drawings\Alternative Study\FIGURE 10-27.dwg
Wed, 2009/10/08 - 9:12am



NOTES:

1. FIGURE IS BASED ON FIGURE 9.5 FROM KLOHN CRIPPEN, SNC LAVALIN REPORT 186PP144-02-01 DATED JANUARY 2003.

SCALE

50 0 50 100 150 200 250m

SNC·LAVALIN

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DFTG	XXXXXX
DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	XXXXXX

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PEACE RIVER SITE C PROJECT

SEVEN DAM CASCADE
SITE 7E
GENERAL ARRANGEMENT

DATE

DWN

FIG NO FIGURE 10-28

DWG NO

R

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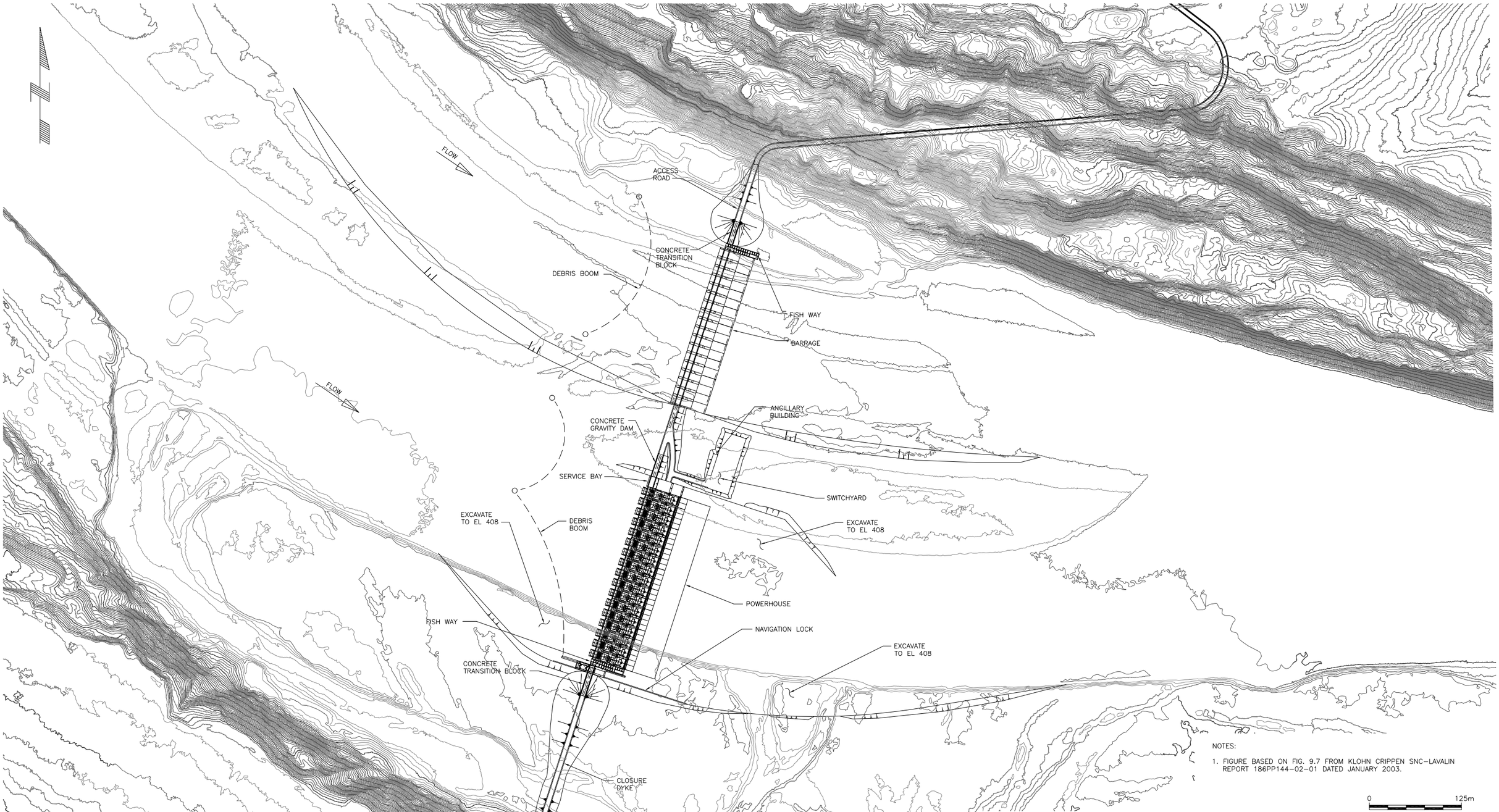
X:\017348 - Site C\41 - Civil Engineering\410K - Sketches-Drawings\Alternative Study\FIGURE 10-28.dwg
Mike Stanley
2009/10/08 - 9:10am



NOTES:

1. FIGURE BASED ON FIG. 9.7 FROM KLOHN CRIPPEN SNC–LAVALIN REPORT 186PP144–02–01 DATED JANUARY 2003.

SNC·LAVALIN

Klohn Crippen Berger

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DFTG	XXXXXX
DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	XXXXXX

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PEACE RIVER SITE C PROJECT

SEVEN DAM CASCADE
SITE 7G
GENERAL ARRANGEMENT

DATE	FIG NO	FIGURE 10-29
DWN	DWG NO	R

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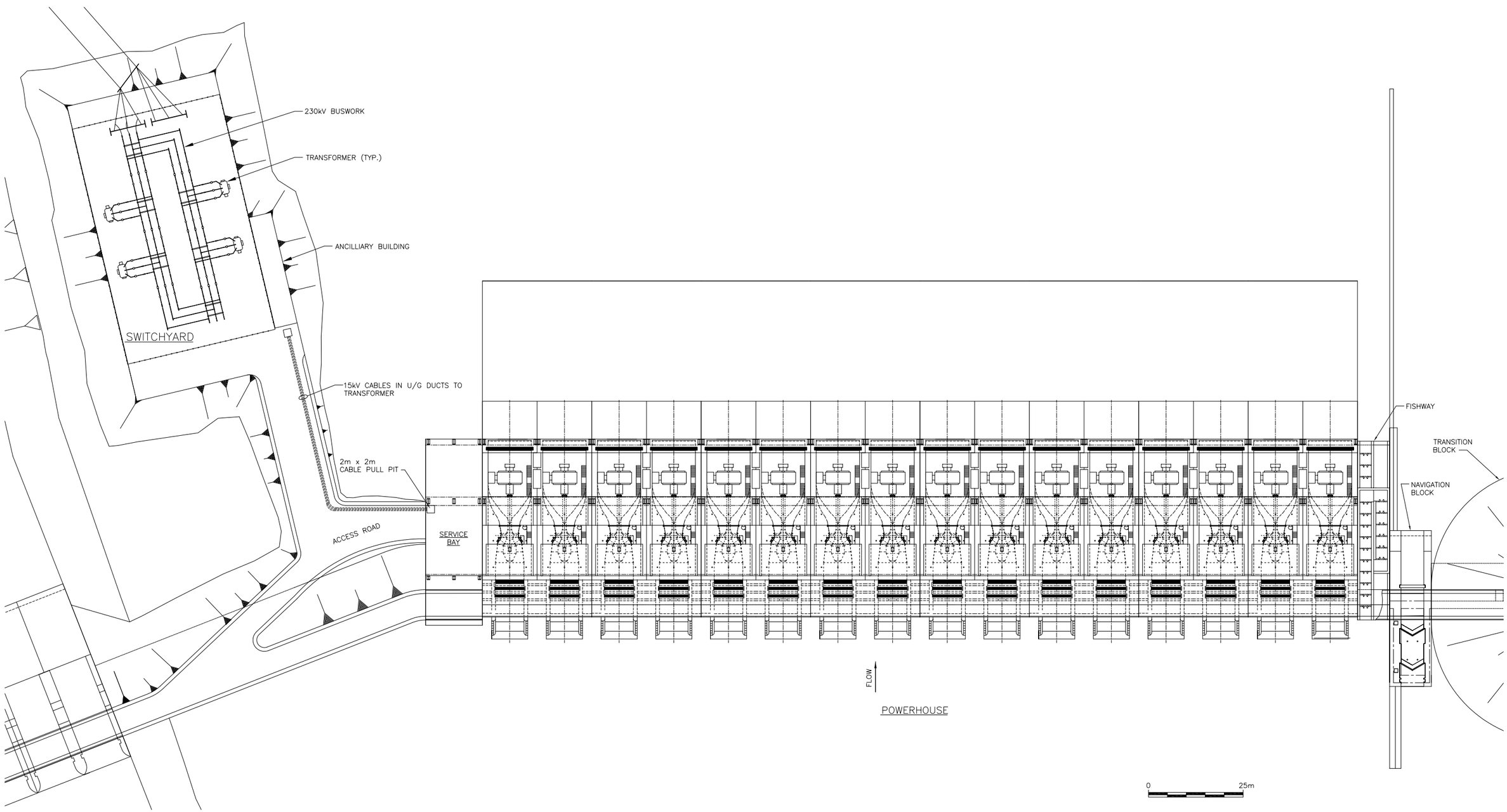
R

X:\017348 – Site C\41 – Civil Engineering\410K – Sketches–Drawings\Alternative Study\FIGURE 10–29.dwg
Nov 07, 2008 – 9:09am
2009/10/08 – 9:09am



NOTES:

1. FIGURE IS BASED ON FIGURE 8.3 FROM KLOHN CRIPPEN, SNC LAVALIN REPORT 186PP144-02-01 DATED JANUARY 2003.

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INDEP CHK	XXXXXX
DFTG	XXXXXX
DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	XXXXXX

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PEACE RIVER SITE C PROJECT

SEVEN DAM CASCADE
TYPICAL POWERHOUSE,
SERVICE BAY AND SWITCHYARD
PLAN

DATE	FIG NO FIGURE 10-30	
DWN	DWG NO	R

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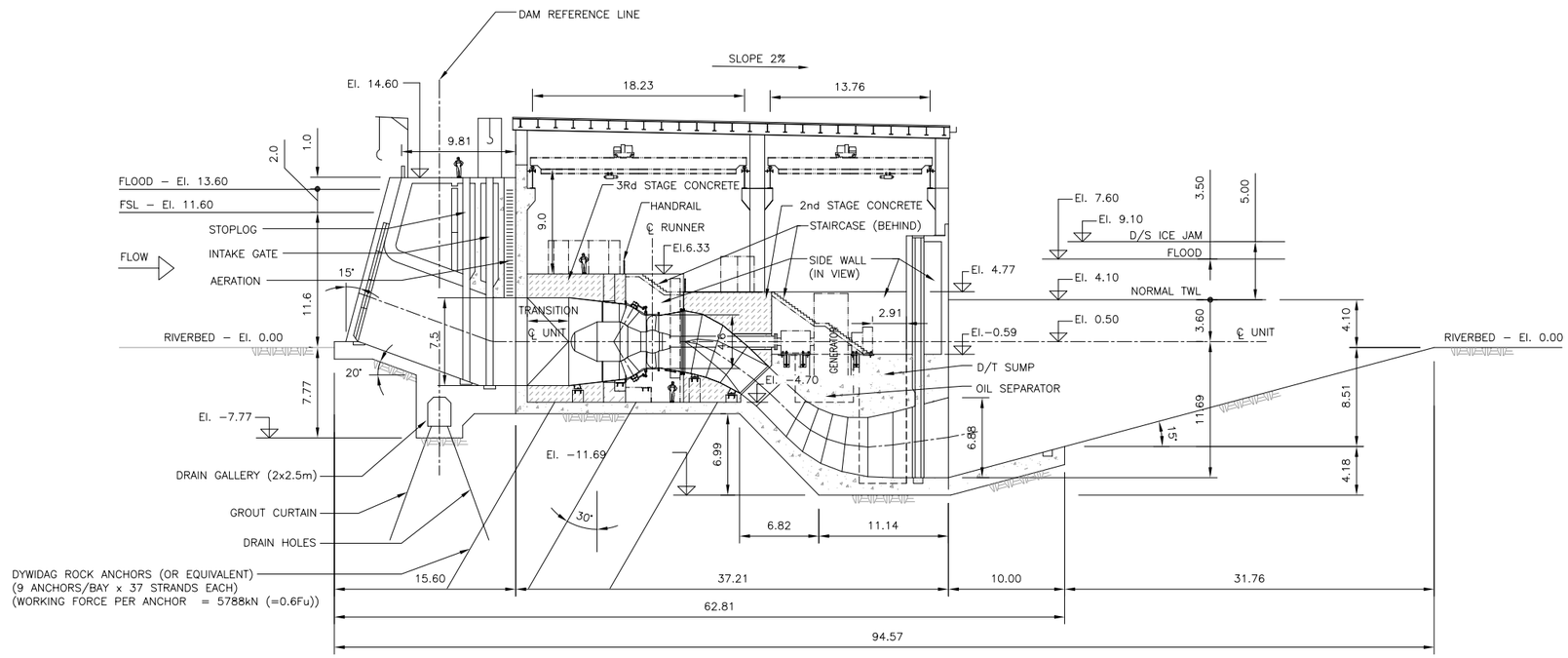
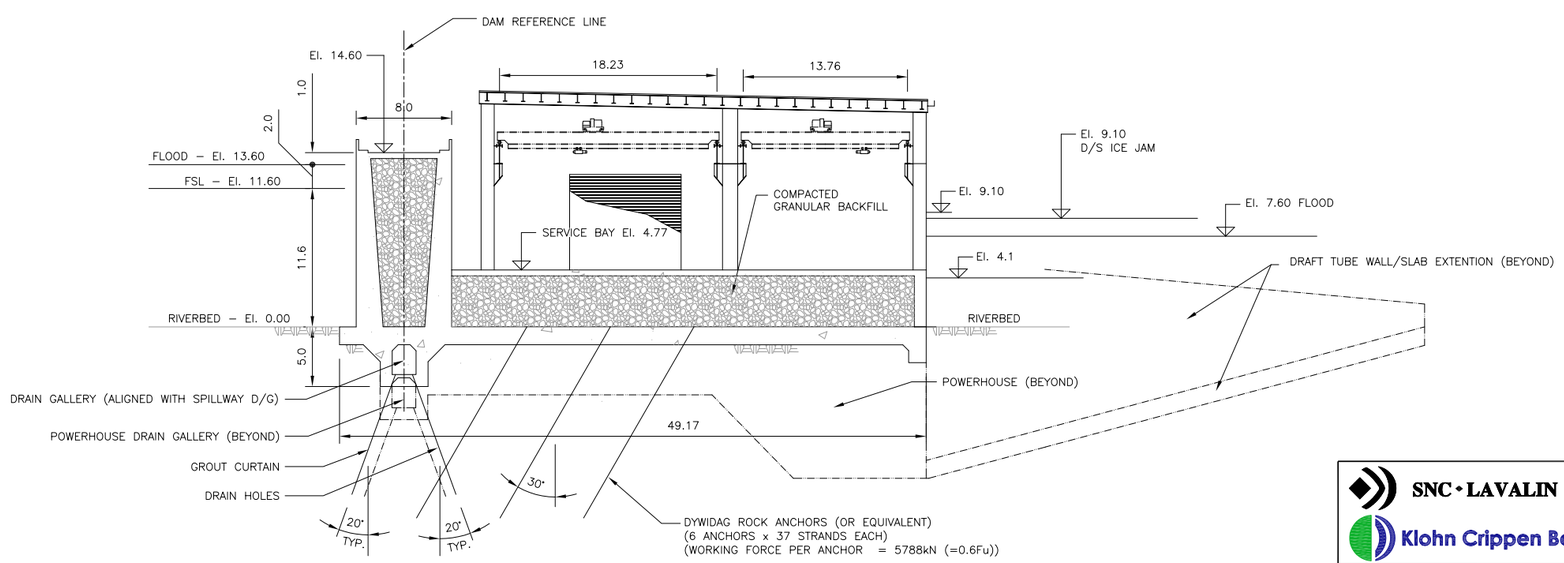
X:\017348 – Site C\41 – Civil Engineering\410K – Sketches–Drawings\Alternative Study\FIGURE 10–30.dwg
Kelly, Brian
2009/10/08 – 9:02am



SECTION – POWERHOUSE



SECTION – SERVICE BAY

NOTES:

1. FIGURE IS BASED ON FIGURE 8.2 FROM KLOHN CRIPPEN SNC LAVALIN REPORT 186PP144–02–01 DATED JANUARY 2003.
2. NOTE THE INDICATED ELEVATIONS ARE RELATIVE TO RIVER BED ELEVATION.

0 25m

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Klohn Crippen Berger

DSGN	XXXXXX
INDEP CHK	XXXXXX
DFTG	XXXXXX
DFTG CHK	XXXXXX
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PEACE RIVER SITE C PROJECT

SEVEN DAM CASCADE
TYPICAL POWERHOUSE AND SERVICE BAY SECTION

DATE
DWN
FIG NO FIGURE 10-31
DWG NO
R

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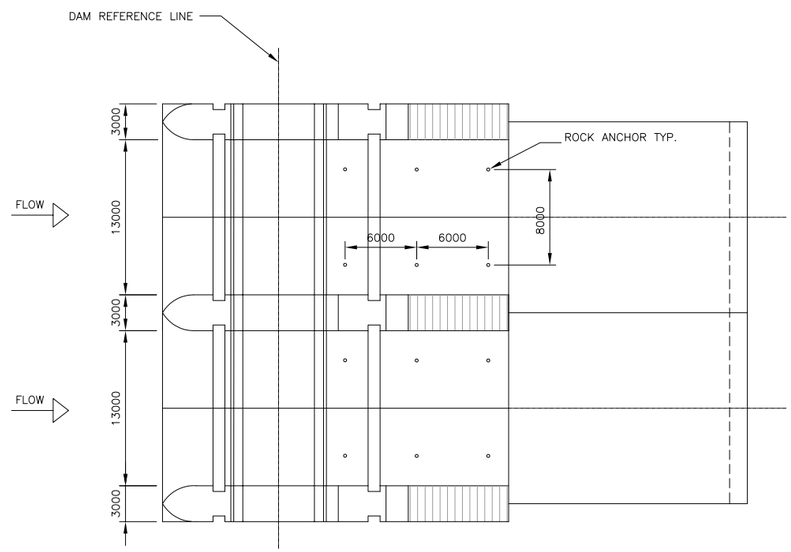
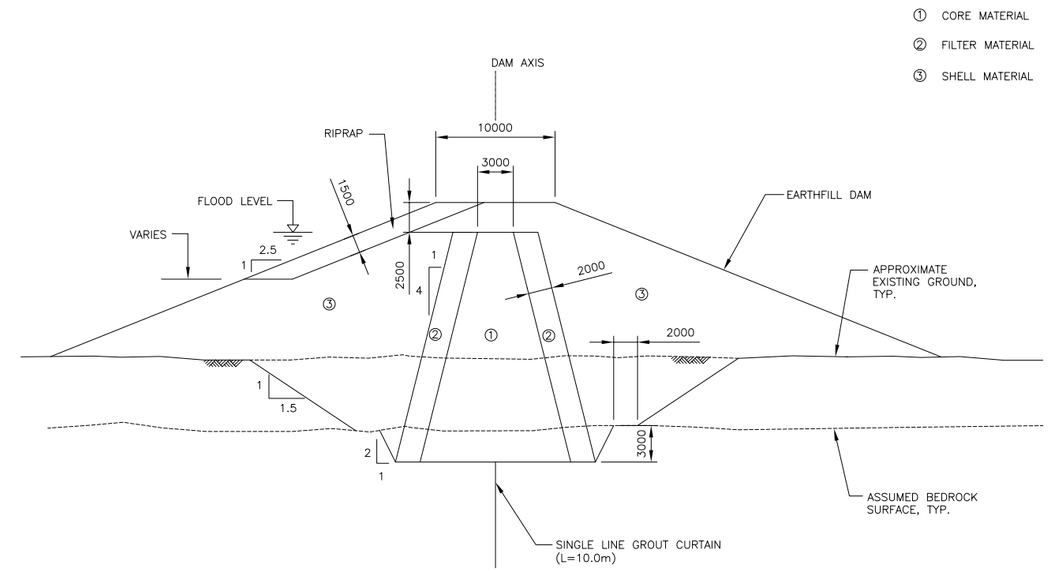
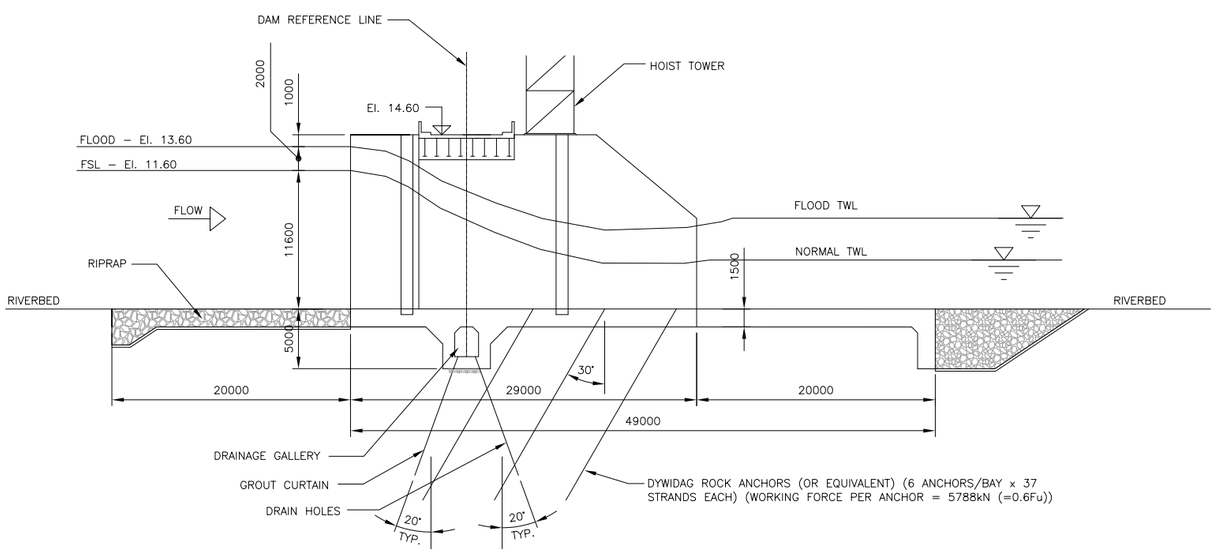
X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\\FIGURE 10–31.dwg
Kelly, Ryan – 2009/10/08 – 8:59am



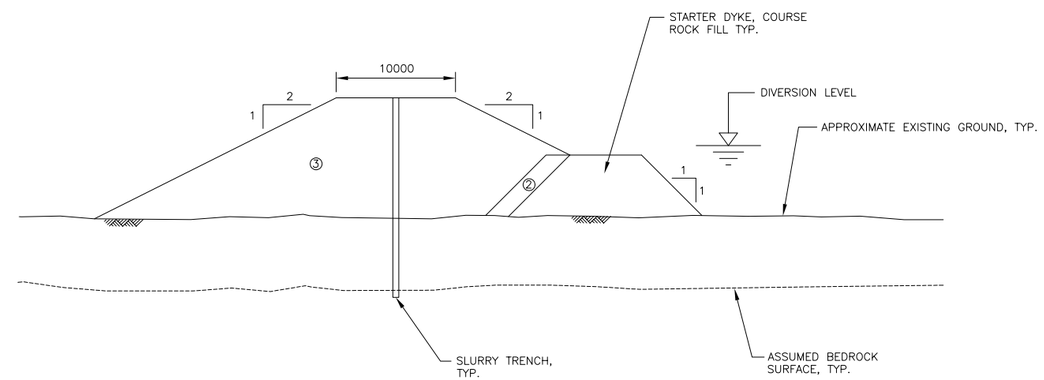
PLAN – BARRAGE



TYPICAL SECTION THROUGH EARTHFILL DAM



SECTION – BARRAGE



TYPICAL SECTION THROUGH COFFERDAM

DRAFT

NOTE:

1. FIGURE IS BASED ON FIGURE 8.5 AND FIGURE 8.6 FROM KLOHN CRIPPEN SNC LAVALIN REPORT 186PP144–02–01 DATED JANUARY 2003.

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Klohn Crippen Berger

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DFTG CHK	XXXXXX
REPORT NO.	XXXXXX
PROJ. NO.	XXXXXX

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PEACE RIVER SITE C PROJECT

SEVEN DAM CASCADE
TYPICAL BARRAGE PLAN AND SECTION,
TYPICAL EARTHFILL DAM SECTION

DATE
DWN
FIG NO FIGURE 10-32
DWG NO
R

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X:\017348 – Site C\41 – Civil Engineering\41DK – Sketches–Drawings\Alternative Study\FIGURE 10–32.dwg
KRAMER, Ian
2009/10/08 – 9:30am

Appendix A

Facilities Characteristics Matrix

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A1 – Engineering Facility Characteristics Matrix

PHYSICAL CHARACTERISTICS

Location of Alternatives
Geological Characteristics
Hydrological and Reservoir Characteristics
Infrastructure Characteristics
River Diversion Characteristics
Excavation and Disposal Characteristics
Dam Characteristics
Approach Channel Characteristics
Intake/Water Conduits/Powerhouse Characteristics
Spillway Characteristics
Tailrace Characteristics
Mechanical/Electrical Characteristics
Switchyard Characteristics
Transmission Line Characteristics
Other Characteristics

CONSTRUCTION ASPECTS AND CONSIDERATIONS

Availability of Construction Material
Areas for Temporary Works, Camps and Laydown
Accessibility Characteristics

SCHEDULE ESTIMATES

RELATIVE COST ESTIMATES

ENERGY ESTIMATES

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A2 – Environmental Areas - Themed and TEM Data (as related to Reservoirs, Transmission Lines, Dam Footprint and Highway Re-Alignment)

THEMED DATA

Proposed Protected Areas
Visual Landscape Inventory
Petroleum Titles
Oil and Gas Fields
Property: BC Hydro leased
Property: BC Hydro owned
Property: crown
Property: private
Land Act Tenures
Hunting Zones
Trapline Areas
Cut Blocks
Old Growth Management Areas
Timber Harvesting Land Base Class "C"
Timber Harvesting Land Base Class "N"
Timber Harvesting Land Base Class "P"
Timber Harvesting Land Base Class "X"
Recreational Reserves/Sites
Grazing Leases

TEM (TERRESTRIAL ECOSYSTEM MAPPING) DATA

TEM - AM:ap - Creamy peavine (seral association) (01) Majority*
TEM - AM:ap - Creamy peavine (seral association) (01) Minority*
TEM - CB - cutbank (00) Majority*
TEM - CB - cutbank (00) Minority*
TEM - CF - Cultivated field (00) Majority*
TEM - CF - Cultivated field (00) Minority*
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Majority*
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Minority*
TEM - GB - Gravel bar (00) Majority*
TEM - GB - Gravel bar (00) Minority*
TEM - SE - Sedge wetland (09) Majority*
TEM - SE - Sedge wetland (09) Minority*
TEM - SH:ac - Cow parsnip (seral association) (07) Majority*
TEM - SH:ac - Cow parsnip (seral association) (07) Minority*
TEM - WS - Willow sedge (00) Majority*
TEM - WS - Willow sedge (00) Minority*
TEM - SH:sw - Currant-horsetail (07) Majority*
TEM - SH:sw - Currant-horsetail (07) Minority*

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**Within the TEM database provided, the area of each TEM polygon is further broken down into three ecosystems defined by a percentage of the overall polygon. The TEM area analysis was split into two area calculations for each type of ecosystem; a majority and minority area. For example: The total area of polygon A is 10 ha. Within polygon A there is 60% cultivated field, 20% gravel bar and 20% willow sedge. Therefore, the majority area of cultivated field is 6 ha, while the minority area of both gravel bar and willow sedge is 20 ha each.*

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Site C Evaluation of Alternatives

Facility Characteristics

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Physical Characteristics							
- Location of Alternates							
Location Description *(note kms are the river distances downstream of WAC Bennett Dam)	km 105.5; 7 km southwest of the City of Fort St. John and approx. 1 km d/s of the Moberly River	C1: km 100; u/s of Moberly River, d/s of Tea Creek C2: km 102.5; 2 km u/s Moberly	km 94; just d/s of Wilder Creek	7b: km 39.5; slightly u/s from the Cascade 7b site Low C3: km 105.5; approx location of C3	3a: km 47; d/s of Farrell Creek 3b: km 83.5; d/s of Cache Creek 3c: km 105.5; approx location of C3	4a: km 45; just d/s of Farrell Creek 4b: km 67; just d/s of Halfway River 4c: km 87.5; d/s of Cache Creek 4d: km 105.5; approx location of C3	7a: km 27; near Hudson's Hope (HH) 7b: km 40.5; 11 km d/s HH 7c: km 53; between Farrell Ck. and Halfway R. 7d: historically @ km 62.5, u/s of Halfway R. near Attachie Slide; revised/moved to km 69 7e: km 82.5; just d/s of Cache Creek 7f: km 95.5; d/s of Wilder

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							Creek 7g: km 106; just d/s of C3
- Geological Characteristics							
Physical and Topography	suitable site given the terrace on the right bank to accommodate structures	suitable sites for the dam, however extensive excavations required for the structures	suitable site given the terrace on the right bank to accommodate structures	7b: suitable site, the island allows for river channel diversion; Low C3: topography suitable, similar to C3	sites selected so every project had equal head based on old river profile; the suitability of the sites was not evaluated	same as the three dam option, but note that 4b would need to be moved to avoid the Attachie slide area	all sites selected to be suitable, but note that 7d would need to be moved due to updated river profile
Surficial Geology	glacial deposits of sand, gravel and cobbles and glaciolacustrine deposits; riverbed alluvial deposits up to 10 m deep	same as C3	same as C3	same as C3	same as C3	same as C3	same as C3
Bedrock Geology	Shaftesbury shale	same as C3	same as C3	7b: Gates sandstone formation; C3: Shaftesbury shale	3a/3b/3c: same as C3	4a/4b/4c/4d: same as C3	7a/7b: Gates sandstone formation; 7c/7d/7e/7f/7g: same as C3

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Slope Stability	slope angles set based on field investigations, lab tests, and stability analysis	assumed to be same as for C3 but due to higher slopes, flatter angles may be required resulting in more excavation	the stability of the slopes is unknown and assumed to be same as C3	7b: assumed to be good, with minor shoreline instabilities; Low C3: right bank similar to C3, left bank could be shallower than C3	Conditions at site 3a and 3b unknown and are assumed to be similar to Site C. Dam 3c located at Site C therefore same as Site C.	Conditions at sites 4a, 4b and 4c unknown and are assumed to be similar to Site C. Dam 4d is located at Site C therefore same as Site C.	minor shoreline instability expected; subsurface conditions to be confirmed in areas of possible reservoir induced slumps
Seismicity	seismic design updated since previous studies (PGA = 0.23g)	same as C3; higher slopes mean higher bank instabilities due to increased PGA	seismic design set to 0.23g	seismic design set to 0.23g	same as C3	same as C3	seismic design updated since previous studies (PGA = 0.23g)
Geological Investigations	geological conditions investigated and well understood	minimal investigations undertaken	no investigations undertaken, two day site visit conducted in 2009	7b: no investigations undertaken C3: well investigated	no investigation s undertaken except for 3c	no investigation s undertaken except for 4d	no investigations undertaken except for 7g

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
- Hydrological and Reservoir Characteristics							
Flows: Mean Annual (m^3/s)	1,251	1,240	1,240	7b: 1,141 Low C3: 1,251	3a: 1,141 3b: 1,240 3c: 1,251	4a: 1,141 4b/4c: 1,240 4d: 1,251	7a/7b/7c: 1,141 7d/7e/7f: 1,240 7g: 1,251
Flows: IDF (m^3/s)	20,810	20,810	20,810	7b: 9,300 Low C3: 20,810	3a: 10,000 3b/3c: 20,000	4a: 10.000 4b/4c/4d: 20,000	7a: 9,300 7b: 10,200 7c: 11,300 7d: 12,500 7e: 17,000 7f: 18,000 7g: 20,810
Maximum Normal Reservoir Level (MNRL) (m)	461.8	461.8	461.8	7b: 461.8 Low C3: 446.7	3a: 461.8 3b: 445.3 3c: 428.7	4a: 461.8 4b: 449.4 4c: 437.0 4d: 424.6	7a: 460.0 7b: 454.1 7c: 446.2 7d: 438.2 7e: 431.0 7f: 425.0 7g: 417.0
Tailwater Elevation at Mean Annual Flow (m)	411.0	C1: 412.8 C2: 412.1	417.4	7b: 447.0 Low C3: 411.0	3a: 445.4 3b: 428.7 3c: 411.0	4a: 449.4 4b: 437.0 4c: 424.6 4d: 411.0	7a: 454.3 7b: 446.4 7c: 438.5 7d: 431.2 7e: 425.1 7f: 417.3 7g: 410.5
Gross Head at Mean Annual Flow (m)	50.8	C1: 49.0 C2: 49.7	44.4	7b: 14.9 Low C3:	3a: 16.5 3b: 16.6	4a: 12.4 4b: 12.4	7a: 5.7 7b: 7.7

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				35.7 Total: 50.6	3c: 17.7 Total: 50.8	4c: 12.4 4d: 13.6 Total: 50.8	7c: 7.7 7d: 7.0 7e: 5.9 7f: 7.7 7g: 6.5 Total: 48.2
Total Gross Head at Max Capacity (m)	50.0	C1: 48.0 C2: 48.8	43.5	49.4	49.8	49.8	45.2
Total Net Head at Max Capacity (m)	48.8	C1: 46.8 C2: 47.6	42.3	47.3	46.4	45.4	41.1
Reservoir Area (ha)	9,313.6	C1: 8,320.9 C2: 8,568.4	7,677.7	7,668.7	7,372.41	7,379.7	5,657.2
Reservoir shoreline (km)	Perimeter: 298.35 Islands: 20.92	C1 Perimeter: 257.6 C1 Islands: 19.78 C2 Perimeter: 265.02 C2 Islands: 20.04	Perimeter: 241.69 Islands: 19.78	Perimeter: 257.8 Islands: 41.84	Perimeter: 241.03 Islands: 26.71	Perimeter: 237.27 Islands: 28.39	Perimeter: 259.12 Islands: 169.10
Reservoir Volume (Mm^3)	2,330.7	C1: 2,010.5 C2: 2,107.6	1,750.5	7b: 113.7 Low C3: 1,109.2 Total: 1,222.9	3a: 216.8 3b: 435.6 3c: 211.3 Total: 863.7	4a: 194.1 4b: 246.6 4c: 186.1 4d: 122.5 Total: 749.4	7a: 10.2 7b: 39.4 7c: 44.9 7d: 49.5 7e: 48.5 7f: 52.9 7g: 24.7

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							Total: 270.1
Reservoir Filling Time (days)	62.0	C1: 60.8 C2: 61.5	55.1	7b: 20.5 Low C3: 44.3 Total: 64.7	3a: 26.2 3b: 30.4 3c: 21.9 Total: 78.5	4a: 24.9 4b: 22.1 4c: 22.1 4d: 16.9 Total: 85.9	7a: 9.9 7b: 12.2 7c: 12.2 7d: 9.5 7e: 11.9 7f: 10.7 7g: 8.1 Total: 74.4
Reservoir Flushing Time (days)	21.4	C1: 18.6 C2: 19.5	16.2	7b: 1.2 Low C3: 10.2 Total: 11.4	3a: 2.2 3b: 4.0 3c: 2.0 Total: 8.2	4a: 2.0 4b: 2.3 4c: 1.7 4d: 1.1 Total: 7.1	7a: 0.1 7b: 0.4 7c: 0.5 7d: 0.5 7e: 0.4 7f: 0.5 7g: 0.2 Total: 2.6
Length of river and tributaries flooded (km)[1]							
○ Peace River	84.85	C1: 78.69 C2: 81.46	72.76	84.85	84.85	84.85	84.18
○ Moberly River	11.6	n/a	n/a	7.83	3.79	2.82	1.16
○ Halfway River	15.46	C1: 15.46 C2: 15.46	15.46	8.6	7.82	9.79	4.20
○ Cache Creek	11.49 (two tribs)	C1: 11.49	11.49	6.67	6.2	4.29	3.11

[1] Measured from existing tributary mouth

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
		C2: 11.49					
o Farrell Creek	3.6	C1: 3.6 C2: 3.6	3.6	1.05	3.6	3.6	0.91
o Tea Creek	1.09	C1: 1.09 C2: 1.09	n/a	0.81	0.44	0.35	0.15
o Wilder Creek	2.86	C1: 2.86 C2: 2.86	2.86	1.98	0.83	0.57	0.61
o Lynx Creek	1.19	C1: 1.19 C2: 1.19	1.19	1.19	1.19	1.19	0.44
o Maurice Creek	1.07	C1: 1.07 C2: 1.07	1.07	1.07	1.07	1.07	0.21
Area of river and tributaries flooded (ha)[2]							
o Peace River	7,958.47	C1: 7,366.66 C2: 7,604.88	6,723.46	6,886.25	6,747.56	6,741.76	5,493.52
o Moberly River	391.61	n/a	n/a	246.63	95.22	69.09	24.19
o Halfway River	681.63	C1: 681.63 C2: 681.63	681.63	377.87	347.01	429.25	108.68
o Cache Creek	157.7	C1: 157.7 C2: 157.7	157.7	96.64	89.4	49.7	20.86
o Farrell Creek	58.88	C1: 58.88 C2: 58.88	58.88	12.05	58.88	58.88	0.08
o Tea Creek	9.28	C1: 9.28 C2: 9.28	n/a	4.03	1.05	0.66	0

[2] Measured from existing tributary mouth

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
○ Wilder Creek	27.95	C1: 27.95 C2: 27.95	27.95	17.15	5.21	2.28	2.66
○ Lynx Creek	28.08	C1: 28.08 C2: 28.08	28.08	28.08	28.08	28.08	7.39
○ Maurice Creek	3.43	C1: 3.43 C2: 3.43	3.43	3.43	3.43	3.43	0.69
Shoreline created (km)[3]							
○ Peace River	Perimeter: 206.81 Islands: 15.79	C1 Perimeter: 191.49 C1 Islands: 15.79 C2 Perimeter: 198.91 C2 Islands: 15.79	Perimeter: 177.61 Islands: 15.53	Perimeter: 199.1 Islands: 36.37	Perimeter: 194.2 Islands: 22.08	Perimeter: 188.74 Islands: 71.64	Perimeter: 227.75 Islands: 160.43
○ Moberly River	Perimeter: 25.43 Islands: 0.88	C1: n/a C2: n/a	n/a	Perimeter: 18.5 Islands: 1.65	Perimeter: 7.99 Islands: 0.72	Perimeter: 8.43 Islands: 2.77	Perimeter: 3.69 Islands: 0.06
○ Halfway River	Perimeter: 31.38 Islands: 4.05	C1 Perimeter: 31.38 C1 Islands: 4.05 C2 Perimeter:	Perimeter: 31.38 Islands: 4.05	Perimeter: 19.03 Islands: 2.3	Perimeter: 17.67 Islands: 3.23	Perimeter: 19.31 Islands: 4.17	Perimeter: 17.19 Islands: 7.22

[3] Measured from new tributary mouth.

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
		31.38 C2 Islands: 4.05					
o Cache Creek	Perimeter: 17.68 Islands: 0.08	C1 Perimeter: 17.68 C1 Islands: 0.08 C2 Perimeter: 17.68 C2 Islands: 0.08	Perimeter: 17.68 Islands: 0.08	Perimeter: 9.01 Islands: 0.74	Perimeter: 8.81 Islands: 0.48	Perimeter: 4.79 Islands: 0	Perimeter: 3.4 Islands: 0.17
o Farrell Creek	Perimeter: 7.34 Islands: 0.12	C1 Perimeter: 7.34 C1 Islands: 0.12 C2 Perimeter: 7.34 C2 Islands: 0.12	Perimeter: 7.34 Islands: 0.12	Perimeter: 4.31 Islands: 0.78	Perimeter: 7.34 Islands: 0.12	Perimeter: 7.34 Islands: 0.12	Perimeter: 3.62 Islands: 0.79
o Tea Creek	Perimeter: 2.03 Islands: 0	C1 Perimeter:2.03 C1 Islands: 0 C2 Perimeter: 2.03 C2 Islands: 0	n/a	Perimeter: 1.58 Islands: 0	Perimeter: 0.75 Islands: 0	Perimeter: 0.58 Islands: 0	Perimeter: 0 Islands: 0
o Wilder Creek	Perimeter: 4.73 Islands: 0	C1 Perimeter: 4.73 C1 Islands: 0	Perimeter: 4.73 Islands: 0	Perimeter: 3.32 Islands: 0	Perimeter: 1.32 Islands: 0.08	Perimeter: 0.96 Islands: 0	Perimeter: 1.22 Islands: 0

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
		C2 Perimeter: 4.73 C2 Islands: 0					
o Lynx Creek	Perimeter: 2.95 Islands: 0	C1 Perimeter: 2.95 C1 Islands: 0 C2 Perimeter: 2.95 C2 Islands: 0	Perimeter: 2.95 Islands: 0	Perimeter: 2.95 Islands: 0	Perimeter: 2.95 Islands: 0	Perimeter: 2.95 Islands: 0	Perimeter: 2.25 Islands: 0.43
o Maurice Creek	Perimeter: 2.22 Islands: 0	Perimeter: 2.22 Islands: 0	Perimeter: 2.22 Islands: 0	Perimeter: 2.22 Islands: 0	Perimeter: 2.22 Islands: 0	Perimeter: 2.22 Islands: 0	Perimeter: 0.50 Islands: 0
- Infrastructure Characteristics							
Segments of Highway 29 to be Relocated (km)							
Lynx Creek Segment	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Farrell Creek Segment	2.5	2.5	2.5	2.5	2.5	2.5	0.52
Halfway River Segment	4.2	4.2	4.2	4.2	0.84	0.86	0.84
Bear Flat Segment	7.9	7.9	7.9	3.7	2.2	0.71	0.70
Lengths of Highway 29 Crossings to be Relocated (m)							
Lynx Creek	420	420	420	420	420	420	420
Farrell Creek	285	285	285	285	285	285	90
Halfway River	970	970	970	970	970	920	950
Cache Creek	410	410	410	410	410	440	320
New Permanent	left bank: 6.4	C2: left bank:	left bank: 3.1	left bank: 6.5	left bank: 3.4	left bank:	left bank: 5.1

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Access Roads (km)	km; right bank: 9.1 km	1.2 km of existing roads to be upgraded, 5.8 km of new roads; right bank: 1.5km of new roads	km of existing roads to be upgraded; 4.4 km of new roads; right bank: 1.4km of new roads	km; right bank: 9.1 km	km of existing roads to be upgraded, 7.3 km of new roads; right bank: 13.8 km of new roads	11.1 km of existing roads to be upgraded, 10.1 km of new roads; right bank: 15.5 km of new roads	km of existing roads to be upgraded, 14.3 km of new roads; right bank: 18.3 km of new roads, 5.2 km of existing roads to be upgraded
Number of New Bridges Required	one powerhouse access bridge, 520 m long	C2: one powerhouse access bridge, 750m long	one powerhouse access bridge, 1250 m long	one powerhouse access bridge, 520 m long	three access bridges, combined length of 2200 m	four access bridges, combined length of 3250 m	The original study assumed access between banks via cofferdams and made no allowance for any new bridges. The latest study made allowance for new bridges at all dam sites except 7b (which would make use of in-

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							river and cofferdam access). Cost estimate did not include bridge allowances.
- River Diversion Characteristics							
Location	left bank	same as C3	same as C3	7b: phase one right river channel, phase two left river channel; Low C3: same as C3	phase one river diversion, phase two diversion sluices under spillway bays	phase one river diversion, phase two diversion sluices under spillway bays	various
Type	diversion tunnels, 2 x 9.8 m dia	diversion tunnels, 2 x 9.8 m dia	diversion tunnels, 2 x 9.8 m dia	7b: phase one river channel, phase two left river channel via regulating structures; Low C3: same as C3	phase one river channel, phase two sluices under four bays of the spillway	same as 3 dam option	phased diversion using the river channel
Length	~ 790 m and ~ 890 m	assumed to be the same as C3	assumed to be same as C3, but possibly longer	7b: natural channel length Low C3: same as C3	assumed to be similar to C3	assumed to be similar to C3	variable length diversion channels

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Duration of diversion (months)	46 months	~ 70 months assuming 2yr longer construction period	assumed to be the same as C3	7b: river diverted for about 2 years through south channel while dam is constructed across north channel and then diverted for about 1 year through spillway and north channel while the dam is constructed across the . Low C3: at least equal to C3 (likely greater due to additional excavation). Sequencing of diversions not determined,	For each dam the river would be trained into a channel on one side of the river for 5 years during construction of the intakes, powerhouse and spillway. Thereafter the river would be diverted through the spillway for about 1 year as the dam is constructed across the river. Sequencing of diversions not determined,	For each dam the river would be trained into a channel on one side of the river for 5 years during construction of the intakes, powerhouse and spillway. Thereafter the river would be diverted through the spillway for about 1 year as the dam is constructed across the river. Sequencing of diversions not determined,	~ 14 months river diversion, and 27 months through regulating structure

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				i.e. projects could be constructed concurrently or consecutively.	i.e. projects could be constructed concurrently or consecutively .	i.e. projects could be constructed concurrently or consecutively .	
- Excavation and Relocation of Surplus Excavated Materials							
Total Volume of Excavation (Mm3)	41.0	C1: 145.8 C2: 138.6	26.9	7b: 1.4 C3: 41.5	34.7 to 57.5	44.3 to 69.2	14.3
Volume of Dam Materials/Fill required (Mm^3)	12.6	C1: 25.6 C2: 20.7	10.1	7b: 0.24 (RCC) C3: 7.8	8.9	8.3	1.5
Location Offsite Borrow	gravels from right bank terrace, impervious till from north bank	same as C3	same as C3	7b: assumed that river bed alluvium would be suitable for both RCC and concrete therefore materials come from required excavations; Low C3: same as C3	river bed and local sources	river bed and local sources	river bed and local sources

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Location of Relocated Surplus Excavated Materials	placed in earthfill dykes along the river bank (studies done already)	placed in upper plateau on right bank	assumed to be placed on river banks within body of upstream reservoir	7b: assumed that surplus materials could be relocated on site; Low C3: same as C3	3a/3b: placed on left and right banks at site and on upper right bank plateau; 3c: same as C3	4a/4b: placed on upper right bank plateau; 4c: placed on left bank at dam site; 4d: same as C3	assumed to be placed on both banks at dam sites and along river banks in earthfill dykes where possible
- Dam Characteristics							
Number of Dams	one	one	one	7b: two C3: one	three	four	7a/7b/7e/7g: one 7c/7d/7f: two
Dam Type(s)	zoned earthfill dam	zoned earthfill dam	zoned earthfill dam	7b: RCC dams C3: earthfill dam	earthfill dams	earthfill dams	7a/7f: concrete barrage with earthfill section 7b/7c/7d/7e/7g: concrete barrage
Dam Height (m) (*note: in estimating dam heights, earthfill dams assumed to have the same flood surcharge and freeboard allowances as Site C)	60 (from river bed), 77 from bedrock	assumed to be 58* (from river bed), 75 from bedrock	assumed to be 53.6* (from river bed), 70.6 from bedrock	7b: 34 (assumes 10 m of alluvium in river channel) Low C3: assumed to be 45.7* from river bed (63.7 from bedrock)	assumed to be 27* (from river bed), 37 from bedrock	assumed to be 22* (from river bed), 32 from bedrock	varies from 18.7 to 20. 7 assuming 3 m of freeboard on concrete structures and 10 m of alluvium in river channel

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							(earthfill structures are 1.5 m higher due to greater freeboard)
Crest Elevation (m)	470.0	same as C3	469.4	7b: 469.0 Low C3: 454.3	3a: assumed to be 470.0 3b: assumed to be 453.5 3c: assumed to be 436.9	4a: assumed to be 470.0 4b: assumed to be 457.6 4c: assumed to be 445.2 4d: assumed to be 432.8	7a: 463.0 7b: 457.1 7c: 449.1 7d: 441.2 7e: 434.0 7f: 428.0 7g: 420.0 (concrete structures have 3 m freeboard above MNRL, and earthfill structures have 4.5 m freeboard)
- Approach Channel Characteristics							

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Approach Channel Location/ Configuration	excavated into right bank	same layout as C3	same layout as C3 but longer	7b: located in existing left hand river channel Low C3: same layout as C3	same layout as C3	same layout as C3	located in existing river channel
- Intake/Water Conduits/Powerhouse Characteristics							
Intake	six gated intakes adjacent to spillway on right bank	same as C3	same as C3	7b: six gated intakes in left hand river channel Low C3: same layout as C3	same as C3	same as C3	sixteen or seventeen gated intakes with invert at riverbed level
Water Conduits	9.35 m ID steel-lined penstocks, 210 m long	same layout as C3	same layout as C3	7b: water travels from intake directly to turbine Low C3: same as C3	same layout as C3 but slightly shorter penstocks	same layout as C3 but slightly shorter penstocks	7.5 m ID conveyance between intake and turbines less than 10 m long
Size of Powerhouse	26 m x 168 m	same as C3	same as C3	7b: 57 m x 159 m Low C3: same as C3	28.5 m x 180.6 m	29.3 m x 187.9 m	7a/7b/7c: 36 m x 231 m 7d/7e/7f/7g: 36 m x 246 m
Size of Service bay	26 m x 55 m	same as C3	same as C3	7b: 35 m x 31 m Low C3: same as C3	28.5 m x 59.4 m	29.3 m x 61.9 m	36 m x 15 m

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
- Spillway Characteristics							
Location	right bank	same as C3	same as C3	7b: overflow section on right channel, regulating structure on left channel structures; Low C3: same as C3	right bank	right bank	7a: right bank 7b/7g: left channel 7c/7d/7e/7f: left bank
Layout	concrete headworks structure with six radial gates; concrete ogee crest spillway; concrete lined chute and stilling basin	same as C3	same as C3	7b: three regulating spillway bays with radial gates adjacent to powerhouse and a free overflow spillway in right bank; Low C3: same layout as C3	concrete headworks structure with radial gates; concrete broad crested weir spillway; concrete lined chute and stilling basin shorter than C3	same as three dam option with an even shorter stilling basin	gated barrage with sill at riverbed level (vertical lift gates & stoplogs); riprap apron u/s, short apron and cutoff wall d/s, and self launching apron with riprap protection
Capacity (m^3/s)	17,500	same as C3	same as C3	7b: 9,300 Low C3: same as C3	3a: 10,000 3b/3c: 20,000	4a: 10.000 4b/4c/4d: 20,000	7a: 9,300 7b: 10,200 7c: 11,300 7d: 12,500

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							7e: 17,000 7f: 18,000 7g: 20,810
- Tailrace Characteristics							
Tailrace Location/Layout	open channel excavated into right bank	same as C3	same as C3 but tailrace and spilling basin excavation elevation is 5.4 m higher than C3	7b: existing left river channel; Low C3: same as C3	excavated into right bank	excavated into right bank	7a: excavated into right bank; 7b/7f/7g: existing right channel; 7c/7d/7e: existing main channel
- Mechanical/Electrical Characteristics							
Turbines – number	6 – 150 MW units	same as C3	same as C3	7b: 6 – 40 MW units Low C3: 6 – 105 MW units	6 – 50 MW units per site	6 – 37.5 MW units per site	8 MW units 7a to 7c: sixteen units 7d to 7g: seventeen units
Turbines – type	vertical shaft Francis units	same as C3	same as C3	propeller type turbine units	vertical shaft Kaplan/ Propeller units	same as for 3 dam option	horizontal axis S-turbines
Total Installed Capacity (MW)	900	C1: 863 C2: 878	781	859	841	826	705
Number of Intake Gates	six	six	six	7b: eighteen Low C3: six	six	six	7a to 7c: sixteen 7d to 7g:

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							seventeen
Size of Intake Gates	6.8 m x 9.35 m	same as C3	same as C3	7b: 5.56 m x 14.5 m Low C3: same as C3	same as C3	same as C3	7.5 m x 7.5 m
Number of Spillway Gates	six	six	six	7b: three Low C3: six	3a: six 3b/3c: ten	4a: eleven 4b/4c/4d: twenty-one	7a: seventeen 7b: thirteen 7c: fifteen 7d: twenty-two 7e: thirty-seven 7f: thirty-two 7g: forty-seven
Size of Spillway Gates	16.2 m x 16.4 m	same as C3	same as C3	7b: 12 m x 19 m Low C3: same as C3	3a: 14.7 m x 17 m 3b/3c: 17.5 m x 18 m	4a: 12.2 m x 13 m 4b/4c/4d: 13 m x 13 m	7a: 13 m x 11.5 m 7b: 13 m x 13.7 m 7c: 13 m x 13.5 m 7d: 13 m x 11.4 m 7e: 13 m x 10.3 m 7f: 13 m x 11 m 7g: 13 m x 10 m
- Switchyard Characteristics							

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Switchyard Locations	separate switchgear facility adjacent to powerhouse	separate switchgear facility adjacent to powerhouse	separate switchgear facility adjacent to powerhouse	adjacent to powerhouse	adjacent to powerhouse	adjacent to powerhouse	adjacent to powerhouse
Footprint area (ha)	0.72	0.72	0.72	Site 7b: 0.65 Low C3: 0.65	2.02	2.67	4.62
- Transmission Line Characteristics							
Number of Transmission Corridors	one new corridor on south bank running alongside existing corridor to Peace Canyon GS substation; existing transmission line corridor to be widened to accommodate 2 new 500 kV lines	same as C3	same as C3	two new corridors on south bank running to Peace Canyon GS substation;	three new corridors on south bank running to Peace Canyon GS substation; existing transmission line corridor to be widened to accommodat e 2 new 500 kV lines	four new corridors on south bank running to Peace Canyon GS substation; existing transmission line corridor to be widened to accommodate 2 new 500 kV lines	seven new corridors on north bank to connect to Peace Canyon GS substation; main corridor to be widened to accommodate new 230 kV line
Characteristics of Transmission Lines and Corridors:	two lines, each single circuit, three-phase operating at 500 kV;	two lines, each single circuit, three-phase operating at 500 kV;	two lines, each single circuit, three-phase operating at	two lines, each single circuit, three-phase operating at 500 kV;	three lines	four lines	1000 MW load carrying capacity; single line, double circuit

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
	additional switchgear required at Peace Canyon	additional switchgear required at Peace Canyon	500 kV; additional switchgear required at Peace Canyon	additional switchgear required at Peace Canyon			230 kV transmission line
Length (km)	75.9	76.6	C2: 78	90	110.6	128.5	104.7
Cleared Area (ha)	910.2	920.5	C2: 938.3	676	1325.3	1538	1250.9
- Other Characteristics							
Navigation Facilities	boat ramps	same as C3	same as C3	same as C3	same as C3	same as C3	a navigation lock provided at each site for pleasure boats
Fish Passage	trap and truck	trap and truck	trap and truck	trap and truck	trap and truck	trap and truck	passage provided at each site
Construction Aspects and Considerations							
- Availability of Construction Material							
Dam Fill (or RCC aggregate)	readily available	same as C3	same as C3	7b: assumed to be readily available from river alluvium; Low C3: same as C3	assumed to be available in riverbed & terraces	assumed to be available in riverbed & terraces	assumed to be available in riverbed & terraces
Dam Core Material	believed to be readily available within 10 km of site	same as C3	same as C3	7b: n/a; Low C3: same as C3	assumed to be available within 10 km of site	assumed to be available within 10 km of site	assumed to be available within 10 km of site

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Concrete Aggregate	readily available	same as C3	same as C3	7b: assumed to be readily available from river alluvium; Low C3: same as C3	assumed to be readily available from river alluvium	assumed to be readily available from river alluvium	assumed to be readily available from river alluvium
Slope Erosion Protection	assumed to be railed in from Lemorary Quarry	same as C3	same as C3	7b: minimal erosion protection required; Low C3: same as C3	same as C3	same as C3	same as C3
- Areas for Temporary Works, Camps and Laydown							
Construction Camp Location/Area	left and right banks	left bank, on top of plateau	left bank	7b: left bank downstream of dry creek; Low C3: left and right banks	3a/3b: left bank within 1 km of dam site; 3c: same as C3	4a/4b/4c: left bank within 1 km of dam site; 4d: same as C3	7a/7b/7c/7d/7e/ 7f: left banks adjacent to dam site (within 1 km of site); 7g: left bank
Laydown Area Location	left and right banks	left and right banks on top of plateau	left and right bank terraces, as well as upper left bank plateau	7b: left bank & Gates island; Low C3: left and right banks	3a/3b: left bank within 1 km of dam site; 3c: same as C3	4a/4b/4c: left bank within 1 km of dam site; 4d: same as C3	7a/7b/7c/7d/7e/ 7f: left banks adjacent to dam site (within 1 km of site); 7g: left bank

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
- Accessibility Characteristics							
Access Rail	available to site	could be available to site, but would require a bridge over the Moberly, otherwise trucked from Fort St. John	available to Fort St. John and trucked	7b: available to Fort St. John and trucked; Low C3: same as C3	3a/3b: available to Fort St. John and trucked; 3c: available to site	4a/4b/4c: available to Fort St. John and trucked; 4d: available to site	7a/7b/7c/7d/7e: available to Fort St. John and trucked; 7f: potentially available with bridge over Moberly; 7g: available to site
Access by Rd	available from Fort St. John	available from Fort St. John	available from Fort St. John	7b: available via Hwy 29; Low C3: same as C3	3a/3b: available via Hwy 29; 3c: available from Fort St. John	4a/4b/4c: available via Hwy 29; 4d: available from Fort St. John	7a/7b/7c/7d/7e: available via Hwy 29; 7f, 7g: available from Fort St. John
Schedule Estimates							
Site Investigations (note * estimated additional time required to investigate the site to the same level as Site C)	can be completed during the regulatory phase	+ 2 yrs*	+ 2yrs*	+ 1yrs*	+ 3yrs*	+ 3yrs*	+ 4yrs*

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Applications and Design	~ 2yrs	+1 yr	+1 yr	+1 year	+ 2 years	+ 2 years	+ 2 years
Construction (note * estimated additional time for construction, for cascade projects assumed the projects are staggered)	~ 7yrs	+ 2 yrs*	assumed to the be same as Site C	+ 2yrs*	+ 6yrs*	+ 8yrs*	+ 6yrs*
Relative Cost Estimates							
Energy Cost Ratio	1.00	2.14	1.38	1.55	1.88	2.27	1.76
Energy Estimates							
Total Gross Head @ Weighted Average Flow (m)	50.8	49.7	44.4	50.6	50.8	50.8	48.2
Total Net Head @ Weighted Average Flow (m)	50.4	49.2	44.0	49.8	49.5	49.1	46.7
Total Average Annual Energy Production (GW.h)	4600	4454	3980	4431	4379	4369	3902
Relative Average Energy Production	1.00	0.97	0.87	0.96	0.95	0.95	0.85
Total Firm Annual Energy Production (GW.h)	4000	3873	3461	3853	3807	3799	3393

Engineering Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Relative Firm Annual Energy Production	1.00	0.97	0.87	0.96	0.95	0.95	0.85

Site C Evaluation of Alternatives

Environmental Areas

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Themed Data							
- Area Affected by Reservoir (ha)							
Proposed Protected Areas	6,356.64	C1: 5471.37 C2: 5,676.00	4,933.97	Low C3: 4,860.92 7b: 945.04 Total: 5,805.96	3a: 1,410.71 3b: 2,331.22 3c: 1,842.50 Total: 5,584.43	4a: 1,318.57 4b: 1,479.35 4c: 1,250.67 4d: 1,547.96 Total: 5,596.55	7a: 204.13 7b: 653.45 7c: 675.92 7d: 855.01 7e: 736.02 7f: 936.14 7g: 603.68 Total: 4,664.35
Visual Landscape Inventory	9,318.80	C1: 8,325.77 C2: 8,573.31	7,682.24	Low C3: 6,481.72 7b: 1,191.30 Total: 7,673.02	3a: 1,818.42 3b: 3,581.79 3c: 1,976.39 Total: 7,376.60	4a: 1,699.52 4b: 2,180.16 4c: 1,859.15 4d: 1,645.11 Total: 7,383.94	7a: 268.53 7b: 721.49 7c: 783.75 7d: 1,187.40 7e: 1,073.56 7f: 992.67 7g: 633.27 Total: 5,660.67
Petroleum Titles	4,023.14	C1: 2,944.47 C2: 3,190.91	2,575.42	Low C3: 2,950.80 7b: 261.48 Total: 3,212.28	3a: 262.04 3b: 924.98 3c: 1,593.67 Total: 2,780.69	4a: 262.04 4b: 0.00 4c: 1,021.43 4d: 1,315.95 Total:	7a: 133.82 7b: 82.70 7c: 0.00 7d: 0.00 7e: 719.10

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
						2,599.42	7f: 770.85 7g: 542.84 Total: 2,249.31
Oil and Gas Fields	1,619.17	C1: 851.19 C2: 1,098.73	507.65	Low C3: 1,295.04 7b: 0.00 Total: 1,295.04	3a: 0.00 3b: 231.23 3c: 816.76 Total: 1,047.99	4a: 0.00 4b: 0.00 4c: 319.55 4d: 709.63 Total: 1,029.18	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 167.79 7f: 135.58 7g: 430.15 Total: 733.52
Property: BC Hydro Leased	655.04	C1: 653.00 C2: 653.00	653.00	Low C3: 326.32 7b: 43.78 Total: 370.10	3a: 85.89 3b: 291.74 3c: 3.55 Total: 381.19	4a: 70.86 4b: 66.43 4c: 217.36 4d: 2.20 Total: 356.86	7a: 0.00 7b: 13.90 7c: 35.66 7d: 89.25 7e: 93.43 7f: 1.75 7g: 0.11 Total: 151.82
Property: BC Hydro Owned	24.84	C1: 21.30 C2: 21.30	21.30	Low C3: 6.38 7b: 3.77 Total: 10.15	3a: 3.77 3b: 5.16 3c: 0.01 Total: 8.94	4a: 3.77 4b: 3.97 4c: 2.09 4d: 0.00 Total: 9.83	7a: 0.00 7b: 0.00 7c: 2.77 7d: 0.00 7e: 1.58 7f: 0.00 7g: 0.00 Total: 4.35

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Property: Crown	3,544.02	C1: 2,862.27 C2: 2,995.11	2,575.11	Low C3: 2,267.72 7b: 212.70 Total: 2,480.42	3a: 348.56 3b: 998.61 3c: 787.42 Total: 2,134.59	4a: 333.57 4b: 893.59 4c: 269.42 4d: 643.59 Total: 2,140.17	7a: 21.40 7b: 84.98 7c: 60.30 7d: 333.60 7e: 90.79 7f: 339.74 7g: 96.81 Total: 1,027.63
Property: Private	515.05	C1: 515.05 C2: 515.05	498.25	Low C3: 196.69 7b: 63.46 Total: 260.15	3a: 247.50 3b: 159.50 3c: 8.44 Total: 415.43	4a: 232.82 4b: 62.41 4c: 114.73 4d: 3.76 Total: 413.73	7a: 1.53 7b: 41.78 7c: 25.82 7d: 13.04 7e: 60.26 7f: 1.89 7g: 0.67 Total: 144.99
Land Act Tenures	18,351.79	C1: 15,167.30 C2: 15,729.51	13,929.11	Low C3: 13,608.89 7b: 1,825.83 Total: 15,434.72	3a: 2,925.78 3b: 6,491.40 3c: 4,954.73 Total: 14,371.91	4a: 2,711.07 4b: 4,204.79 4c: 3,320.05 4d: 4,144.41 Total: 14,380.32	7a: 174.96 7b: 1,402.92 7c: 1,479.71 7d: 1,186.70 7e: 1,833.10 7f: 2,325.08 7g: 1,595.66 Total: 9,998.13
Hunting Zones	6,459.11	C1: 5,584.42 C2: 5,750.71	5,342.17	Low C3: 4,352.01 7b: 1,191.30 Total:	3a: 1,818.33 3b: 2,024.74 3c: 1,523.18 Total:	4a: 1,699.42 4b: 1,967.47 4c: 569.43 4d: 1,224.18	7a: 268.53 7b: 721.49 7c: 783.65 7d: 959.38

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				5,543.31	5,366.25	Total: 5,460.50	7e: 210.61 7f: 857.94 7g: 441.76 Total: 4,243.36
Trapline Areas	9,318.69	C1: 8,325.66 C2: 8,573.20	7,682.13	Low C3: 6,481.61 7b: 1,191.30 Total: 7,672.91	3a: 1,818.33 3b: 3,581.78 3c: 1,976.39 Total: 7,376.50	4a: 1,699.42 4b: 2,180.15 4c: 1,859.14 4d: 1,645.11 Total: 7,383.82	7a: 268.53 7b: 721.49 7c: 783.65 7d: 1,187.40 7e: 1,073.55 7f: 992.67 7g: 633.26 Total: 5,660.55
Cut Blocks	3.09	C1: 3.09 C2: 3.09	3.09	Low C3: 0.00 7b: 3.09 Total: 3.09	3a: 3.09 3b: 0.00 3c: 0.00 Total: 3.09	4a: 3.09 4b: 0.00 4c: 0.00 4d: 0.00 Total: 3.09	7a: 0.00 7b: 1.58 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 1.58
Old Growth Management Areas	0.00	C1: 0.00 C2: 0.00	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.00 4d: 0.00 Total: 0.00	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Timber Harvesting Land Base Class "C"	272.74	C1: 157.53 C2: 222.25	145.95	Low C3: 216.56 7b: 12.21 Total: 228.77	3a: 12.21 3b: 120.04 3c: 59.60 Total: 191.86	4a: 12.21 4b: 127.98 4c: 0.02 4d: 52.86 Total: 193.07	7a: 0.00 7b: 9.27 7c: 0.00 7d: 35.22 7e: 0.00 7f: 0.00 7g: 4.13 Total: 48.63
Timber Harvesting Land Base Class "N"	2,373.82	C1: 2,082.67 C2: 2,118.34	1,852.43	Low C3: 1,592.71 7b: 192.75 Total: 1,785.46	3a: 275.31 3b: 757.44 3c: 535.27 Total: 1,568.02	4a: 257.43 4b: 562.12 4c: 326.23 4d: 457.75 Total: 1,603.52	7a: 1.67 7b: 65.68 7c: 142.05 7d: 222.10 7e: 117.46 7f: 231.67 7g: 75.25 Total: 855.88
Timber Harvesting Land Base Class "P"	262.11	C1: 164.60 C2: 164.60	164.60	Low C3: 151.44 7b: 0.96 Total: 152.40	3a: 0.96 3b: 104.52 3c: 4.50 Total: 109.99	4a: 0.96 4b: 87.39 4c: 7.40 4d: 3.04 Total: 98.79	7a: 0.00 7b: 0.05 7c: 0.00 7d: 28.23 7e: 0.00 7f: 0.00 7g: 0.55 Total: 28.83
Timber Harvesting Land Base Class "X"	6,409.85	C1: 5,920.72 C2: 6,067.86	5,519.03	Low C3: 4,520.76 7b: 985.37 Total:	3a: 1,529.82 3b: 2,599.71 3c: 1,376.94 Total:	4a: 1,428.79 4b: 1,402.62 4c: 1,525.46 4d: 1,131.39	7a: 266.78 7b: 646.49 7c: 641.59 7d: 901.81

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				5,506.13	5,506.47	Total: 5,488.27	7e: 956.07 7f: 760.96 7g: 553.29 Total: 4,726.98
Recreational Reserves/Sites	44.50	C1: 44.50 C2: 44.50	38.36	Low C3: 40.76 7b: 2.16 Total: 42.92	3a: 2.16 3b: 32.94 3c: 7.67 Total: 42.77	4a: 2.16 4b: 3.23 4c: 28.66 4d: 7.67 Total: 41.72	7a: 0.00 7b: 1.91 7c: 3.23 7d: 0.00 7e: 5.63 7f: 2.27 7g: 3.25 Total: 16.29
Grazing Leases	176.07	C1: 176.07 C2: 176.07	176.07	Low C3: 26.69 7b: 0.00 Total: 26.69	3a: 0.00 3b: 19.63 3c: 0.00 Total: 19.63	4a: 0.00 4b: 27.39 4c: 0.00 4d: 0.00 Total: 27.39	7a: 0.00 7b: 0.00 7c: 0.04 7d: 1.70 7e: 0.00 7f: 0.00 7g: 0.00 Total: 1.74
- Area Affected by Transmission Line (ha)							
Proposed Protected Areas	0.00	C2: 47.61	27.11	13.64	92.42	91.22	0.00
Visual Landscape Inventory	910.23	C2: 938.26	920.54	675.98	1,325.27	1,538.04	1,250.91
Petroleum Titles	769.63	C2: 797.66	806.89	553.42	1,222.58	1,397.47	809.31
Oil and Gas Fields	173.48	C2: 200.42	219.92	92.96	377.99	412.85	279.95

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Property: BC Hydro Leased	0.00	C2: 0.00	0.00	0.00	0.00	0.00	36.93
Property: BC Hydro Owned	0.20	C2; 0.20	0.20	0.20	0.20	0.20	1.84
Property: Crown	3.93	C2: 45.47	55.51	22.01	68.25	72.74	138.62
Property: Private	0.00	C2: 0.00	0.00	0.00	0.00	0.00	527.89
Land Act Tenures	865.26	C2: 960.76	746.26	618.43	1,230.98	1,267.84	241.76
Hunting Zones	910.23	C2: 938.26	920.54	675.98	1,325.27	1,538.04	624.15
Trapline Areas	910.23	C2: 938.26	920.54	675.98	1,325.27	1,538.04	1,250.91
Cut Blocks	32.22	C2: 32.22	48.61	20.79	67.27	80.53	19.35
Old Growth Management Areas	23.89	C2: 23.89	23.89	16.71	52.15	64.56	0.00
Timber Harvesting Land Base Class "C"	311.15	C2: 311.29	304.21	179.63	491.94	563.72	63.38
Timber Harvesting Land Base Class "N"	119.52	C2: 122.76	105.06	100.85	248.41	325.57	90.79
Timber Harvesting Land Base Class "P"	6.53	C2: 19.08	47.84	9.70	38.90	43.95	23.78
Timber Harvesting Land Base Class "X"	473.04	C2: 485.13	463.44	385.80	546.02	604.81	1,072.96
Recreational Reserves/Sites	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
Grazing Leases	101.64	C2: 100.36	22.34	34.62	100.29	100.20	96.95
- Area Affected by Dam Footprint (ha)							
Proposed Protected Areas	87.16	C2: 152.73	248.32	Low C3: 99.73 7b: 28.35	3a: 146.76 3b: 67.19 3c: 101.92	4a: 101.01 4b: 133.97 4c: 127.29	7a: 10.51 7b: 19.56 7c: 8.34

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				Total: 128.08	Total: 315.88	4d: 101.90 Total: 464.17	7d: 20.08 7e: 51.87 7f: 93.19 7g: 32.44 Total: 236.00
Visual Landscape Inventory	1,010.57	C2: 1,537.95	381.55	Low C3: 1,025.46 7b: 87.38 Total: 1,112.84	3a: 356.81 3b: 287.20 3c: 1,028.87 Total: 1,672.88	4a: 260.33 4b: 310.19 4c: 431.25 4d: 1,028.99 Total: 2,030.75	7a: 172.50 7b: 135.61 7c: 178.01 7d: 164.02 7e: 245.96 7f: 194.92 7g: 215.95 Total: 1,306.96
Petroleum Titles	416.56	C2: 2,010.80	199.09	Low C3: 431.45 7b: 19.81 Total: 451.26	3a: 0.00 3b: 235.74 3c: 434.86 Total: 670.59	4a: 0.00 4b: 0.00 4c: 407.47 4d: 434.97 Total: 842.44	7a: 10.57 7b: 46.57 7c: 5.88 7d: 0.00 7e: 80.69 7f: 41.01 7g: 126.18 Total: 310.90
Oil and Gas Fields	0.00	C2: 0.00	0.00	Low C3: 216.88 7b: 0.00 Total: 216.88	3a: 0.00 3b: 169.49 3c: 216.88 Total: 386.37	4a: 0.00 4b: 0.00 4c: 221.40 4d: 216.88 Total: 438.27	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 107.33 7f: 0.00 7g: 16.24

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							Total: 123.57
Property: BC Hydro Leased	146.56	C2: 0.00	0.00	Low C3: 147.16 7b: 7.22 Total: 154.38	3a: 40.09 3b: 0.00 3c: 147.67 Total: 187.76	4a: 75.70 4b: 163.07 4c: 264.62 4d: 147.67 Total: 651.06	7a: 2.44 7b: 13.70 7c: 0.00 7d: 110.13 7e: 16.52 7f: 0.00 7g: 35.31 Total: 178.11
Property: BC Hydro Owned	55.53	C2: 44.11	0.00	Low C3: 55.53 7b: 0.00 Total: 55.53	3a: 0.00 3b: 0.00 3c: 55.53 Total: 55.53	4a: 0.00 4b: 0.21 4c: 0.00 4d: 55.53 Total: 55.74	7a: 0.47 7b: 0.00 7c: 0.00 7d: 1.76 7e: 0.00 7f: 0.00 7g: 47.27 Total: 49.50
Property: Crown	37.47	C2: 1,136.26	224.77	Low C3: 51.86 7b: 27.91 Total: 79.77	3a: 200.52 3b: 171.98 3c: 54.58 Total: 427.09	4a: 124.56 4b: 116.23 4c: 135.58 4d: 54.76 Total: 431.13	7a: 4.87 7b: 15.32 7c: 5.87 7d: 6.54 7e: 101.92 7f: 91.28 7g: 27.43 Total: 253.23
Property: Private	179.11	C2: 274.46	101.56	Low C3: 179.11 7b: 77.44	3a: 96.73 3b: 101.14 3c: 179.11	4a: 43.65 4b: 2.51 4c: 0.09	7a: 40.06 7b: 83.28 7c: 148.10

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				Total: 256.55	Total: 376.98	4d: 179.11 Total: 225.36	7d: 28.59 7e: 115.80 7f: 91.54 7g: 12.02 Total: 519.37
Land Act Tenures	1,617.21	C2: 1,045.21	578.67	Low C3: 1,675.52 7b: 66.10 Total: 1,741.62	3a: 366.06 3b: 453.52 3c: 1,688.48 Total: 2,508.07	4a: 242.53 4b: 337.98 4c: 307.43 4d: 1,688.88 Total: 2,576.81	7a: 17.80 7b: 67.73 7c: 27.59 7d: 71.86 7e: 346.53 7f: 197.44 7g: 361.01 Total: 1,089.97
Hunting Zones	617.83	C2: 1,155.62	234.98	Low C3: 632.63 7b: 87.38 Total: 720.01	3a: 356.81 3b: 83.52 3c: 636.04 Total: 1,076.37	4a: 260.33 4b: 97.66 4c: 135.08 4d: 120.79 Total: 613.84	7a: 172.50 7b: 135.61 7c: 178.01 7d: 4.23 7e: 45.28 7f: 84.15 7g: 114.59 Total: 734.36
Trapline Areas	1,010.57	C2: 1,537.95	381.55	Low C3: 1,025.46 7b: 87.38 Total: 1,112.84	3a: 356.81 3b: 287.20 3c: 1,028.87 Total: 1,672.88	4a: 260.33 4b: 310.19 4c: 431.25 4d: 1,028.99 Total: 2,030.75	7a: 172.50 7b: 135.61 7c: 178.01 7d: 164.02 7e: 245.96 7f: 194.92 7g: 215.95

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							Total: 1,306.96
Cut Blocks	0.00	C2: 68.75	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 37.45 3b: 0.00 3c: 0.00 Total: 37.45	4a: 24.62 4b: 0.00 4c: 0.00 4d: 0.00 Total: 24.62	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
Old Growth Management Areas	216.88	C2: 1,495.40	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.00 4d: 0.00 Total: 0.00	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
Timber Harvesting Land Base Class "C"	423.81	C2: 103.22	76.15	Low C3: 429.68 7b: 0.00 Total: 429.68	3a: 0.00 3b: 0.00 3c: 429.97 Total: 429.97	4a: 90.00 4b: 0.06 4c: 0.00 4d: 429.97 Total: 520.03	7a: 2.30 7b: 0.00 7c: 0.90 7d: 0.10 7e: 0.15 7f: 25.45 7g: 60.50 Total: 89.41
Timber Harvesting Land Base Class "N"	112.02	C2: 30.52	132.24	Low C3: 120.43 7b: 0.06	3a: 138.48 3b: 142.53 3c: 122.78	4a: 0.00 4b: 101.78 4c: 109.03	7a: 3.17 7b: 0.01 7c: 4.82

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				Total: 120.49	Total: 403.78	4d: 122.94 Total: 333.75	7d: 9.04 7e: 88.35 7f: 62.95 7g: 35.56 Total: 203.88
Timber Harvesting Land Base Class "P"	3.01	C2: 481.32	0.00	Low C3: 3.01 7b: 0.00 Total: 3.01	3a: 0.00 3b: 0.00 3c: 3.01 Total: 3.01	4a: 0.00 4b: 4.20 4c: 0.77 4d: 3.01 Total: 7.98	7a: 0.35 7b: 0.00 7c: 15.06 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.09 Total: 15.49
Timber Harvesting Land Base Class "X"	471.70	C2: 922.89	173.16	Low C3: 472.32 7b: 87.32 Total: 559.64	3a: 218.34 3b: 144.67 3c: 473.08 Total: 836.09	4a: 170.32 4b: 204.15 4c: 321.45 4d: 473.03 Total: 1,168.95	7a: 166.68 7b: 135.60 7c: 157.24 7d: 154.88 7e: 157.45 7f: 106.51 7g: 119.80 Total: 998.17
Recreational Reserves/Sites	1.84	C2: 0.00	0.00	Low C3: 1.84 7b: 0.00 Total: 1.84	3a: 0.00 3b: 0.00 3c: 1.84 Total: 1.84	4a: 0.00 4b: 0.00 4c: 0.00 4d: 434.97 Total: 434.97	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 7.04 7f: 0.00 7g: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							Total: 7.04
Grazing Leases	120.79	C2: 0.00	0.00	Low C3: 120.79 7b: 0.00 Total: 120.79	3a: 58.04 3b: 0.00 3c: 120.79 Total: 178.83	4a: 35.36 4b: 0.00 4c: 0.00 4d: 120.79 Total: 156.15	7a: 0.00 7b: 0.00 7c: 4.78 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 4.78
- Area Affected by Highway Re-Alignment (ha)							
Proposed Protected Areas							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
Visual Landscape Inventory							
o Bear Flat	36.22	C2: 36.22	36.22	14.79	15.08	5.26	5.80
o Farrell Creek	12.33	C2: 12.33	12.33	13.16	12.31	12.31	3.31
o Halfway River	22.46	C2: 22.46	22.46	22.89	8.17	6.38	10.15
o Lynx Creek	40.35	C2: 40.35	40.35	42.96	40.35	40.35	33.45
o Total	111.37	C2: 111.37	111.37	93.81	75.90	64.30	52.71
Petroleum Tiles							
o Bear Flat	28.99	C2: 28.99	28.99	7.68	0.00	0.00	0.0
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	22.25	C2: 22.25	22.25	22.15	22.25	22.25	14.07
o Total	51.25	C2: 51.25	51.25	29.83	22.25	22.25	14.07
Oil and Gas Fields							
o Bear Flat	4.34	C2: 4.34	4.34	2.97	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	4.34	C2: 4.34	4.34	2.97	0.00	0.00	0.00
Property: BC Hydro Leased							
o Bear Flat	6.92	C2: 6.92	6.92	5.93	10.45	2.41	2.91
o Farrell Creek	1.66	C2: 1.66	1.66	1.89	1.66	1.66	0.39
o Halfway River	9.38	C2: 9.38	9.38	9.65	4.31	2.33	4.39
o Lynx Creek	9.91	C2: 9.91	9.91	9.80	9.90	9.90	7.26.
o Total	27.86	C2: 27.86	27.86	27.27	26.32	16.30	14.95
Property BC Hydro: Owned							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.0
o Halfway River	0.67	C2: 0.67	0.67	0.67	0.00	0.00	0.00
o Lynx Creek	0.27	C2: 0.27	0.27	0.27	0.27	0.27	0.67
o Total	0.94	C2: 0.94	0.94	0.94	0.27	0.27	0.67
Property: Crown							
o Bear Flat	2.34	C2: 2.34	2.34	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Halfway River	7.49	C2: 7.49	7.49	7.61	3.64	3.98	5.09
o Lynx Creek	0.75	C2: 0.75	0.75	0.77	0.75	0.75	0.19
o Total	10.58	C2: 10.58	10.58	8.39	4.39	4.73	5.28
Property: Private							
o Bear Flat	25.38	C2: 25.38	25.38	6.92	2.86	0.67	0.28
o Farrell Creek	6.58	C2: 6.58	6.58	6.60	6.58	6.58	0.02
o Halfway River	2.54	C2: 2.54	2.54	2.54	0.00	0.00	0.00
o Lynx Creek	21.67	C2: 21.67	21.67	21.43	21.67	21.67	17.98
o Total	56.17	C2: 56.17	56.17	37.50	31.11	28.92	18.28
Land Act Tenures							
o Bear Flat	0.14	C2: 0.14	0.14	9.29	14.23	5.24	2.80
o Farrell Creek	0.00	C2: 0.00	0.00	0.71	0.00	0.00	2.58
o Halfway River	7.28	C2: 7.28	7.28	7.67	10.21	7.49	12.54
o Lynx Creek	2.04	C2: 2.04	2.04	5.40	2.03	2.03	4.52
o Total	9.45	C2: 9.45	9.45	23.07	26.48	14.77	25.44
Hunting Zones							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	12.33	C2: 12.33	12.33	13.16	12.31	12.31	3.31
o Halfway River	5.37	C2: 5.37	5.37	5.23	6.78	5.95	8.71
o Lynx Creek	40.35	C2: 40.35	40.35	42.96	40.35	40.35	33.45
o Total	58.05	C2: 58.05	58.05	61.35	59.44	58.60	45.47
Trapline Areas							
o Bear Flat	36.22	C2: 36.22	36.22	14.79	15.08	5.26	5.80
o Farrell Creek	12.33	C2: 12.33	12.33	13.16	12.31	12.31	3.31
o Halfway River	22.46	C2: 22.46	22.46	22.89	8.17	6.38	10.15
o Lynx Creek	40.35	C2: 40.35	40.35	42.96	40.35	40.35	33.45
o Total	111.37	C2: 111.37	111.37	93.81	75.90	64.30	52.71

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Cut Blocks							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
Old Growth Management Areas							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
Timber Harvesting Land Base Class “C”							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
Timber Harvesting Land Base Class “N”							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.24	C2: 0.24	0.24	0.32	0.00	0.12	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.24	C2: 0.24	0.24	0.32	0.00	0.12	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Timber Harvesting Land Base Class "P"							
o Bear Flat	2.53	C2: 2.53	2.53	0.05	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.25	C2: 0.25	0.25	0.25.	0.00	0.26	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	2.79	C2: 2.79	2.79	0.30	0.00	0.26	0.00
Timber Harvesting Land Base Class "X"							
o Bear Flat	33.69	C2: 33.69	33.69	14.74	15.08	5.26	5.80
o Farrell Creek	12.33	C2: 12.33	12.33	13.16	12.31	12.31	3.31
o Halfway River	21.97	C2: 21.97	21.97	22.32	8.17	6.00	10.15
o Lynx Creek	40.35	C2: 40.35	40.35	42.96	40.35	40.35	33.45
o Total	108.34	C2: 108.34	108.34	93.19	75.90	63.92	52.71
Recreational Reserves/Sites							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
Grazing Leases							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
TEM (Terrestrial Ecosystem Mapping) Data (detailed Peace River/existing transmission line corridor)							
- Area Affected by Reservoirs (ha)							
TEM -AM:ap - Creamy peavine (seral association) (01) Majority	961.62	C1: 726.47 C2: 836.33	630.17	Low C3: 459.80 7b: 105.26 Total: 565.07	3a: 187.87 3b: 82.74 3c: 244.00 Total: 514.62	4a: 175.98 4b: 68.45 4c: 74.49 4d: 218.26 Total: 537.19	7a: 1.56 7b: 51.18 7c: 26.38 7d: 9.83 7e: 25.30 7f: 82.59 7g: 24.38 Total: 221.22
TEM -AM:ap - Creamy peavine (seral association) (01) Minority	148.74	C1: 125.52 C2: 125.52	125.52	Low C3: 70.86 7b: 25.70 Total: 96.56	3a: 54.37 3b: 46.35 3c: 7.22 Total: 107.94	4a: 50.35 4b: 20.70 4c: 31.41 4d: 2.32 Total: 104.78	7a: 1.36 7b: 6.61 7c: 9.18 7d: 2.75 7e: 11.71 7f: 0.56 7g: 0.16 Total: 32.33
TEM - CB - cutbank (00) Majority	157.45	C1: 142.92 C2: 148.43	131.67	Low C3: 89.09 7b: 10.74 Total: 99.83	3a: 15.21 3b: 45.35 3c: 17.09 Total: 77.65	4a: 15.21 4b: 14.60 4c: 21.15 4d: 11.73 Total: 62.70	7a: 5.81 7b: 0.99 7c: 4.08 7d: 6.35 7e: 7.22 7f: 6.44 7g: 2.24 Total: 33.14

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
TEM - CB - cutbank (00) Minority	113.78	C1: 100.13 C2: 103.23	90.53	Low C3: 52.87 7b: 16.81 Total: 69.68	3a: 20.08 3b: 30.78 3c: 7.55 Total:58.41	4a: 19.94 4b: 18.87 4c: 12.64 4d: 4.69 Total: 56.14	7a: 0.00 7b: 8.80 7c: 0.04 7d: 5.34 7e: 5.02 7f: 0.32 7g: 1.39 Total: 20.92
TEM - CF - Cultivated field (00) Majority	537.90	C1: 531.97 C2: 531.97	531.39	Low C3: 320.81 7b: 38.79 Total: 359.60	3a: 68.01 3b: 299.75 3c: 5.64 Total: 373.40	4a: 65.74 4b: 46.78 4c: 254.61 4d: 4.13 Total: 371.27	7a: 4.84 7b: 8.80 7c: 30.03 7d: 55.93 7e: 125.48 7f: 1.75 7g: 10.39 Total: 237.22
TEM - CF - Cultivated field (00) Minority	140.41	C1: 140.41 C2: 140.41	140.41	Low C3: 100.56 7b: 18.60 Total: 119.16	3a: 26.51 3b: 96.80 3c: 0.00 Total: 123.31	4a: 20.06 4b: 92.86 4c: 7.64 4d: 0.00 Total:120.56	7a: 0.00 7b: 1.26 7c: 3.41 7d: 20.16 7e: 7.61 7f: 0.00 7g: 0.00 Total: 32.45
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Majority	1,095.91	C1: 926.46 C2: 930.45	784.25	Low C3: 986.30 7b: 39.53 Total:	3a: 114.43 3b: 466.42 3c: 369.79 Total: 950.64	4a: 107.76 4b: 133.63 4c: 406.52 4d: 316.52	7a: 9.06 7b: 38.18 7c: 71.19 7d: 70.85

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
				1,025.83		Total: 964.43	7e: 237.33 7f: 165.49 7g: 92.02 Total: 684.13
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Minority	333.00	C1: 323.10 C2: 323.10	323.10	Low C3: 196.99 7b: 49.57 Total: 246.56	3a: 49.57 3b: 161.29 3c: 25.60 Total: 236.46	4a: 49.57 4b: 109.16 4c: 72.52 4d: 25.62 Total: 256.88	7a: 23.70 7b: 18.51 7c: 44.82 7d: 4.83 7e: 55.00 7f: 20.53 7g: 23.09 Total: 190.47
TEM - GB - Gravel bar (00) Majority	728.65	C1: 727.69 C2: 728.65	602.72	Low C3: 581.84 7b: 141.77 Total: 723.62	3a: 186.30 3b: 341.12 3c: 196.31 Total: 723.73	4a: 183.30 4b: 228.25 4c: 132.61 4d: 178.20 Total: 722.36	7a: 28.69 7b: 108.17 7c: 96.12 7d: 186.78 7e: 88.22 7f: 104.88 7g: 80.53 Total: 693.39
TEM - GB - Gravel bar (00) Minority	495.37	C1: 443.40 C2: 447.38	425.49	Low C3: 393.29 7b: 15.58 Total: 408.87	3a: 19.20 3b: 193.62 3c: 187.78 Total: 400.60	4a: 19.20 4b: 86.84 4c: 142.89 4d: 173.05 Total: 421.98	7a: 8.22 7b: 8.88 7c: 1.92 7d: 12.40 7e: 127.86 7f: 120.83 7g: 67.04 Total: 347.16

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
TEM - SE - Sedge wetland (09) Majority	56.09	C1: 56.09 C2: 56.09	56.09	Low C3: 0.00 7b: 0.0 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.00 4d: 0.00 Total: 0.00	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
TEM - SE - Sedge wetland (09) Minority	46.42	C1: 46.42 C2: 46.42	46.39	Low C3: 28.39 7b: 0.00 Total: 28.39	3a: 0.00 3b: 1.73 3c: 10.59 Total: 12.32	4a: 0.00 4b: 7.78 4c: 15.80 4d: 2.05 Total: 25.63	7a: 0.00 7b: 0.00 7c: 4.29 7d: 0.00 7e: 0.00 7f: 8.64 7g: 0.00 Total: 12.93
TEM - SH:ac - Cow parsnip (seral association) (07) Majority	376.38	C1: 352.02 C2: 352.02	347.19	Low C3: 273.03 7b: 17.65 Total: 290.68	3a: 32.16 3b: 183.42 3c: 59.18 Total: 274.77	4a: 32.16 4b: 214.77 4c: 1.75 4d: 57.89 Total: 306.57	7a: 0.00 7b: 15.39 7c: 19.72 7d: 55.54 7e: 0.00 7f: 57.25 7g: 0.07 Total: 147.97
TEM - SH:ac - Cow parsnip (seral association) (07) Minority	159.40	C1: 73.26 C2: 124.60	72.10	Low C3: 149.11 7b: 0.00 Total: 149.11	3a: 12.47 3b: 2.44 3c: 144.27 Total: 159.18	4a: 12.47 4b: 0.00 4c: 14.13 4d: 131.36	7a: 0.00 7b: 0.00 7c: 1.58 7d: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
						Total: 157.96	7e: 0.00 7f: 47.70 7g: 9.33 Total: 58.61
TEM - WS - Willow sedge (00) Majority	29.52	C1: 29.52 C2: 29.52	29.52	Low C3: 13.78 7b: 0.00 Total: 13.78	3a: 0.00 3b: 0.69 3c: 12.56 Total: 13.25	4a: 0.00 4b: 0.00 4c: 2.94 4d: 8.74 Total: 11.68	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 10.94 7g: 0.00 Total: 10.94
TEM - WS - Willow sedge (00) Minority	5.16	C1: 5.16 C2: 5.16	5.16	Low C3: 4.95 7b: 0.00 Total: 4.95	3a: 0.00 3b: 4.66 3c: 0.00 Total: 4.66	4a: 0.00 4b: 5.14 4c: 0.00 4d: 0.00 Total: 5.14	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
TEM - SH:sw - Currant-horsetail (07) Majority	0.00	C1: 0.00 C2: 0.00	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.00 4d: 0.00 Total: 0.00	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7f: 0.00 Total: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
TEM - SH:sw - Currant-horsetail (07) Minority	0.00	C1: 0.00 C2: 0.00	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.00 4d: 0.00 Total: 0.00	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7f: 0.00 Total: 0.00
- Area Affected by Transmission Line (ha)							
TEM -AM:ap - Creamy peavine (seral association) (01) Majority	413.30	C2: 428.68	382.12	257.01	445.13	441.18	114.89
TEM -AM:ap - Creamy peavine (seral association) (01) Minority	29.09	C2: 28.20	23.66	13.21	29.03	30.55	27.77
TEM - CB - cutbank (00) Majority	0.64	C2: 0.64	0.64	0.64	0.64	0.73	15.80
TEM - CB - cutbank (00) Minority	1.96	C2: 5.24	1.96	2.41	1.96	3.45	20.52
TEM - CF - Cultivated field (00) Majority	39.43	C2: 39.43	39.89	36.19	40.82	44.82	248.75
TEM - CF - Cultivated field (00) Minority	1.52	C2: 1.52	1.52	1.52	1.52	1.52	9.88
TEM - FM02: - Cottonwood-spruce-	0.00	C2: 2.07	0.00	0.00	0.00	0.00	3.92

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
red-osier dogwood (09) Majority							
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Minority	0.00	C2: 0.00	0.00	0.00	0.00	0.00	4.68
TEM - GB - Gravel bar (00) Majority	0.00	C2: 0.00	0.00	0.00	0.00	0.00	2.20
TEM - GB - Gravel bar (00) Minority	0.00	C2: 1.09	0.00	0.00	0.00	0.00	4.68
TEM - SE - Sedge wetland (09) Majority	35.57	C2: 35.68	19.02	18.34	35.79	35.77	0.00
TEM - SE - Sedge wetland (09) Minority	20.12	C2: 38.86	8.12	14.21	35.04	33.66	0.00
TEM - SH:ac - Cow parsnip (seral association) (07) Majority	8.54	C2: 10.40	8.54	3.90	8.54	8.54	6.79
TEM - SH:ac - Cow parsnip (seral association) (07) Minority	0.63	C2: 0.63	0.63	0.63	0.63	0.63	4.39
TEM - WS - Willow sedge (00) Majority	5.08	C2: 5.08	5.08	2.67	5.08	5.08	0.00
TEM - WS - Willow sedge (00) Minority	5.83	C2: 5.83	5.83	2.71	5.83	6.34	0.00
TEM - SH:sw -	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Currant-horsetail (07) Majority							
TEM - SH:sw - Currant-horsetail (07) Minority	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
- Area Affected by Dam Footprint (ha)							
TEM -AM:ap - Creamy peavine (seral association) (01) Majority	598.14	C2: 433.40	121.35	Low C3: 610.16 7b: 19.10 Total: 629.26	3a: 80.04 3b: 103.74 3c: 612.29 Total: 796.07	4a: 57.44 4b: 25.87 4c: 25.61 4d: 612.33 Total: 721.26	7a: 55.55 7b: 46.05 7c: 11.60 7d: 5.01 7e: 48.73 7f: 43.66 7g: 116.76 Total: 327.35
TEM -AM:ap - Creamy peavine (seral association) (01) Minority	29.13	C2: 22.31	28.34	Low C3: 29.13 7b: 19.10 Total: 48.23	3a: 122.18 3b: 1.29 3c: 29.13 Total: 152.59	4a: 65.93 4b: 0.00 4c: 7.34 4d: 29.13 Total: 102.40	7a: 1.47 7b: 25.33 7c: 4.63 7d: 3.33 7e: 13.92 7f: 20.34 7g: 29.13 Total: 98.15
TEM - CB - cutbank (00) Majority	11.84	C2: 1.05	0.00	Low C3: 12.93 7b: 0.00 Total: 12.93	3a: 1.96 3b: 0.00 3c: 13.72 Total: 15.69	4a: 0.00 4b: 15.45 4c: 7.00 4d: 13.75 Total: 36.20	7a: 1.79 7b: 0.00 7c: 2.55 7d: 6.67 7e: 0.35

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							7f: 0.00 7g: 4.40 Total: 15.77
TEM - CB - cutbank (00) Minority	30.65	C2: 22.75	0.00	Low C3: 30.65 7b: 0.34 Total: 30.99	3a: 2.16 3b: 3.94 3c: 30.65 Total: 36.74	4a: 0.00 4b: 14.58 4c: 13.83 4d: 30.65 Total: 59.06	7a: 0.76 7b: 0.00 7c: 0.00 7d: 0.39 7e: 0.00 7f: 0.00 7g: 15.52 Total: 16.67
TEM - CF - Cultivated field (00) Majority	75.89	C2: 189.94	86.62	Low C3: 77.60 7b: 41.27 Total: 118.87	3a: 49.61 3b: 40.57 3c: 77.71 Total: 167.89	4a: 50.43 4b: 148.52 4c: 177.75 4d: 77.69 Total: 454.40	7a: 88.16 7b: 63.57 7c: 74.08 7d: 119.13 7e: 108.33 7f: 67.89 7g: 39.53 Total: 560.68
TEM - CF - Cultivated field (00) Minority	22.90	C2: 4.34	0.00	Low C3: 22.90 7b: 1.74 Total: 24.64	3a: 0.91 3b: 0.00 3c: 22.90 Total: 23.80	4a: 6.10 4b: 0.20 4c: 0.00 4d: 22.90 Total: 29.21	7a: 0.00 7b: 0.00 7c: 28.77 7d: 0.20 7e: 0.00 7f: 0.00 7g: 0.00 Total: 28.97
TEM - FM02: -	18.11	C2: 3.39	10.64	Low C3: 18.11	3a: 0.00	4a: 0.74	7a: 0.93

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
Cottonwood-spruce-red-osier dogwood (09) Majority				7b: 0.17 Total: 18.28	3b: 0.00 3c: 18.12 Total: 18.12	4b: 0.75 4c: 1.56 4d: 18.11 Total: 21.15	7b: 7.82 7c: 0.00 7d: 5.96 7e: 0.25 7f: 6.23 7g: 7.89 Total: 29.08
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Minority	26.49	C2: 0.00	0.00	Low C3: 26.40 7b: 0.00 Total: 26.40	3a: 0.24 3b: 0.00 3c: 26.52 Total: 26.76	4a: 0.00 4b: 0.00 4c: 0.32 4d: 26.49 Total: 26.81	7a: 0.00 7b: 0.00 7c: 0.76 7d: 1.09 7e: 0.34 7f: 0.00 7g: 6.01 Total: 8.20
TEM - GB - Gravel bar (00) Majority	0.51	C2: 0.00	15.08	Low C3: 0.51 7b: 0.34 Total: 0.85	3a: 0.25 3b: 1.49 3c: 0.51 Total: 2.25	4a: 0.00 4b: 0.99 4c: 4.13 4d: 0.51 Total: 5.63	7a: 1.56 7b: 0.00 7c: 1.96 7d: 1.42 7e: 0.00 7f: 6.30 7g: 0.00 Total: 11.24
TEM - GB - Gravel bar (00) Minority	3.79	C2: 3.23	1.56	Low C3: 3.79 7b: 0.00 Total: 3.79	3a: 0.00 3b: 0.00 3c: 3.80 Total: 3.80	4a: 0.00 4b: 0.00 4c: 0.77 4d: 3.79 Total: 4.56	7a: 0.00 7b: 0.57 7c: 0.00 7d: 0.16 7e: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							7f: 0.00 7g: 6.01 Total: 6.74
TEM - SE - Sedge wetland (09) Majority	0.00	C2: 12.99	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 13.62 3c: 0.00 Total: 13.62	4a: 0.00 4b: 0.00 4c: 0.00 4d: 0.00 Total: 0.00	7a: 0.84 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.84
TEM - SE - Sedge wetland (09) Minority	4.00	C2: 110.00	0.00	Low C3: 4.00 7b: 0.00 Total: 4.00	3a: 0.00 3b: 0.00 3c: 4.00 Total: 4.00	4a: 0.00 4b: 0.00 4c: 1.10 4d: 4.00 Total: 5.10	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 16.61 7f: 0.00 7g: 0.00 Total: 16.61
TEM - SH:ac - Cow parsnip (seral association) (07) Majority	0.00	C2: 0.00	2.61	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.74 4d: 0.00 Total: 0.74	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
TEM - SH:ac - Cow	0.41	C2: 25.41	0.00	Low C3: 0.41	3a: 0.00	4a: 0.00	7a: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
parsnip (seral association) (07) Minority				7b: 0.00 Total: 0.41	3b: 3.95 3c: 0.41 Total: 4.35	4b: 0.00 4c: 0.00 4d: 0.41 Total: 0.41	7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.37 7f: 0.00 7g: 2.31 Total: 2.68
TEM - WS - Willow sedge (00) Majority	0.00	C2: 0.00	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.74 4d: 0.00 Total: 0.74	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
TEM - WS - Willow sedge (00) Minority	0.00	C2: 2.88	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.74 4d: 0.00 Total: 0.74	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
TEM - SH:sw - Currant-horsetail (07) Majority	0.00	C2: 0.00	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.74 4d: 0.00 Total: 0.74	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
							7f: 0.00 7g: 0.00 Total: 0.00
TEM - SH:sw - Currant-horsetail (07) Minority	0.00	C2: 0.00	0.00	Low C3: 0.00 7b: 0.00 Total: 0.00	3a: 0.00 3b: 0.00 3c: 0.00 Total: 0.00	4a: 0.00 4b: 0.00 4c: 0.74 4d: 0.00 Total: 0.74	7a: 0.00 7b: 0.00 7c: 0.00 7d: 0.00 7e: 0.00 7f: 0.00 7g: 0.00 Total: 0.00
- Area Affected by Highway Realignment (ha)							
TEM -AM:ap - Creamy peavine (seral association) (01) Majority							
o Bear Flat	12.66	C2: 12.66	12.66	3.68	5.57	1.28	1.37
o Farrell Creek	1.47	C2: 1.47	1.47	1.63	1.47	1.47	0.48
o Halfway River	1.05	C2: 1.05	1.05	1.05	0.00	0.00	0.00
o Lynx Creek	15.41	C2: 15.41	15.41	16.77	15.41	15.41	15.43
o Total	30.59	C2: 30.59	30.59	23.13	22.44	18.16	17.28
TEM -AM:ap - Creamy peavine (seral association) (01) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.29	2.03	1.90
o Farrell Creek	5.03	C2: 5.03	5.03	5.02	5.01	5.01	0.50

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	2.81	C2: 2.81	2.81	2.81	2.81	2.81	1.63
o Total	7.84	C2: 7.84	7.84	7.83	8.11	9.85	4.03
TEM - CB - cutbank (00) Majority							
o Bear Flat	0.01	C2: 0.01	0.01	0.03	0.55	3.00	2.94
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.56
o Halfway River	0.54	C2: 0.54	0.54	0.92	0.05	0.06	0.09
o Lynx Creek	2.90	C2: 2.90	2.90	2.90	2.90	2.90	2.90
o Total	3.46	C2: 3.46	3.46	3.86	3.50	5.97	6.50
TEM - CB - cutbank (00) Minority							
o Bear Flat	0.14	C2: 0.14	0.14	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.56	0.04	0.70
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.23
o Total	0.14	C2: 0.14	0.14	0.00	0.56	0.04	0.94
TEM - CF - Cultivated field (00) Majority							
o Bear Flat	12.48	C2: 12.48	12.48	8.73	7.82	0.78	1.32
o Farrell Creek	6.44	C2: 6.44	6.44	6.48	6.44	6.44	0.77
o Halfway River	14.41	C2: 14.41	14.41	14.41	7.41	4.04	9.10
o Lynx Creek	12.72	C2: 12.72	12.72	12.46	12.72	12.72	8.25
o Total	46.04	C2: 46.04	46.04	42.07	34.39	23.97	19.45
TEM - CF - Cultivated field (00) Minority							
o Bear Flat	8.36	C2: 8.36	8.36	0.86	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Farrell Creek	0.19	C2: 0.19	0.19	0.34	0.19	0.19	0.48
o Halfway River	0.00	C2: 0.00	0.00	0.01	0.00	0.00	0.00
o Lynx Creek	2.46	C2: 2.46	2.46	2.46	2.46	2.46	4.64
o Total	11.01	C2: 11.01	11.01	3.66	2.65	2.65	5.12
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Majority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.41	0.00	0.00	0.54
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.10
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.41	0.00	0.00	0.64
TEM - FM02: - Cottonwood-spruce-red-osier dogwood (09) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
TEM - GB - Gravel bar (00) Majority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.04	0.00	0.00	0.00
o Halfway River	0.04	C2: 0.04	0.04	0.04	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.04	C2: 0.04	0.04	0.08	0.00	0.00	0.00
TEM - GB - Gravel bar (00) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
TEM - SE - Sedge wetland (09) Majority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.11	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.11	0.00	0.00
TEM - SE - Sedge wetland (09) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
TEM - SH:ac - Cow parsnip (seral association) (07) Majority							

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.02	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.02	0.00	0.00	0.00
TEM - SH:ac - Cow parsnip (seral association) (07) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.01	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.01	0.00	0.00	0.00
TEM - WS - Willow sedge (00) Majority							
o Bear Flat	0.00	C2: 0.00	0.00	0.02	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.02	0.00	0.00	0.00
TEM - WS - Willow sedge (00) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
TEM - SH:sw - Currant-horsetail (07) Majority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.48	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.48	0.00	0.00
TEM - SH:sw - Currant-horsetail (07) Minority							
o Bear Flat	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Farrell Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Halfway River	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Lynx Creek	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
o Total	0.00	C2: 0.00	0.00	0.00	0.00	0.00	0.00
TEM (Terrestrial Ecosystem Mapping) Data (1:50,000 biophysical mapping of the Lower Halfway area)							
- Area Affected by Transmission Line (ha)							
TEM -AM:ap - Creamy peavine (seral association) (01) Majority	N/A	N/A	N/A	N/A	N/A	N/A	295.08
TEM -AM:ap - Creamy peavine (seral association) (01) Minority	N/A	N/A	N/A	N/A	N/A	N/A	433.10

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				7b and Low C3	3 dam	4 dam	7 dam
TEM - CB - cutbank (00) Majority	N/A	N/A	N/A	N/A	N/A	N/A	6.30
TEM - CB - cutbank (00) Minority	N/A	N/A	N/A	N/A	N/A	N/A	40.54
TEM - CF - Cultivated field (00) Majority	N/A	N/A	N/A	N/A	N/A	N/A	129.46
TEM - SE - Sedge wetland (09) Majority	N/A	N/A	N/A	N/A	N/A	N/A	16.03
TEM - SE - Sedge wetland (09) Minority	N/A	N/A	N/A	N/A	N/A	N/A	93.02
TEM (Terrestrial Ecosystem Mapping) Data (1:50,000 biophysical mapping of the Fort St. John East and Pine-Moberly areas)							
- Area Affected by Transmission Line (ha)							
TEM -AM:ap - Creamy peavine (seral association) (01) Majority	0.00	C2: 0.33	20.85	13.80	122.40	140.08	0.00
TEM -AM:ap - Creamy peavine (seral association) (01) Minority	0.00	C2: 0.00	0.00	0.00	20.78	153.19	4.74
TEM - CF - Cultivated field (00) Majority	0.00	C2: 0.00	0.00	0.00	0.00	38.99	11.18
TEM - SE - Sedge wetland (09) Majority	0.00	C2: 0.00	5.50	0.00	16.80	43.02	0.00
TEM - SE - Sedge wetland (09) Minority	0.00	C2: 0.00	11.46	10.55	42.00	18.48	0.00

Appendix B

Physical Environment Matrix

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Physical Environment

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
CONSTRUCTION - Cofferdams, tunnels and borrow/disposal areas - Hwy 29 relocation, bridges and access roads - Dam, powerhouse and transmission line construction - Reservoir clearing and filling							
Geological Environment - Construction							
Physiography Reservoir filling resulting in loss or alteration of Peace River physiographic features	[2]The Peace River valley has formed through progressive down-cutting of the glacial overburden and underlying sedimentary rock by the flow of water. This has resulted in a broad, flat bottomed river valley up to 230 m below the top of the surrounding plain, which is part of the Alberta Plateau [Interior Plains] physiographic region. C3 reservoir would flood a land area of 6,183 ha possibly resulting in the loss or alteration of some of the existing physiographic features along a 85 km section of the Peace River valley by flooding low lying terraces and islands.	C1 reservoir would flood 5,475 ha of land (11% < C3). The C2 reservoir 5,619 ha of land (9% < C3). C1 or C2 reservoir would inundate a 79 km and 81 km section of Peace River valley (6 and 4 km < C3). Moberly River physiography would not be altered (i.e., flooded). Assumed slightly less potential to affect (i.e., inundate) physiographic features based on less inundation area and length.	Wilder reservoir would flood 5,032 ha of land (19% < C3). Wilder reservoir would inundate 73 km section of Peace River valley ((12 km < C3). Moberly River physiography would not be altered (i.e., flooded). Assumed moderately less potential to affect physiographic features based on less inundation area and length of flooding.	7b and Low C3 reservoirs would flood 4,629 ha of land (25% < C3). 7b and Low C3 reservoirs would inundate 85 km section of Peace River (similar to C3). Low C3 reservoir depth would be less than C3. Assumed less potential to affect physiographic features based on less inundation area and depth of flooding.	3 cascade reservoirs would flood 4,351 ha of land (30% < C3). 3 cascade reservoirs would inundate 85 km section of Peace River (similar to C3). Cascade reservoir depths would be less than C3. Assumed less potential to affect physiographic features based on less inundation area and depth of flooding.	4 cascade reservoirs would flood 4,358 ha of land (30% < C3). 4 cascade reservoirs would inundate 85 km section of Peace River (similar to C3). Cascade reservoir depths would be less than C3. Assumed less potential to affect physiographic features based on less inundation area and depth of flooding.	7 cascade reservoirs would flood 2,737 ha of land (56% < C3). 7 cascade reservoirs would inundate 85 km section of Peace River (similar to C3). Cascade reservoir depths would be less than C3. Assumed moderately less potential to affect physiographic features based on less inundation area and depth of flooding.
Topography Dam facility and associated infrastructure construction footprint resulting in alteration of the local topography (i.e., landforms) at dam site	C3 dam will require total excavation of 41 million m^3 of overburden and bedrock. C3 dam facility structures and associated infrastructure will require (i.e., alter) a total land area footprint of 1011 ha that includes: - camp areas, staging and laydown areas	C1 dam will require total excavation of 145.8 million m^3 of overburden and bedrock (3.6 times > C3). C2 dam will require total excavation of 138.6 million m^3 of overburden and bedrock (3.4 times > C3). C1 or C2 dam facility	Wilder dam will require total excavation of 26.9 million m^3 of overburden and bedrock (34% < C3). Wilder dam facility structures and associated infrastructure will require a land area of	7b and Low C3 will require total excavation of 42.9 million m^3 of overburden and bedrock (5% < C3). 7b and Low C3 dam facility structures and associated infrastructure will require a land area	No excavation quantity available for 3 cascade construction. 3 cascade dam facility structures and associated infrastructure will require a land area of 1673 ha (66% > C3).	No excavation quantity available for 4 cascade construction. 4 cascade dam facility structures and associated infrastructure will require a land area of 2469 ha (144% > C3).	No excavation quantity available for 7 cascade construction. 7 cascade dam facility structures and associated infrastructure will require a land area of

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
Note, effect to topography by reservoir inundation considered under physiography.	- dam site excavation and disposal areas - cofferdams and dewatered areas - facility structures (dam, intake, penstocks, powerhouse, spillway, stilling basin, switch-yard, etc.). C3 dam facility construction and infrastructure will alter the local topography at the damsite.	structures and associated infrastructure will require a land area of 1528 ha (52% > C3). C1 or C2 dam facility construction and infrastructure will have greater effect on the local topography compared to C3.	382 ha (62% < C3). Wilder dam facility construction and infrastructure will have less effect on the local topography compared to C3.	of 1113 ha (10% > C3). 7b and Low C3 dam facility construction and infrastructure will similar effect on the local topography compared to C3.	Combined, 3 cascade land area footprint would have greater effect on topography than C3, but possibly on a per dam basis, there could be less site-specific effect due to smaller footprints.	Combined, 4 cascade land area footprint would have greater effect on topography than C3, but possibly on a per dam basis, there could be less site-specific effect due to smaller footprints.	1307 ha (29% > C3). Combined, 3 cascade land area footprint would have greater effect on topography than C3, but possibly on a per dam basis, there could be less site-specific effect due to smaller footprints.
Soils Reservoir filling and facility construction (e.g. roads, dam, etc.) resulting in loss of existing soils which support productive uses (e.g. agriculture) Note, effects to water quality resulting from vegetation clearing and soil disturbance are considered under Water Quality. Note, bedrock geology addressed in Engineering Matrix.	**Reservoir Filling** [10]Previous study mapped soils within a 6,035 ha associated with the C3 reservoir. Dominant soils are within the 'Alluvial' soil series and include sandy loam, silt loam and gravel. About 4,490 ha (74%) of these soils were identified as having characteristics that could support some form of agricultural use (e.g. alfalfa, domestic forage, grazing) and 409 ha (7%) identified as highly productive for a wide range of agricultural crops. C3 reservoir would flood a land area of 6,183 ha, which in turn would eliminate the potential productive use (agricultural or otherwise) of the existing soils.	C1 reservoir would flood 5,475 ha of land (11% < C3). The C2 reservoir 5,619 ha of land (9% < C3). Assumed less potential effect to soils based on smaller amount of land area inundated (9-11% <C3).	Assumed less potential effect to soils since Wilder reservoir would flood 5,032 ha of land (19% < C3).	Assumed less potential effect to soils since 7b and Low C3 reservoirs would flood 4,629 ha of land (25% < C3).	Assumed less potential effect to soils since 3 cascade reservoirs would flood 4,351 ha of land (30% < C3).	Assumed less potential effect soils since 4 cascade reservoirs would flood 4,358 ha of land (30% < C3).	Assumed less potential effect to soils since 7 cascade reservoirs would flood 2,737 ha of land (56% < C3).
	Facility Construction C3 facility construction requires: 40.4 km new/relocated roads 1011 ha dam facility / infrastructure footprint New transmission line clearing not included since soils will still support vegetation. Facility footprint would eliminate the potential productive use of the	C1 or C2 facilities requires: 33.7 km of roads; 17% < C3 1528 ha facility; 52% > C3 Moderately greater loss/disturbance to soils based on larger facility footprint.	Wilder facilities require: 34.6 km of roads; 14% < C3 382 ha facility; 62% < C3 Moderately less loss/disturbance to soils based on smaller facility footprint.	7b and Low C3 requires: 36.3 km of roads; 10% < C3 1113 ha facility; 10% > C3 Slightly greater loss/disturbance to soils based on slightly larger facility footprint.	3 dam cascade requires: 42.0 km of roads; 4% > C3 1673 ha facility; 66% > C3 Moderately greater loss/disturbance to soils based on larger facility footprint.	4 dam cascade requires: 53.9 km of roads; 33% > C3 2469 ha facility; 144% > C3 Significantly greater loss/disturbance to soils based on larger facility footprint.	7 dam cascade requires: 59.6 km of roads; 48% > C3 1307 ha facility; 29% > C3 Moderately greater loss/disturbance to soils based on larger

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	existing soils.						facility footprint.
Shoreline Erosion Reservoir clearing and filling resulting in terrain instability and shoreline erosion	[3]C3 reservoir filling is not expected to change the stability of the high bank shoreline areas. In general, reservoir flooding may result in sloughing of the disintegrated and weathered shale banks and beaching due to wave action on overburden. The C3 reservoir would require vegetation clearing within the 6,183 ha land area inundated by the C3 reservoir prior to filling. The C3 reservoir would create 319 km of shoreline (298 km of valley shoreline and 20.9 km of island shoreline) which could be prone to local instability and shoreline erosion during reservoir clearing and filling.	The C1 reservoir would create 277 km of shoreline (258 km of valley shoreline and 19.8 km of island shoreline); 13% < C3. The C2 reservoir would create 285 km of shoreline (265 km of valley shoreline and 20 km of island shoreline); 11% < C3. Assumed slightly less potential effect based on less length of reservoir shoreline created compared to C3.	Wilder reservoir would create 261 km of shoreline (242 km of valley shoreline and 19.8 km of island shoreline); 18% < C3. Assumed slightly less potential effect based on less length of reservoir shoreline created compared to C3.	Combined Low C3 and 7b reservoir would create 300 km of shoreline (258 km of valley shoreline and 41.8 km of island shoreline); 6% < C3. Assumed similar potential effect based on similar length of reservoir shoreline created compared to C3. Although lower C3 reservoir may reduce potential for shoreline instabilities on steep slopes.	Combined 3 reservoirs would create 268 km of shoreline (241 km of valley shoreline and 26.7 km of island shoreline); 16% < C3. Assumed moderately less potential effect based on lower cascade reservoir depth and less length of reservoir shoreline created compared to C3.	Combined 4 reservoirs would create 265 km of shoreline (237 km of valley shoreline and 28.4 km of island shoreline); 17% < C3. Assumed moderately less potential effect based on lower cascade reservoir depth and less length of reservoir shoreline created compared to C3.	Combined 7 reservoirs would create 428 km of shoreline (259 km of valley shoreline and 169 km of island shoreline); 34% <u>more</u> than C3. Assumed slightly <u>more</u> potential effects based on more length of reservoir shoreline created, although lower reservoirs may reduce potential for shoreline instabilities on steep slopes.
Mineral and Aggregate Resources Reservoir filling and dam construction resulting in decreased ability to extract resources and/or depletion of existing resources	**Metallic Minerals** [1]There is low metallic mineral (e.g. gold, silver and copper) potential in the C3 reservoir area and there are no mineral or placer claims in the reservoir area or in the 3 km buffer area. **Coal** [1]The reservoir and downstream area are known to have good coal potential, but it is unlikely that [surface] coal mining would occur in the reservoir area [due to scarcity of natural outcrops]. [15]There is a coal license in the project footprint in the vicinity of Lynx Creek. The license area is a total of 6,670 ha, with about 97 ha in the project footprint. [15]The best potential for	C1 reservoir would flood 5,475 ha of land (11% < C3). The C2 reservoir 5,619 ha of land (9% < C3). The C1 dam construction would require 26.7 million $m^3$of fill material (42% > C3). The C2 dam construction would require 21.8 million m^3 (16% > C3). C1 or C2 reservoir would inundate less land and use more aggregates for dam construction compared to C3. Overall effects on aggregate resource assumed similar to	Wilder reservoir would flood 5,032 ha of land (19% < C3). The Wilder dam construction would require 15.6 million $m^3$of fill material (17% < C3). Wilder reservoir would inundate less land and use less aggregates for dam construction compared to C3. Overall effect assumed	7b and Low C3 reservoirs would flood 4,629 ha of land (25% < C3). The 7b dam construction would require 0.24 million $m^3$of fill material. No fill quantity available for Low C3, but is assumed less than C3. 7b and Low C3 reservoir would inundate less land and use less aggregates for dam construction compared to C3. Overall effect assumed	3 cascade reservoirs would flood 4,351 ha of land (30% < C3). No fill quantity available for 3 cascade construction, but is assumed less than C3. 3 cascade reservoirs would inundate less land and use less aggregates for dam construction compared to C3. Overall effect assumed similar to C3.	4 cascade reservoirs would flood 4,358 ha of land (30% < C3). No fill quantity available for 4 cascade construction, but is assumed less than C3. 4 cascade reservoirs would inundate less land and use less aggregates for dam construction compared to C3. Overall effect assumed similar to C3.	7 cascade reservoirs would flood 2,737 ha of land (56% < C3). No fill quantity available for 7 cascade construction, but is assumed less than C3. 7 cascade reservoirs would inundate less land and use less aggregates for dam construction compared to C3. Overall effect assumed similar to

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	relatively less deformed coal seams is at depths between 400 and 700 m. [12]The Site C development would not prevent the extraction of deep coal or gas deposits under the Peace River. **Aggregates** [1]The reservoir area has ±1,560 ha of land in sand and gravel tenures and 50 placer claims locally. An Order In Council gives precedence to hydro development over placer claims. [15]A previous survey[14] of granular resources identified ~1,300 million m^3 of granular material in the project area with about 6% of the volume in the C3 reservoir. It was concluded that a very large inventory of aggregate would remain after the project. The C3 dam construction would require 12.6 million $m^3$of fill material. Based on the above, the C3 project is not expected to: • significantly affect metallic minerals since these have low potential in reservoir area; • significantly effect the ability for future extraction of coal since this resource (if present) would be extracted by subsurface mining techniques; • significantly effect or deplete existing aggregate resources based on assumption that existing aggregate resources used for dam	C3 since adequate supply is available from reservoir area prior to filling and substantial amounts of aggregate will still be available from areas outside of reservoir.	similar to C3.	similar to C3.			C3.

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	construction prior to reservoir filling.						
Oil and Gas Resources Reservoir filling resulting in decreased ability to extract resources	Previous studies did not conduct a substantive analysis of the oil and gas resources. Recent study[15] has identified existing facilities and areas of existing and potential oil and gas within the project area, but did not assessed specific effects from the project. [15]There are eight wells and four oil and gas facilities within the planned [10,865 ha] project footprint. Areas of tenures include: • 1,946 ha of drilling licences and 2,077 ha of oil and gas leases in the reservoir; • 245 ha of drilling licences and 114 ha of oil and gas lease at the dam site; • 700 ha of drilling licences and oil and gas leases along the transmission line. [15]Oil potential within the project area is considered negligible. Conventional gas potential was identified within 1,695 ha area mostly within the C3 reservoir. Coalbed methane potential is considered to be present throughout the entire project area. [15]The C3 reservoir would inundate land where oil and gas exploration and production is occurring, has occurred in the past, or where there is future development potential. This could result in a loss of land, facilities and/or the future ability to exploit nearby oil and gas	The C1 reservoir would inundate 851 ha of area identified as oil and gas fields (48% < C3). The C2 reservoir would inundate 1099 ha of area identified as oil and gas fields (32% < C3). Assumed moderately less potential to affect oil and gas resource extraction based on smaller oil & gas area inundated compared to C3.	The Wilder reservoir would inundate 508 ha of area identified as oil and gas fields (69% < C3). Assumed significantly less potential to affect oil and gas resource extraction based on smaller oil & gas area inundated compared to C3.	The Low C3 reservoir (only) would inundate 1295 ha of area identified as oil and gas fields (20% < C3). Assumed less potential to affect oil and gas resource extraction based on smaller oil & gas area inundated compared to C3.	The 3 cascade reservoirs (3b & 3c only) would inundate 1048 ha of area identified as oil and gas fields (35% < C3). Assumed less potential to affect oil and gas resource extraction based on smaller oil & gas area inundated compared to C3.	The 4 cascade reservoirs (4c & 4d only) would inundate 1029 ha of area identified as oil and gas fields (36% < C3). Assumed less potential to affect oil and gas resource extraction based on smaller oil & gas area inundated compared to C3.	The 7 cascade reservoirs (7e, 7f & 7g only) would inundate 734 ha of area identified as oil and gas fields (55% < C3). Assumed moderately less potential to affect oil and gas resource extraction based on smaller oil & gas area inundated compared to C3.

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	resources. The C3 reservoir would inundate 1619 ha of area identified as oil and gas fields. Based on the above, the C3 reservoir is not expected to significantly affect future extraction of existing oil and gas resources based on the assumption that directional drilling techniques can be used to access these resources, including coalbed methane.						
Hydrologic Environment - Construction							
Flows and Water Levels Flow diversions (e.g. cofferdams and tunnels) resulting in changes to Peace River flows and water levels Reservoir filling resulting in decreased flows in Peace River	**Flow Diversions** During construction of the dam, spillway and powerhouse, cofferdams and 2 x 9.8 m diameter diversion tunnels would be used to divert the river around the construction area. Significant alteration to flows is not expected since diversion tunnels will pass upstream inflows. However, upstream water levels (i.e., upstream of the cofferdam(s)) would increase with varying discharge; at a low end flow of 300 m^3/s, the level would be elev. 410.4 m, inundating an area of 5.1 ha. At a high end flow of 2000 m^3/s, the level would be elev. 423.6 m which inundating an area of 1963.8 ha. The Peace River would be diverted for a period of ± 46 months.	C1 or C2 flow diversion would be 70 months using 2 x 9.8 m diameter diversion tunnels. Assumed similar effects to upstream water levels and area of inundation resulting from flow diversion as C3, but Moberly River flows would not have to be diverted.	Wilder flow diversion would be 46 months using 2 x 9.8 m diameter diversion tunnels. Assumed similar effects to upstream water levels and area of inundation resulting from flow diversion as C3, but Moberly River flows would not have to be diverted.	No flow diversion duration quantity available, but is assumed similar to C3 by means of phased diversion using river channel. More dam sites require more diversion facilities. Water level increases caused by diversion tunnels expected to be less using river channels. Overall effects assumed similar to C3.	No flow diversion duration quantity available, but is assumed similar to C3 by means of phased diversion using river channel. More dam sites require more diversion facilities. Water level increases caused by diversion tunnels expected to be less using river channels. Overall effects assumed similar to C3.	No flow diversion duration quantity available, but is assumed similar to C3 by means of phased diversion using river channel. More dam sites require more diversion facilities. Water level increases caused by diversion tunnels expected to be less using river channels. Overall effects assumed similar to C3.	7 cascade flow diversion would be 40 months by phased diversion using river channel. More dam sites require more diversion facilities. Water level increases caused by diversion tunnels expected to be less using river channels. Possible increase in flow velocity as river is diverted from one side of the river to the other (i.e., decreased flow area). Overall effects assumed similar to C3.
	Reservoir Filling The C3 reservoir volume would be 2,331 million m^3. Based on a filling	The C1 reservoir volume would be 2,011 million m^3 (14% < C3).	Wilder Creek reservoir volume would be 1,751 million m^3; 25% < C3.	Combined Low C3 and 7b reservoir volume would be 1,223 million	Combined 3 reservoir volume would be 864 million m^3 (63% < C3).	Combined 4 reservoir volume would be 749 million m^3 (68% < C3).	Combined 7 reservoir volume would be 270 million m^3; 88% < C3.

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	flow rate of 431m^3/s (0.8 m/day), filling the C3 reservoir would take 62 days during July and August. During filling, Peace River mean monthly flows downstream of C3 would be decreased by 431m^3/s. Month Change / Ex. Avg. Flow (m^3/s) / Less Div. Flow (m^3/s) Jul -65% / 1109 / 678 Aug -56% / 971 / 540 Sep -61% / 1114 / 683 No significant effect on downstream flows is anticipated given that the above range of predicted flow changes is within BC Hydro's operational compliance range (for upstream existing dams) of 283 m^3/s to 1,982m^3/s.	Filling the C1 reservoir would take 60.8 days; 2% < C3. The C2 reservoir volume would be 2,108 million m^3 (10% < C3). Filling the C2 reservoir would take 61.5 days; 1% < C3. Potential effects assumed similar to C3 based on recognition that predicted flow changes during filling would be within BC Hydro's operational compliance range.	Filling the Wilder reservoir would take 55.1 days; 11% < C3. Potential effects assumed similar to C3 based on recognition that predicted flow changes during filling would be within BC Hydro's operational compliance range.	m^3 (48% < C3). Filling the 7b and Low C3 reservoirs would take 64.7 days; 4% more than C3. Potential effects assumed similar to C3 based on recognition that predicted flow changes during filling would be within BC Hydro's operational compliance range.	Filling the 3 cascade reservoirs would take 78.5 days; 27% more than C3. Potential effects assumed similar to C3 based on recognition that predicted flow changes during filling would be within BC Hydro's operational compliance range.	Filling the 4 cascade reservoirs would take 85.9 days; 39% more than C3. Potential effects assumed similar to C3 based on recognition that predicted flow changes during filling would be within BC Hydro's operational compliance range.	Filling the 7 cascade reservoirs would take 74.4 days; 20% more than C3. Potential effects assumed similar to C3 based on recognition that predicted flow changes during filling would be within BC Hydro's operational compliance range.
Water Quality - Construction							
Suspended Sediment / Turbidity Construction activities involving vegetation removal (e.g. clearing, stripping, grading) resulting in soil erosion and increased suspended sediment (turbidity) to receiving watercourses, and in-water construction effects	**Dam Facility and Infrastructure** C3 dam facility structures and associated infrastructure will require a total land and water area of 1033 ha that includes: - camp areas - staging areas and laydown areas - dam site excavation and disposal areas - cofferdams and dewatered areas - facility structures (dam, intake, penstocks, powerhouse, spillway, stilling basin, switch-yard, etc.). Removal of vegetation and soil disturbance, and in-water facility	C1 or C2 dam facility and infrastructure will require a land and water area of 1555 ha (51% > C3). Assumed moderately greater potential effects to water quality based on larger extent of land & water area cleared or disturbed during construction.	Wilder dam facility and infrastructure will require a land and water area of 517 ha (50% < C3). Assumed moderately less potential effects to water quality based on smaller extent of land & water area cleared/disturbed.	7b and Low C3 dam facility and infrastructure will require a land and water area of 1169 ha (13% > C3). Assumed similar potential effects to water quality based on similar extent of land & water area cleared/disturbed.	3 cascade dam facility and infrastructure will require a land and water area of 1679 ha (63% > C3). Assumed moderately greater potential effects to water quality based on larger extent of land & water area cleared/disturbed.	4 cascade dam facility structures and infrastructure will require a land and water area of 2473 ha (140% > C3). Assumed significantly greater potential effects to water quality based on larger extent of land & water area cleared/disturbed.	7 cascade dam facility and infrastructure will require a land and water area of 1321 ha (28% > C3). Assumed slightly greater potential effects to water quality based on larger extent of land & water area cleared/disturbed.

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
due to cofferdam installation/removal, and facility construction resulting in water quality effects due to increased turbidity	construction (i.e., cofferdam installation/removal) is expected to increase the potential for effects to water quality (suspended sediment, turbidity) from soil erosion from runoff.						
	Reservoir Clearing and Filling The C3 reservoir would require vegetation clearing within the 6,183 ha land area inundated by the C3 reservoir prior to filling. [16]A total of 4,610 ha of vegetated area (i.e., treed and non-treed) to be cleared has been estimated for C3. This corresponds to 75% of the total land area inundated by the reservoir. Removal of vegetation and soil disturbance in cleared areas (prior to filling) along with saturation and mobilization of sediments from other non-vegetated exposed areas (during filling) is expected to increase the potential for effects to water quality (suspended sediment, turbidity). Retaining base vegetation and tree stumps on selected areas to be cleared (e.g. steep slopes) could reduce these effects.	The C1 reservoir would flood 5,475 ha of land (11% < C3). The C2 reservoir would flood 5,619 of land (9% < C3). Based on a 75% vegetative clearing factor, C1 would require 4,106 ha of clearing (11% < C3). C2 reservoir would require 4,214 ha of clearing (9% < C3). Assumed slightly less potential effects to water quality based on smaller extent of land inundated and vegetation clearing.	The Wilder Creek reservoir would flood 5,032 ha of land (19% < C3). Based on a 75% vegetative clearing factor, Wilder would require 3,774 ha of clearing (19% < C3). Assumed marginally less potential effects to water quality based on smaller extent of land inundated and vegetation clearing.	The combined 7b and Low C3 reservoirs would flood 4,629 ha of land (25% < C3). Based on a 75% vegetative clearing factor, 7b and Low C3 would require 3,472 ha of clearing (25% < C3). Assumed marginally less potential effects to water quality based on smaller extent of land inundated and vegetation clearing.	The 3 cascade reservoirs would flood 4,351 of land (30% < C3). Based on a 75% vegetative clearing factor, 3 reservoir would require 3,263 ha of clearing (30% < C3). Assumed marginally less potential effects to water quality based on smaller extent of l90 and inundated and vegetation clearing.	The 4 cascade reservoirs would flood 4,358 ha of land (30% < C3). Based on a 75% vegetative clearing factor, 4 reservoir would require 3,269 ha of clearing (30% < C3). Assumed marginally less potential effects to water quality based on smaller extent of land inundated and vegetation clearing.	The 7 cascade reservoirs would flood 2,737 ha of land (56% < C3). Based on a 75% vegetative clearing factor, 7 reservoir would require 2,053 ha of clearing (56% < C3). Assumed moderately less potential effects to water quality based on smaller extent of land inundated and vegetation clearing.
	Highways, Roads and Bridges C3 requires the following: 22.3 km of Hwy 29 relocated 2.1 km of Hwy 29 crossings relocated 15.5 km of new access roads <u>0.52 km for 1 new powerhouse access bridge</u> 40.4 km of roads	C1 or C2 requires: 22.3 km of Hwy 29 relocated 2.1 km of Hwy 29 crossings relocated 8.5 km of new access roads <u>0.75 km powerhouse access bridge</u>	Wilder requires the following: 22.3 km Hwy 29 relocated 2.1 km Hwy 29 crossings rel. 8.9 km of new access roads	7b and Low C3 requires: 18.1 km Hwy 29 relocated 2.1 km Hwy 29 crossings rel. 15.6 km of new access roads <u>0.52km new powerhouse</u>	3 dam requires the following: 13.2 km Hwy 29 relocated 2.1 km Hwy 29 crossings rel. 24.5 km of new access roads	4 dam requires the following: 11.8 km Hwy 29 relocated 2.1 km Hwy 29 crossings rel. 36.7 km of new access roads	7 dam requires the following: 9.8 km Hwy 29 relocated 1.8 km Hwy 29 crossings rel. 42.9 km of new access roads

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	**3 dam**	**4 dam**	**7 dam**
	Removal of vegetation and soil disturbance is expected to increase the potential for soil erosion from exposed areas by runoff.	33.7 km of roads; 17% < C3 Slightly less potential effect to water quality based on smaller extent of roads compared to C3.	1.25 km powerhouse bridge 34.6 km of roads; 14% < C3 Slightly less potential effect to water quality based on smaller extent of roads compared to C3.	bridge 36.3 km of roads; 10% < C3 Slightly less potential effect to water quality based on smaller extent of roads compared to C3.	2.2 km new 3 access bridges 42.0 km of roads; 4% > C3 Similar potential effect to water quality based on similar extent of roads compared to C3.	3.25 km 4 new access bridges 53.9 km of roads; 33% > C3 Moderately more potential effect to water quality based on larger extent of roads compared to C3.	5.05 km 7 new access bridges 59.6 km of roads; 48% > C3 Moderately more potential effect to water quality based on larger extent of roads compared to C3.
	Transmission Lines [1]C3 requires two 500 kV transmission lines from C3 to Peace Canyon GS adjacent to the existing 118 m wide, 76 km transmission corridor presently used by two 138 kV lines. C3 requires: 75.9 km of new transmission lines 910.2 ha of vegetation clearing Removal of vegetation and soil disturbance is expected to increase the potential for soil erosion from exposed areas by runoff.	C1 or C2 requires 1 new T/L corridor on south bank running alongside existing corridor to Peace Canyon GS and widening of existing 138 kV corridor to accommodate 2 new 500kV lines. C1 or C2 requires: 76.6 km T/L; 1% > C3 920.5 ha T/L clearing; 1% > C3 Potential effects assumed similar to C3 based on similar area cleared (within 5% of C3).	Wilder requires 1 new T/L corridor on south bank running alongside existing corridor to Peace Canyon GS and widening of existing 138 kV corridor to accommodate 2 new 500kV lines. Wilder requires: 78 km T/L; 3% > C3 938.3 ha T/L clearing; 3% > C3 Potential effects assumed similar to C3 based on similar area cleared (within 5% of C3).	7b and Low C3 requires 2 new corridors on south bank running to Peace Canyon GS and widening of existing 138 kV corridor to accommodate 2 new 500kV lines. 7b and Low C3 requires: 90 km T/L; 19% < C3 676 ha T/L clearing; 26% < C3 Assumed less potential effect to water quality based on smaller area cleared.	3 dam requires 3 new corridors on south bank running to Peace Canyon GS and widening of existing 138 kV corridor to accommodate 2 new 500kV lines. 3 cascade requires: 110.6 km T/L; 46% > C3 1325 T/L ha clearing; 46% > C3 Slightly greater potential effect to water quality due to soil erosion based on larger extent of area cleared.	4 dam requires 4 new corridors on south bank running to Peace Canyon GS and widening of existing 138 kV corridor to accommodate 2 new 500kV lines. 4 cascade requires: 128.5 km T/L; 69% > C3 1538 ha clearing; 69% >C3 Moderately greater potential effect to water quality due to soil erosion based on larger extent of area cleared.	7 dam would require 7 new corridors on north bank to connect to Peace Canyon GS and widening of main corridor to accommodate new 230kv line. 7 cascade requires: 104.7 km T/L; 38% > C3 1251 ha clearing; 37% >C3 Slightly greater potential effect to water quality due to soil erosion based on larger extent of area cleared.
Atmospheric Environment - Construction							
Air Quality Construction vehicle and equipment exhaust, fugitive dust (equipment, road traffic, blasting, wind generated dust from	[1]During construction, there would be a temporary impact on air quality as a result of the operation of heavy machinery (exhaust emissions), and fugitive dust [wind erosion] and burning of debris [particulate matter]. C3 construction requires:	C1 or C2 construction requires: 33.7 km roads; 17% < C3 1555 ha dam facility; 51% > C3 920.5 ha T/L clearing; 1% > C3 4,106 ha of clearing; 11% < C3	Wilder construction requires: 34.6 km roads; 14% < C3 517 ha dam facility; 50% < C3 938.3 ha T/L clearing; 3% > C3 3,774 ha of clearing;	7b and Low C3 requires: 36.3 km roads; 10% < C3 1169 ha dam facility; 13% > C3 676 ha T/L clearing; 26% < C3 3,472 ha of clearing; 25% < C3	3 cascade requires: 42.0 km roads; 4% > C3 1679 ha dam facility; 63% > C3 1325 ha T/L clearing; 46% > C3 3,263 ha of clearing; 30% < C3	4 cascade requires: 53.9 km roads; 33% > C3 2473 ha dam fac.; 140% > C3 1538 ha TL clearing; 69% > C3 3,269 ha of clearing; 30% < C3	7 cascade requires: 59.6 km roads; 48% > C3 1321 ha dam fac.; 28% > C3 1251 ha TL clearing; 37% > C3 2,053 ha of clearing 56% < C3

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
exposed/disturbed soils) and vegetation burning resulting in effects to air quality	40.4 km new/relocated roads 1011 ha dam facility / infrastructure footprint 910.2 ha T/L vegetation clearing 4,610 ha of vegetative clearing	Potential effects to air quality assumed slightly more than C3 based on larger facility footprint.	19% < C3 Potential effects to air quality assumed moderately less based on smaller overall construction footprint	Potential effects to air quality assumed slightly less based on smaller overall construction footprint.	Potential effects to air quality assumed moderately more based on larger overall construction footprint. Multiple dams may have a longer construction period than C3, extending the duration of effects to air quality.	Potential effects to air quality assumed significantly more based on larger overall construction footprint. Multiple dams may have a longer construction period than C3, extending the duration of effects to air quality.	Potential effects to air quality assumed moderately more based on larger overall construction footprint. Multiple dams may have a longer construction period than C3, extending the duration of effects to air quality.
OPERATION - maintain level near FSL - maintain flows >10,000 cfs - emergency flow releases (spilling) - maintain facilities and transmission line corridors							
Geologic Environment - Operation							
Shoreline Stability and Erosion Presence of reservoir and operation (i.e., water level fluctuations) resulting in shoreline instability and erosion Note, seismicity is discussed in Engineering Matrix	[1]C3 reservoir would increase the likelihood of small landslides (< 20,000 m^3) along the low bank areas, though the effect on high bank areas would be minimal. Bank stability downstream of the dam is not expected to be affected. Bank protection would be required at Hudson's Hope to minimize the risk of slumping of reservoir banks. [3]Reservoir [flooding] may result in sloughing of the disintegrated and weathered shale banks and beaching due to wave action on overburden. The C3 reservoir would create 319 km of shoreline (298 km of valley shoreline and 20.9 km of island shoreline). Maximum (normal) water level fluctuation will be ±0.9 m (1.8 m operating band). For approximately 90% of the time,	The C1 reservoir would create 277 km of shoreline (258 km of valley shoreline and 19.8 km of island shoreline); 13% < C3. The C2 reservoir would create 285 km of shoreline (265 km of valley shoreline and 20 km of island shoreline); 11% < C3. C1 or C2 reservoir water level fluctuations similar to C3 at ±0.9 m. Assumed slightly less potential effects based on less length of reservoir shoreline created and similar expected range of water fluctuations.	Wilder reservoir would create 261 km of shoreline (242 km of valley shoreline and 19.8 km of island shoreline); 18% < C3. Assumed slightly less potential effects based on less length of reservoir shoreline created and similar expected range of water fluctuations.	Combined Low C3 and 7b reservoir would create 300 km of shoreline (258 km of valley shoreline and 41.8 km of island shoreline); 6% < C3. Potential effects assumed similar to C3 based on similar length of reservoir shoreline created (within 6% of C3).	Combined 3 reservoirs would create 268 km of shoreline (241 km of valley shoreline and 26.7 km of island shoreline); 16% < C3. Assumed moderately less potential effects based on less length of reservoir shoreline created and smaller separate reservoirs would be less susceptibility to shoreline erosion from wind generated wave action due to reduced open water fetch length. However, there may be increased reservoir water level fluctuations due to smaller reservoir surface areas	Combined 4 reservoirs would create 265 km of shoreline (237 km of valley shoreline and 28.4 km of island shoreline); 17% < C3. Assumed moderately less potential effects based on less length of reservoir shoreline created and smaller separate reservoirs would be less susceptibility to shoreline erosion from wind generated wave action due to reduced open water fetch length. However, there may be increased reservoir water level fluctuations due to smaller reservoir surface areas	Combined 7 reservoirs would create 428 km of shoreline (259 km of valley shoreline and 169 km of island shoreline); 34% <u>more</u> than C3. Assumed moderately less potential effects based on less length of reservoir shoreline created and smaller separate reservoirs would be less susceptibility to shoreline erosion from wind generated wave action due to reduced open water fetch length. However, there may be increased reservoir water level

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	reservoir water levels are expected to be within ±0.3 m.						fluctuations due to smaller reservoir surface areas
Hydrologic Environment - Operation							
Flows and Water Levels Operational effects on the timing and magnitude of reservoir levels and downstream river flows For reference, mean monthly flows at C3 (1979-2007) are: Month Avg. Flow (m^3/s) Jan 1461 Feb 1430 Mar 1319 Apr 1254 May 1032 Jun 1017 Jul 1109 Aug 971 Sep 1114 Oct 1276 Nov 1453 Dec 1588 Peace River mean annual flow at C3 is 1251 m^3/s. The inflow design flood at C3 is 20,810 m^3/s.	**Reservoirs** [6]Reservoir water levels will be subject to daily, weekly or seasonal fluctuations in response to upstream flow releases. Level fluctuations would be < *2 m, 80% of the time, although drawdown of up to 6 m or more could occur during power emergencies. [1]In exceptional circumstances, the C3 reservoir could rise above the normal maximum reservoir level due to unexpected rainfall runoff. Further, the reservoir could also be drawn down 11.8 m to the Emergency Operating Level of 450 m for system emergencies. *Current 2009 project info states maximum (normal) water level fluctuation will be ±0.9 m (1.8 m operating band). For approximately 90% of the time, reservoir water levels are expected to be within ±0.3 m.	C1 or C2 reservoir water level fluctuations similar to C3.	Wilder reservoir water level fluctuations similar to C3.	Smaller, separate dams may result in increased reservoir water level fluctuations due to smaller reservoir surface areas and operational responses to inflow from Halfway River, which is flashy in nature.	Smaller, separate dams may result in increased reservoir water level fluctuations due to smaller reservoir surface areas and operational responses to inflow from Halfway River, which is flashy in nature.	Smaller, separate dams may result in increased reservoir water level fluctuations due to smaller reservoir surface areas and operational responses to inflow from Halfway River, which is flashy in nature.	Smaller, separate dams may result in increased reservoir water level fluctuations due to smaller reservoir surface areas and operational responses to inflow from Halfway River, which is flashy in nature.
	Receiving Waters [1]The Peace River flow regime downstream of C3 would not be altered appreciably except during the initial reservoir filling period since the station will operate as a run-of-river. It is assumed that run-of-river operation will result in similar timing and magnitude of flows as experienced for existing conditions	Run-of--river station operation will ensure that Peace River flows and levels downstream of C3 will not be significantly different than C3. Peace River mean annual flow at C1 or C2 is 1240 m^3/s.	Run-of--river station operation will ensure that Peace River flows and levels downstream of C3 will not be significantly different than C3. Peace River mean annual flow at Wilder is 1240 m^3/s.	Run-of--river station operation will ensure that Peace River flows and levels downstream of C3 will not be significantly different than C3. Peace River mean annual flows are: 1140 m^3/s at 7b and 1251 m^3/s and	Run-of--river station operation will ensure that Peace River flows and levels downstream of C3 will not be significantly different than C3. Peace River mean annual flows are: 3a: 1141 m^3/s 3b: 1240 m^3/s	Run-of--river station operation will ensure that Peace River flows and levels downstream of C3 will not be significantly different than C3. Peace River mean annual flows are: 4a: 1141 m^3/s	Run-of--river station operation will ensure that Peace River flows and levels downstream of C3 will not be significantly different than C3. Peace River mean annual flows are: 7a/b/c: 1141 m^3/s

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	**3 dam**	**4 dam**	**7 dam**
	downstream of C3. Peace River mean annual flow at C3 is 1251 m^3/s. The C3 spillway will be designed to pass 17,500 m^3/s.	C1 or C2 spillway will be designed to pass 17,500 m^3/s.	Wilder spillway will be designed to pass 17,500 m^3/s.	Low C3. 7b and Low C3 spillways will be designed to pass the following: 7b: 9300m³/s C3: 17,500m³/s	3c: 1251 m^3/s 3 cascade spillways will be designed to pass: 3a: 10,000m³/s 3b/3c: 20,000 m^3/s.	4b/c: 1240 m^3/s 4d: 1251 m^3/s. 4 cascade spillways will be designed to pass: 4a: 10,000 m³/s 4b/4c/4d:20,000 m^3/s.	7d/e/f: 1240 m^3/s g: 1251 m^3/s 7 cascade spillways will be designed to pass: 7a: 9,300 m³/s 7b: 10,200 m³/s 7c: 11,300 m³/s 7d: 12,500 m³/s 7e: 17,000 m³/s 7f: 18,000 m³/s 7g: 20,810 m^3/s.
Reservoir Flushing Rate Presence of reservoir resulting in slowing of river velocities resulting increased residence (i.e., travel) time Note, information only; 0 weight applied since this factor considered in Water Quality	The C3 reservoir volume would be 2,331 million m^3. Based on a mean annual flow of 1251 m^3/s, the C3 reservoir flushing time would be 21.4 days. Hydraulic modeling indicates a flow velocity of 0.07 m/s at the reservoir mid-point for mean annual flow.	C1 reservoir flushing rate would be 18.6 days (13% < C3). C2reservoir flushing rate would be 19.5 days (9% < C3). Hydraulic modeling indicates a flow velocity of 0.07 m/s at the reservoir mid-point for mean annual flow. C1 or C2 reservoirs would have similar residence time compared to C3 reservoir (within 9-13% < C3).	Wilder reservoir flushing rate would be 16.2 days; 24% < C3. Hydraulic modeling indicates a flow velocity of 0.07 m/s at the reservoir mid-point for mean annual flow. Wilder reservoir would have slightly shorter residence time compared to C3 reservoir, allowing for slightly better reservoir flushing.	7b and Low C3 reservoir flushing rate would be 11.4 days; 47% < C3. Hydraulic modeling indicates flow velocities of 0.09 m/s (Low C3) to 0.15 m/s (7b) for mean annual flow. Smaller 7b and Low C3 reservoirs would have much shorter residence time compared to C3 reservoir, allowing for much better reservoir flushing.	3 cascade reservoir flushing rate would be 8.2 days; 62% < C3. Hydraulic modeling indicates flow velocities of 0.15 m/s (Low 3c) to 0.21 m/s (3a) for mean annual flow. Series of 3 smaller reservoirs would have much shorter residence time compared to C3 reservoir, allowing for much better reservoir flushing.	4 cascade reservoir flushing rate would be 7.1 days; 67% < C3. Hydraulic modeling indicates flow velocities of 0.14 m/s (4a) to 0.21 m/s (4d) for mean annual flow. Series of 4 smaller reservoirs would have much shorter residence time compared to C3 reservoir, allowing for much better reservoir flushing.	7 cascade reservoir flushing rate would be 2.6 days; 88% < C3. Hydraulic modeling indicates flow velocities of 0.46 m/s (4a) to 1.39 m/s (7f) for mean annual flow. Series of 7 smaller reservoirs would have significantly shorter residence time compared to C3 reservoir, allowing for significantly better reservoir flushing.
Ice Formation Presence of reservoir and operation may affect ice conditions in the reservoir and in the downstream Peace River	[1, 12]Ice cover would be expected to form on the reservoir in most years. The river would normally remain open for 30 to 65 km downstream of the dam and there would be a greater frequency of open water in the vicinity of the Clayhurst ferry than at present. [1, 6]No increased risk of downstream	Potential effects assumed similar to C3 based on similar C1 or C2 reservoir surface area (within 11% of C3), volume (within 14% of C3) and operating conditions. Moberly River ice	Potential effects assumed similar to C3 based on similar reservoir surface area (within 18% of C3), volume (within 25% of C3) and operating conditions.	Assumed similar ice effects in upstream reservoir(s), but ice effects downstream of Low C3 dam due to lower/smaller C3 reservoir are unknown.	Assumed similar ice effects in upstream reservoir(s, but ice effects downstream of C3 due to separate, smaller cascade reservoirs are unknown.	Assumed similar ice effects in upstream reservoir(s), but ice effects downstream of C3 due to separate, smaller cascade reservoirs are unknown.	[5]Currently, a stable ice sheet normally forms downstream of C3. However, the construction of a cascade of small dams will increase the probability of ice formation [assumed context to be in the

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	ice jamming as confirmed by 2002 study which found no significant effects on the ice regime at Peace River town and that the ice front would never reach Taylor due to warm water releases from the C3 reservoir.	conditions would not be altered.	Moberly River ice conditions would not be altered.				upstream reservoirs] Ice effects downstream of C3 due to lower/smaller cascade reservoirs are unknown.
Channel Morphology Presence of reservoir and operation resulting in changes to sediment transport and deposition within the reservoir, tributaries and Peace River downstream of C3	C3 reservoir would flood (i.e., alter sediment transport and sedimentation processes) within: 84.9 km of Peace River 11.6 km Moberly River 15.5 km Halfway River 11.5 km Cache Creek 3.6 km Farrell Creek 1.1 km Tea Creek 2.9 km Wilder Creek <u>1.2 km Lynx Creek</u> 47.4 km of major tributaries [3]Most tributaries of the Peace River system are in a 'youthful' stage whereas the Peace River has reached a mature stage in its development, but many of the valley slopes are still unstable and active. [5]There is a significant annual sediment load in the reach between Peace Canyon Dam and C3. Discharges from the Peace Canyon Dam are virtually sediment free. The large tributaries; Halfway & Moberly Rivers are the sources of most of the annual sediment load. Halfway River contributes the	C1 or C2 reservoirs would flood (i.e., alter sediment transport and sedimentation processes) within: 78.7- 81.5 km Peace R; 4-7% < C3 0 km Moberly R; 100% < C3 15.5 km Halfway R; = C3 11.5 km Cache Ck; = C3 3.6 km Farrell Ck; = C3 1.1 km Tea Ck; = C3 2.9 km Wilder Ck; = C3 <u>1.2 km Lynx Ck; = C3</u> 35.8 km of major tribs; 24% < C3 Reservoir sedimentation effects assumed slightly less than C3 based on smaller C1 or C2 reservoir surface area (11% < C3), volume (14% < C3) and shorter reservoir flushing time (13% < C3). Sediment transport and/or sedimentation processes associated with Moberly River would not be altered by either C1 or C2. Similar	Wilder Creek reservoir would flood (i.e., alter sediment transport and sedimentation processes) within: 72.8 km Peace R; 14%< C3 0 km Moberly R; 100% < C3 15.5 km Halfway R; = C3 11.5 km Cache Ck; = C3 3.6 km Farrell Ck; = C3 0 km Tea Ck; 100% < C3 2.9 km Wilder Ck; = C3 <u>1.2 km Lynx Ck; = C3</u> 34.7 km of major tribs; 27%<C3 Reservoir sedimentation effects assumed slightly less than C3 based on smaller reservoir surface area (18% < C3), volume (25% < C3) and shorter reservoir flushing time (24% < C3). Sediment transport and/or sedimentation processes associated	Low C3 and 7b reservoirs would flood (i.e., alter sediment transport and sedimentation processes) within: 84.9 km Peace R; = C3 7.8 km Moberly R; 33% < C3 8.6 km Halfway R; 45% < C3 6.7 km Cache Ck; 42% < C3 1.1 km Farrell Ck; 69% < C3 0.8 km Tea Ck; 30% < C3 2.0 km Wilder Ck; 31% < C3 <u>1.2 km Lynx Ck; = C3</u> 28.2 km of major tribs; 40%<C3 Reservoir sedimentation effects assumed moderately less than C3 based on smaller reservoir surface area (18% < C3), volume (48% < C3) and shorter reservoir flushing time (47% < C3). As such, a	Combined 3 reservoirs would flood (i.e., alter sediment transport and sedimentation processes) within: 84.9 km Peace R; = C3 3.8 km Moberly R; 67% < C3 7.8 km Halfway R; 50% < C3 6.2 km Cache Ck; 46% < C3 3.6 km Farrell Ck; = C3 0.4 km Tea Ck; 64% < C3 0.8 km Wilder Ck; 72% < C3 <u>1.2 km Lynx Ck; = C3</u> 23.8 km of major tribs; 50%<C3 Reservoir sedimentation effects assumed moderately less than C3 based on smaller reservoir surface area (21% < C3), volume (63% < C3) and shorter reservoir flushing time (62% <C3). As such, a greater percentage of sediment (clay fraction)	Combined 4 reservoirs would flood (i.e., alter sediment transport and sedimentation processes) within: 84.9 km Peace R; = C3 2.8 km Moberly R; 76% < C3 9.8 km Halfway R; 37% < C3 4.3 km Cache Ck; 63% < C3 3.6 km Farrell Ck; = C3 0.4 km Tea Ck; 64% < C3 0.6 km Wilder Ck; 79% < C3 <u>1.2 km Lynx Ck; = C3</u> 22.7 km of major tribs; 52%<C3 Reservoir sedimentation effects assumed moderately less than C3 based on smaller reservoir surface area (21% < C3), volume (68% < C3) and shorter reservoir flushing time (67% < C3). As such, a greater percentage of sediment (clay fraction)	Combined 7 reservoirs would flood (i.e., alter sediment transport and sedimentation processes) within: 84.2 km Peace R; 1%<C3 1.2 km Moberly R; 76% < C3 4.2 km Halfway R; 73% < C3 3.1 km Cache Ck; 73% < C3 0.9 km Farrell Ck; 75% < C3 0.2 km Tea Ck; 82% < C3 0.6 km Wilder Ck; 79% < C3 <u>0.4 km Lynx Ck;</u> 67% < C3 10.6 km of major tribs; 78%<C3 Reservoir sedimentation effects assumed significantly less than C3 based on smaller reservoir surface area (39% < C3), volume (88% < C3) and shorter

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	largest sediment load, estimated at 2.3 million tons per year. [6]The C3 reservoir would alter morphologic processes within the reservoir and within the lower sections of tributaries entering the reservoir due to trapping of sediments in the reservoir. [12]A ±11 km portion of Halfway River would be transformed into a silty flood plain with invasion of vegetation within 50 years. The Moberly River arm would fill less rapidly with bed-load materials extending into the reservoir. The C3 reservoir would take 700 years to fill with sediment. [6, 12]Downstream of C3, some minor degradation of the Peace River channel may occur due to mobilization and transport of previously deposited river sediments by the dam discharges. [1, 6]The C3 reservoir will trap a significant portion of the river sediments. As such, suspended sediment levels immediately downstream of the C3 dam would be greatly reduced. This would be most noticeable between the dam and the confluence of the Pine River, 14 km downstream of C3.	extent of silting of other tributaries based on similar length of tributaries flooded compared to C3.	with Moberly River and Tea Creek would not be altered. Similar extent of silting of other tributaries based on similar length of tributaries flooded compared to C3.	greater percentage of sediment (clay fraction) would be expected to pass through reservoir compared to C3. Slightly less extent of silting of tributaries based on length of tributaries flooded (40% < C3).	would be expected to pass through the reservoirs compared to C3. Moderately less extent of silting of tributaries based on length of tributaries flooded (50% < C3).	would be expected to pass through the reservoirs compared to C3. Moderately less extent of silting of tributaries based length of tributaries flooded (52% < C3).	reservoir flushing time (88% < C3). As such, a greater percentage of sediment (clay fraction) would be expected to pass through the reservoirs compared to C3. Significantly less extent of silting of tributaries based on length of tributaries flooded (78% < C3).
Groundwater Presence of reservoir may affect local groundwater conditions (e.g. water table)	[3]The most important unit for groundwater is the basal gravel which serves as an aquifer of appreciable potential. The aquifer is overlain by relatively impermeable silt, clay and till, although the gravel does appear to be part of a	Potential effects assumed similar to C3 based on similar C1 or C2 reservoir NWL (461.8 m), surface area (11% < C3) and volume (14% < C3).	Potential effects assumed similar to C3 based on similar reservoir NWL (461.8 m), surface area (18% < C3) and volume (25% < C3).	Assumed less influential effect to local groundwater conditions since Low C3 reservoir NWL will be lower (15 m < C3, smaller area (18% < C3) and smaller	Assumed less influential effect to local groundwater conditions since cascade reservoirs NWL will be lower (up to 33 m < C3), smaller area (21% < C3) and	Assumed less influential effect to local groundwater conditions since cascade reservoirs NWL will be lower (up to 37 m < C3), smaller area (21% < C3) and	Assumed less influential effect to local groundwater conditions since cascade reservoirs NWL will be lower (up to 45 m < C3),

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	**3 dam**	**4 dam**	**7 dam**
	surface recharge system. The groundwater pattern in high banks of overburden is considered very complex; exhibiting a high range of permeability, possibly perched water tables and high piezometric pressures. Seepage from both low and high shale banks has been recorded. Groundwater has been identified as an important factor governing the occurrence of landslides along the Peace R. There are no known studies assessing the effects of C3 on groundwater conditions. It is assumed that the C3 reservoir would raise the local groundwater table in proximity to the reservoir. Although this could possibly benefit existing water wells (if present) in proximity to the reservoir by raising and/or stabilizing water well levels, there is insufficient information to assess whether the effects would be positive or negative.			volume (48% < C3) compared to C3.	smaller volume (63% < C3) compared to C3.	smaller volume (68% < C3) compared to C3.	smaller area (39% < C3) and smaller volume (88% < C3) compared to C3.
Water Quality - Operation							
Suspended Sediment and Nutrients Presence of reservoir resulting in changes to water chemistry (e.g. suspended sediment, total metals, nutrients).	[13]Potential effects of C3 reservoir on water quality [downstream of C3] are: • suspended sediments and turbidity will be reduced; • nutrients, dissolved oxygen, total dissolved solids, hardness and iron will remain similar to present conditions. [6]Suspended sediment levels will be greatly reduced downstream of the C3 dam due to settling out of sediments in the C3 reservoir. This	Potential effects to water quality assumed slightly less than C3 based on smaller C1 or C2 reservoir surface area (11% < C3), volume (14% < C3) and shorter reservoir flushing time (13% < C3). Water quality conditions within Moberly River would not be altered. Presumably less effect to	Potential effects assumed slightly less than C3 based on smaller reservoir surface area (18% < C3), volume (25% < C3) and shorter reservoir flushing time (24% < C3). Water quality conditions within Moberly River would not be altered. Presumably less effect to	7b and Low C3 would have smaller reservoir surface area (18% < C3), volume (48% < C3) and shorter reservoir flushing time (47% < C3). Smaller, separate reservoirs would presumably result in less reservoir sedimentation due to shorter residence time and better flushing, and lower nutrient levels	3 cascade would have smaller reservoir surface area (21% < C3), volume (63% < C3) and shorter reservoir flushing time (62% <C3). Smaller, separate reservoirs would presumably result in less reservoir sedimentation due to shorter residence time and better flushing, and lower nutrient levels	4 cascade would have smaller reservoir surface area (21% <C3), volume (68% < C3) and shorter reservoir flushing time (67% < C3). Smaller, separate reservoirs would presumably result in less reservoir sedimentation due to shorter residence time	7 cascade would have smaller reservoir surface area (39%), volume (88% < C3) and shorter reservoir flushing time (88% < C3). Smaller, separate reservoirs would presumably result in less reservoir sedimentation due to shorter residence time

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	would be most noticeable between the dam and the confluence of the Pine River, 14 km downstream of C3. [6]Dissolved nutrients could be expected to increase in the C3 reservoir due to decaying organic matter and leaching of nutrients from the soil. As the reservoir ages, the nutrient context of the water decreases as nutrients are lost to the bottom sediments and to the outflow. This process could take 5-10 years in small reservoir and 10-30 years in large impoundments. [6]Based on previous study[8] increases in dissolved nutrient levels were deemed insignificant compared to the nutrients entering the reservoir from runoff from forested and agricultural lands. Thus, nutrient levels in the reservoir and outflow were expected to be similar to the levels in the Peace River. [12]No significant oxygen depletion is expected to occur in the reservoir and dissolved oxygen levels would reflect those of water released from Williston Lake (8 mg/1 for July to September).	reservoir suspended sediment and nutrient levels and Peace River downstream of C3 since Moberly River would not drain into C1 or C2 reservoir.	reservoir suspended sediment and nutrient levels and Peace River downstream of C3 since Moberly River would not drain into Wilder reservoir.	due to less decaying vegetation compared to C3.	due to less decaying vegetation compared to C3.	and better flushing, and lower nutrient levels due to less decaying vegetation compared to C3.	and better flushing, and lower nutrient levels due to less decaying vegetation compared to C3.
Water Temperature Reservoir presence and operation resulting in changes to water temperature	[4]Peace River water temperatures were cooler in the summer months than in tributaries, but warmer in the winter months; reflective of the influence of PCD releases. Peace River water temperatures increase the further downstream from the PCD such that the mean monthly water temperature downstream of	Potential effects assumed slightly less than C3 based on smaller C1 or C2 reservoir surface area (11% < C3), volume (14% < C3) and shorter reservoir flushing time (13% < C3). Water temperatures within	Potential effects assumed slightly less than C3 based on smaller reservoir surface area (18% < C3), volume (25% < C3) and shorter reservoir flushing time (24% < C3).	7b and Low C3 would have smaller reservoir surface area (18% < C3), volume (48% < C3) and shorter reservoir flushing time (47% < C3). Smaller and shallower Low C3 reservoir would	3 cascade would have smaller reservoir surface area (21% < C3), volume (63% < C3) and shorter reservoir flushing time (62% <C3). Assumed that a series of smaller, shallower	4 cascade would have smaller reservoir surface area (21% <C3), volume (68% < C3) and shorter reservoir flushing time (67% < C3). Assumed that a series of	7 cascade would have smaller reservoir surface area (39%), volume (88% < C3) and shorter reservoir flushing time (88% < C3). Assumed that a series

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	Kiskatinaw River was 4.7°C warmer in July 2007 than that recorded downstream of PCD. [1, 6]Based on previous study[8] average water temperature in the C3 reservoir during the summer months would be 2-3 °C warmer, reaching a maximum in July of 13.5 °C. In winter, reservoir water temperatures could be 1-2 °C warmer. Since thermal stratification is not expected in the reservoir, the dam will discharge this warmer water downstream.	Moberly River would not be altered.	Water temperatures within Moberly River would not be altered.	presumably have less influential effect on water temperature.	reservoirs would have less influential effect on water temperature.	smaller, shallower reservoirs would have less influential effect on water temperature.	of smaller, shallower reservoirs would have less influential effect on water temperature.
Methylmercury Presence of reservoir resulting in increased methylmercury levels due to decaying vegetation Note, information only; 0 weight applied since this factor scored in Social & Biologic Matrices	[1]Available evidence from other recently formed reservoirs suggest that methyl-mercury levels in the C3 reservoir could increase during the initial years after impoundment due to decaying organic matter. Methylmercury levels would be expected to decline over time to levels similar to natural lakes. The C3 reservoir would flood 6,183 ha of potentially vegetated land. Vegetation clearing prior to reservoir filling will reduce the potential for release of methylmercury from decaying vegetation.	The C1 reservoir would flood 5,475 ha of land (11% < C3). The C2 reservoir 5,619 ha of land (9% <C3). C1 or C2 would have shorter reservoir flushing time (13% < C3). Potential effects assumed similar to C3 based on similar extent of inundated lands and flushing time.	The Wilder Creek reservoir would flood 5,032 ha of land (19% < C3) and have shorter reservoir flushing time (24% < C3). Potential effects assumed slightly less based on smaller extent of inundated lands and shorter flushing time.	The 7b and Low C3 reservoirs would flood 4,629 ha of land (25% < C3) and shorter reservoir flushing time (47% < C3). Potential effects assumed slightly less based on smaller extent of inundated lands and shorter flushing time.	The 3 reservoirs would flood 4,351 ha of land (29% < C3) and have shorter reservoir flushing time (62% <C3). Potential effects assumed moderately less based on smaller extent of inundated lands and shorter flushing time.	The 4 reservoirs would flood 4,358 ha of land (30% < C3). Potential effects assumed moderately less based on smaller extent of inundated lands and shorter flushing time.	The 7 reservoirs would flood 2,737 ha of land (56% < C3) and have shorter reservoir flushing time (88% < C3). Potential effects assumed significantly less based on smaller extent of inundated lands and shorter flushing time.
Dissolved Gases Spillway operation resulting in excessive supersaturation of dissolved gases in discharge flows harmful to fish Note, information	[1]C3 spillway discharges could produce high levels of total dissolved gas in discharge flows harmful to fish downstream. Adding dividing walls and jet deflectors in the spillway is expected to reduce total dissolved gas to acceptable levels. Excessive supersaturation of	Potential effects assumed similar to C3 based on similar spillway height and discharges.	Potential effects assumed similar to C3 based on similar spillway height and discharges.	Potential effects assumed similar to C3 based on similar spillway height and discharges.	[5]There would be less opportunity for gas entrainment for the cascade development than with the [C3] spillways due to lower spillway heights.	There would be less opportunity for gas entrainment for the cascade development than C3 due to lower spillway heights.	There would be less opportunity for gas entrainment for the cascade development than C3 due to lower spillway heights.

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
only; 0 weight applied since this factor scored in Biological Matrix	dissolved gases, primarily nitrogen and oxygen, can cause gas bubble disease and eventual mortality in fish.						
Atmospheric Environment - Operation							
Climatic Conditions Reservoir presence and operation may affect climatic conditions (fog, wind, temperature) in the vicinity of the reservoir area	[1, 7, 12]Direct effects of the C3 reservoir on climatic conditions would be relatively small and 1imited in geographic extent, confined to the terraces within the valley (within 600 m of the reservoir shoreline). [7]Predicted effects include: •Increased frequency and density of fog (~ 28 days per year) particularly during cold weather in spring and fall. • Very small increase in dew during late summer to fall. • Increased wind speeds by 10% near the reservoir year around due the decrease in surface roughness. • Humidity and evaporation rates would increase slightly due to the reservoir, and there could be small changes in air temperature (±0.5 ^{o}C) around the reservoir. • Slightly lower late fall/early winter temperatures (<0.5^{o}C) due to frozen reservoir surface and increased solar reflectivity due to snow cover. Possible slightly higher summer temperatures (<0.5^{o}C) due to vegetation removal and increased humidity. [7]No significant changes to precipitation (rain or snow) expected.	Potential effects assumed similar to C3 based on similar C1 or C2 reservoir surface area (11% < C3), volume (14% < C3) and operating conditions.	Potential effects assumed slightly less C3 based on smaller reservoir surface area (18% < C3) and volume (25% < C3).	7b and Low C3 would have smaller reservoir surface area (18% < C3) and volume (48% < C3). Smaller, separate reservoirs would presumably have reduced effect to specific climate conditions.	3 cascade would have smaller reservoir surface area (21% < C3) and volume (63% < C3). Smaller, separate reservoirs would presumably have reduced effect to specific climate conditions.	4 cascade would have smaller reservoir surface area (21% <C3) and volume (68% < C3). Smaller, separate reservoirs would presumably have reduced effect to specific climate conditions.	7 cascade would have smaller reservoir surface area (39%), and volume (88% < C3). Smaller, separate reservoirs would presumably have reduced effect to specific climate conditions.

Physical Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
GHG GHG emission from decaying vegetation flooded by reservoir and construction emissions	[1]Greenhouse gas emissions from the C3 reservoir could increase during several years after the reservoir is created due to decaying organic matter. Based on KCB provided estimates of GHG emissions using the JW model, the following % differences were calculated compared to C3 GHG estimates.	4.4 to 15.9%	-17.9 to -18.5%	-14.1 to -20.6%	-7.3 to 5.1%	3.7 to 20.9 %	-31.2 to -37.6
Climate Change Effects on the Project due to Climate Change	[1]Preliminary work suggests that a 10 per cent increase or decrease in flows is possible depending on the time of year due to climate change effect associated with global warming. Long-term increases or decreases to flows could result in increased or decreased energy generation, respectively. There are no known current predictions as to the expected trend.	Assumed similar to C3	Assumed similar to C3	Assumed similar to C3	Assumed similar to C3	Assumed similar to C3	Assumed similar to C3

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[11]Peace River Development, Preparatory Activities for Site C Project, Cursory Evaluation of Cascade Option. BC Hydro. November 2002.
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[15]Socio-Economic Baseline and Preliminary Effects Assessment Methodology Site C Project Volume B—Land and Resource Uses. Lions Gate Consulting Inc. June 2009.
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Appendix C

Biological Environment Matrix

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Site C Evaluation of Alternatives

Biological Environment Aspects

Biological Environment

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
CONSTRUCTION **-** Cofferdams, tunnels and/or flow diversion channels as well as burrow/disposal areas - Dam (including spillway) and powerhouse - Reservoir Clearing - Reservoir Filling - Hwy 29 relocation, bridges and access roads **-** Transmission lines							
Aquatic Environment							
Aquatic fauna							
- fish community							
Peace River	- the construction of cofferdams, the main dam and powerhouse, as well as reservoir clearing and filling has the potential to affect up to thirty one species of sport and non-sport species in the Peace River (Compass, 2009) due to loss of habitat (footprint and associated work/transition areas), increased likelihood of sediment releases, and increased potential for water quality impairment due to contaminant releases (fuel spills, cement, etc) and	- the construction of cofferdams, the main dam and powerhouse, as well as reservoir clearing and filling have similar potential effects as those for Site C (cleared and flooded areas similar). - same for access bridge, roads and transmission line.	- the construction of cofferdams, the main dam and powerhouse expected to have similar effects on fish community. Area to be cleared/flooded is approximately 15% less than Site C, and would be expected to have less potential effect due to sediment releases, etc. - same for access bridge, roads and transmission line.	- the construction of cofferdams, the main dam and powerhouse at two sites has the potential for greater effects on the fish community due to loss of habitat (footprint and associated work/transition areas), increased likelihood of sediment releases, and increased potential for water quality impairment due to contaminant releases (fuel spills, cement, etc). - effects due to reservoir clearing and filling are similar to the Wilder Creek	- the construction of cofferdams, the main dam and powerhouse at three sites has the potential for greater effects on the fish community due to loss of habitat (footprint and associated work/transition areas), increased likelihood of sediment releases, and increased potential for water quality impairment due to contaminant releases (fuel spills, cement, etc). - effects due to reservoir clearing and filling are less than the other alternatives	- the construction of cofferdams, the main dam and powerhouse at four sites has the potential for greater effects on the fish community due to loss of habitat (footprint and associated work/transition areas), increased likelihood of sediment releases, and increased potential for water quality impairment due to contaminant releases (fuel spills, cement, etc).	- the construction of cofferdams, the main dam and powerhouse at seven sites has the potential for greater effects on the fish community due to loss of habitat (footprint and associated work/transition areas), increased likelihood of sediment releases, and increased potential for water quality impairment

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	reservoir clearing. Resevoir filling will substantially change habitat conditions. Bridge, access road and transmission line work not expected to significantly affect fish species (small local areas). ***Background*** *- Common sportfish species include mountain whitefish, arctic grayling, rainbow trout and walleye, with less common being bull trout, kokanee, lake whitefish, northern pike, burbot and goldeye (AMEC & LGL, 2008d). The proportion of sport fish in the local community declines from upstream to downstream, while suckers significantly increased (AMEC & LGL, 2008b).* *Mountain whitefish is the dominant species in the river, being distributed throughout the river system from Peace Canyon Dam to below Site C (P&E, 2002, 2003, Mainstream; 2004 – 2008) and is expected to be most affected. Mountain whitefish is found mainly in deep runs and riffles with cobble/gravel substrates, and is uncommon in pools and areas of fine substrate (RL&L, 1990, 1991). Younger fish (1-4 yrs old) exhibited better body condition in Section 1 (below PC Dam), while older fish (5-9 yrs old) exhibited better body condition in Section 5 (below Moberly River). Apparent annual mortality ranges from ~60 to 40%. Reservoir filling/creation will disrupt their food supply (benthic feeder) and is likely to adversely affect populations in the longer term.* *Cool-water species (burbot, walleye, yellow perch and northern pike) are more prevalent in downstream sections (below Cache Creek). Bull trout are distributed throughout the river, with apparent annual mortality ~ 40%. Arctic grayling are mostly in the lower portion below Cache Creek, with more older, larger fish present since 2005. Age 1 fish dominated above Cache Creek, age 2-4 fish dominated in reach from Moberly to Pine River. Apparent annual mortality is ~60%. (P&E, 2002, 2003, Mainstream; 2004 – 2008).* *Rainbow trout and kokanee were predominantly present in upstream sections (Mainstream, 2009), and are expected to be mostly unaffected by construction activities as well as reservoir clearing and filling. Arctic grayling, longnose dace and spottail shiner and trout perch were more predominant in lower sections (Mainstream, 2009), and are expected to be more affected by construction activities, as well as reservoir clearing and filling. Forage/minnow species became more*			alternative. - more opportunity for effect due to access bridge, roads and transmission line (2 sites).	due to the smaller cleared areas and future reservoirs. - more opportunity for effect due to access bridge, roads and transmission line (3 sites).	- effects due to reservoir clearing and filling are less than the other alternatives due to the smaller cleared areas and future reservoirs. - more opportunity for effect due to access bridge, roads and transmission line (4 sites).	due to contaminant releases (fuel spills, cement, etc). - effects due to reservoir clearing and filling are less than all the other alternatives due to the smaller cleared areas and future reservoirs. - most opportunity for effect due to access bridge, roads and transmission line (7 sites).

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	abundant as one moved downstream (Mainstream, 2009), and would also be affected by construction activities, as well as reservoir clearing and filling.						
Moberly River	- construction of cofferdams, the dam and the powerhouse at Site C is expected to alter the composition and abundance of the fish community due to the loss of upstream passage for Peace River fish or Moberly River fish that have moved below Site C back into the Moberly River as well as entrainment of any Moberly River fish that pass downstream through the flow diversion facilities. - reservoir clearing has the potential for direct effects on the adult fish community due to increased turbidity and/or suspended sediment load and on eggs and early life stages due to increased sedimentation over bottom substrate. - reservoir filling will result in habitat changes that may result in the loss of some species from the inundation area (i.e. mountain whitefish) that depend on flowing water benthic organisms as a food supply). ***Background*** *- Surveys during fall 2005 collected 11 species with longnose and white sucker being the most abundant large fish species (an unidentified minnow was the most abundant species), followed by mountain whitefish, longnose dace, redside shiner and largescale sucker. Rainbow trout, burbot and northern pikeminnow each represented ≤1% of the catch. The second highest catch per unit effort (4.3 fish/100 seconds) was attained in this tributary (AMEC & LGL, 2008d).*	Moberly River fish community unaffected by this option as dam is upstream of river.	Moberly River fish community unaffected by this option as dam is upstream of river	- construction of cofferdams, the dam and the powerhouse at Site C is expected to have similar effects as noted for Site C. - reservoir clearing expected to have less effect due to lower dam (at Site C) and smaller cleared area (~37% smaller) within Moberly valley. - lower level of effects anticipated from reservoir filling due to smaller inundation length (7.8 km vs 11.6 km for Site C)	- construction of cofferdams, the dam and the powerhouse at Site C is expected to have similar effects as noted for Site C. - reservoir clearing expected to have significantly less effect due to lower dam (at Site C)and smaller cleared area (~76% smaller) within Moberly valley. - lower level of effects anticipated from reservoir filling due to smaller inundation length (3.8 km vs 11.6 km for Site C)	- construction of cofferdams, the dam and the powerhouse at Site C is expected to have similar effects as noted for Site C. - reservoir clearing expected to have less effect due lower dam (at Site C) and smaller cleared area (~82% smaller) within Moberly valley. - lower level of effects anticipated from reservoir clearing due to smaller inundation length (2.8 km vs 11.6 km for Site C)	- construction of cofferdams, the dam and the powerhouse at Site C is expected to have similar effects as noted for Site C. - reservoir clearing expected to have least effect due lower dam (at Site C) and smaller cleared area (~94% smaller). - lowest level of effects anticipated from reservoir clearing due to smaller inundation length (1.2 km vs 11.6 km for Site C)
Wilder Creek	- construction of cofferdams, the dam and the powerhouse	- no significant difference from Site C	- no significant difference from Site C with the	- similar to Site C in terms of potential effects of	- similar to Site C in terms of potential effects of	- similar to Site C in terms of potential effects	- potential for Wilder Creek fish to be

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	at Site C is unlikely to significantly alter the composition and/or abundance of the fish community of Wilder Creek (predominantly forage fish community that does not travel long distances) - reservoir clearing has the potential for direct effects on the fish community due to increased turbidity and/or suspended sediment load and on eggs and early life stages due to increased sedimentation over bottom substrate. - reservoir filling will result in habitat changes that may reduce the suitability of the habitat within the inundated area for forage fish species that prefer flowing-water environments. ***Background*** *- Longnose dace were the only fish collected during electroshocking surveys in fall 2005 (AMEC & LGL, 2008d). Peamouth and flathead chub were collected in previous surveys (AMEC, 2008)*		exception that there is greater potential for Wilder Creek fish that enter the Peace River to be entrained into the diversion tunnel and passed into the downstream reach with no opportunity of return.	cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~40% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (2.0 km vs 2.9 km for Site C)	cofferdam, dam and powerhouse. - significantly less potential effect from reservoir clearing due lower FSL and smaller cleared area (~80% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (0.8 km vs 2.9 km for Site C)	of cofferdam, dam and powerhouse. - significantly less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~90% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (0.6 km vs 2.9 km for Site C)	passed downstream during the second stage of construction at Site 7F with limited chance of return. - significantly less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~90% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (0.6 km vs 2.9 km for Site C)
Cache Creek and Red Creek	- construction of cofferdams, the dam and the powerhouse at Site C is unlikely to significantly alter the composition and/or abundance of the fish community of Cache or Red Creek (predominantly forage fish community that does not travel long distances). - reservoir clearing has the potential for direct effects on the fish community due to increased turbidity and/or suspended sediment load and effects on eggs and early life	- no significant difference from Site C.	- no significant difference from Site C.	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~40% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (6.7 km vs 11.5 km for Site C)	- similar to Site C except that there is greater potential for Cache Creek fish to be entrained into the diversion flow at Dam 3B and passed into the downstream reach with limited opportunity to return. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~40% smaller) - lower level of effects anticipated from reservoir	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - significantly less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~70% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (4.3 km vs 11.5 km for Site C)	- similar to Site C in terms of potential effects of construction, but significantly greater potential to entrain Cache Creek fish that enter the Peace River into the diversion flow at Dam 7E and pass them downstream with limited opportunity for return. - significantly less potential effect from

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	stages due to increased sedimentation over bottom substrate. - reservoir filling will result in habitat changes that may reduce the suitability of the habitat within the inundated area for forage fish species that prefer flowing-water environments. ***Background*** *- No sportfish, but five other species were identified in Cache Creek during electroshocking surveys in fall 2005. In declining relative abundance, they are: an unidentified minnow, redside shiner, longnose sucker, longnose dace and northern pikeminnow. Only the unidentified minnow and longnose sucker were collected in Red Creek. Cache creek had the highest catch per unit effort of all tributaries sampled (AMEC & LGL, 2008d).*				filling due to smaller inundation length (6.2 km vs11.5 km for Site C)		reservoir clearing due to lower FSL and smaller cleared area (~90% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (3.1 km vs 11.5 km for Site C)
Halfway River	- construction of cofferdams, the dam and the powerhouse at Site C has the potential to somewhat alter the composition and/or abundance of the fish community of Halfway River, particularly migratory species (i.e. bull trout) that pass through the diversion tunnel and are unable to return. Most other sport species (mountain whitefish, arctic grayling) remain within their local areas. - reservoir clearing has the potential for direct effects on the fish community due to increased turbidity and/or suspended sediment load and effects on eggs and early life stages due to increased sedimentation over bottom substrate.	- no significant difference from Site C.	- no significant difference from Site C.	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~45% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (8.6 km vs 15.5 km for Site C).	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~50% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (7.8 km vs 15.5 km for Site C).	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse except that there is significant potential for Halfway River fish that venture into the Peace River to be entrained into the diversion flow at Dam 4B and passed into the downstream reach with limited opportunity to return. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~40% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (9.8 km vs 15.5 km for	- no significant difference from Site C with the exception that there is greater potential for Halfway River fish to be entrained into the diversion flow at Dam 7D and passed into the downstream reach with limited opportunity to return. - significantly less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~85% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (4.2 km vs 15.5 km

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	- reservoir filling will result in habitat changes that may reduce the suitability of the habitat within the inundated area for sport and forage fish species that prefer flowing-water environments, causing them to move to other preferred areas. ***Background*** *– Radiotelemetry investigations in 2007 demonstrated that bull trout can move considerable distances (up to 450 km annually) with two individuals moving from the Pine River system to the upper Halfway River in late summer, and then returning to the Pine River in late fall after the spawning period was over. Juvenile bull trout have been found at various locations within the Halfway River (AMEC & LGL, 2008b).* *A resident population of arctic grayling is present within the upper watershed, and largely remains there with few fish moving downstream into the Peace River (AMEC & LGL, 2008b).* *Radiotagged mountain whitefish also moved into the Halfway River during the fall of 2007 (AMEC & LGL, 2008b). RL&L (1990 & 1991) reported large numbers of spawning whitefish in the lower Halfway during fall 1989 and collected record numbers of larval whitefish in the Peace mainstem below the Halfway River junction the following spring and summer. Electroshocking surveys during fall 2005 collected 12 species with longnose sucker and redside shiner being the most abundant fish species, followed by mountain whitefish, white sucker and largescale sucker, flathead chub, northern pikeminnow and bull trout. Rainbow trout, an unidentified minnow, longnose dace and lake chub each represented _up to 2% of the catch (AMEC & LGL, 2008d).* *Surveys extending 40 km upstream from the Peace River confluence during August 2006 collected 16 species. Sportfish accounted for ~11% of the sample, with mountain whitefish the most numerous (10.5% of total). Suckers accounted for ~1/3 of the sample, with longnose the most abundant (24% of total) followed by largescale (7%). White sucker were absent. Minnows were the most abundant group, with longnose dace (21% of total) and redside shiner (~24% of total) being the most abundant. No distinct upstream/downstream distribution differences were apparent for most species, except mountain whitefish which were more*					Site C).	for Site C).

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	abundant in the lower section (area subject to inundation by Site C dam) (Mainstream, 2009)						
Farrell Creek	- construction of cofferdams, the dam and the powerhouse at Site C is unlikely to significantly alter the composition and/or abundance of the fish community of Farrell Creek. - reservoir clearing has the potential for direct effects on the fish community due to increased turbidity and/or suspended sediment load and effects on eggs and early life stages due to increased sedimentation over bottom substrate. - reservoir filling will result in habitat changes that may reduce the suitability of the habitat within the inundated area for sport and forage fish species that prefer flowing-water environments, causing them to move to other preferred areas. ***Background*** *- Six species identified during electroshocking surveys in fall 2005. In declining relative abundance, they are: longnose dace, an unidentified minnow, longnose sucker, young-of-the-year mountain whitefish, slimy sculpin and redside shiner (AMEC & LGL, 2008d). Rainbow trout was the second most common sportfish species caught in creek in spring 2006 and juveniles were found that summer (AMEC & LGL, 2007). Limited movement of adult arctic grayling and mountain whitefish was also reported into Farrell Creek (RRCS, 1978).*	- no significant difference from Site C.	- no significant difference from Site C.	- construction of cofferdams, the dam and the powerhouse at Site 7b is expected to have little effect on the forage fish community, but has potential to alter the composition and/or abundance of the sport fish community of Farrell Creek (i.e. particularly rainbow trout) if they are unable to return to preferred upstream habitat in the Peace River above Dam 7b after passage through the diversion tunnel. - no difference from Site C in terms of reservoir clearing and filling.	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that there is greater potential for Farrell Creek fish that venture into the Peace River to be entrained into the diversion flow at Dam 3A and passed into the downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that there is greater potential for Farrell Creek fish that venture into the Peace River to be entrained into the diversion flow at Dam 4A and passed into the downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	- construction of cofferdams, the dam and the powerhouse at Site 7b is expected to have little effect on the forage fish community, but has potential to alter the composition and/or abundance of the sport fish community of Farrell Creek (i.e. particularly rainbow trout) if they are unable to return to preferred upstream habitat in the Peace River above Dam 7b after passage through the diversion tunnel. - significantly less effect from reservoir clearing due to lower FSL and small cleared area (~75% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (0.9 km vs 3.6 km for Site C)
Lynx Creek	- construction of cofferdams, the dam and the powerhouse at Site C is unlikely to significantly alter the	- no significant difference from Site C.	- no significant difference from Site C.	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse,

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	composition and/or abundance of the fish community of Farrell Creek. - reservoir clearing has the potential for direct effects on the fish community due to increased turbidity and/or suspended sediment load and effects on eggs and early life stages due to increased sedimentation over bottom substrate. - reservoir filling will result in habitat changes that may reduce the suitability of the habitat within the inundated area for sport and forage fish species that prefer flowing-water environments, causing them to move to other preferred areas. ***Background*** *- Electroshocking surveys during fall 2005 collected 10 species with longnose dace and mountain whitefish being the most abundant, followed by northern pikeminnow, longnose sucker, and rainbow trout. Mountain whitefish were young of the year. Bull trout, an unidentified minnow, white sucker and redside shiner each represented about 1% of the catch (AMEC & LGL, 2008d). Rainbow trout was the second most common sportfish species caught during spring 2006, with juveniles found that summer (AMEC & LGL, 2007)*			there is greater potential for Lynx Creek fish that venture into the Peace River to be entrained into the diversion flow at Dam 7B and passed into the downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	there is greater potential for Lynx Creek fish that venture into the Peace River to be entrained into the diversion flow at Dam 3A and passed into the downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	there is greater potential for Lynx Creek fish that venture into the Peace River to be entrained into the diversion flow at Dam 4A and passed into the downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	except that there is greater potential for Lynx Creek fish that venture into the Peace River to be entrained into the diversion flow at Dam 7B and passed into the downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.
Maurice Creek	- construction of cofferdams, the dam and the powerhouse at Site C is unlikely to significantly alter the composition and/or abundance of the fish community of Farrell Creek. - no inundation of Maurice Creek expected, hence no reservoir clearing or filling effects. ***Background*** *- Eight species identified during electroshocking surveys in fall 2005. In*	- no significant difference from Site C.	- no significant difference from Site C.	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that there is greater potential for Maurice Creek fish (particularly rainbow trout) that venture into the Peace River to be entrained into the diversion flow at Dam 7B and passed into the downstream reach with	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that there is greater potential for Maurice Creek fish (particularly rainbow trout) that venture into the Peace River to be entrained into the diversion flow at Dam 3A and passed into the downstream reach with	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that there is greater potential for Maurice Creek fish (particularly rainbow trout) that venture into the Peace River to be entrained into the diversion flow at Dam 4A and passed into the	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse, except that there is greater potential for Maurice Creek fish (particularly rainbow trout) that venture into the Peace River to be entrained into the diversion flow at

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	declining relative abundance, they are: slimy sculpin, rainbow trout, prickly sculpin, mountain whitefish, and longnose dace. Mountain whitefish were young of the year. Arctic grayling, longnose sucker, and white sucker each made up <1% of the catch (AMEC & LGL, 2008d). Rainbow trout was the second most common sportfish species caught in the creek during spring 2006 and juveniles were found that summer. Bull trout juveniles were also collected. (AMEC & LGL, 2007).			limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	downstream reach with limited opportunity to return. - no difference from Site C in terms of reservoir clearing and filling.	Dam 7B and passed into the downstream reach with limited opportunity to return, and outlet from diversion tunnel at Dam 7A may adversely affect the entrance into the creek. - no difference from Site C in terms of reservoir clearing and filling.
Upstream or downstream fish movement and/or migrations	**-** construction of cofferdams, the dam and the powerhouse at Site C will prevent upstream movement past the work area and will prevent any fish that move downstream through the diversion tunnels from returning upstream. This effect is considered to be the most significant for arctic grayling that utilize the Moberly River for a portion of their spawning run, and those bull trout that move between the Pine and Halfway rivers. No significant effect anticipated for walleye or rainbow trout as movements do not typically span the Site C area. Mountain whitefish would be affected locally (i.e. in the vicinity of the work area), but are present throughout the river system, would be largely unaffected overall. - reservoir clearing is not	- fish movements and/or migrations into the Moberly river will be unaffected by this alternative. Effects on Peace River species are essentially the same as outlined for Site C. - no significant difference for reservoir clearing or filling.	- fish movements and/or migrations into the Moberly river will be unaffected by this alternative. Effects on Peace River species are essentially the same as outlined for Site C. - no significant difference for reservoir clearing or filling.	- effects of Low C are similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. However, the addition of a second work area at 7B increases the potential for disruption of movements and/or migrations. Rainbow trout as well as other sport and forage species within the area above 7B could be entrained into the diversion flow and passed downstream with limited opportunity to return. - no significant difference for reservoir clearing or filling.	**-** construction of cofferdams, the dam and the powerhouse at three sites would further partition the river into short segments and increase the potential for interference with movement and/or migrations. Species that pass through the diversion flows would have limited opportunity to return, potentially affecting species composition within the individual reaches. Sport fish species with the greatest potential to be affected are bull trout, arctic grayling and rainbow trout. - no significant difference for reservoir clearing or filling.	**-** construction of cofferdams, the dam and the powerhouse at four sites would further partition the river into short segments and increase the potential for interference with movement and/or migrations. Species that pass through the diversion flows would have limited opportunity to return, potentially affecting species composition within the individual reaches. Sport fish species with the greatest potential to be affected are bull trout (entrainment through diversion flow at Dam 4B), arctic grayling (entrainment through diversion flow at Dam 4D) and rainbow trout (entrainment through diversion flow at Dam	**-** construction of cofferdams, the dam and the powerhouse at seven sites would further partition the river into short segments and increase the potential for interference with movement and/or migrations. Species that pass through the diversion flows would have limited opportunity to return, potentially affecting species composition within the individual reaches. Sport fish species with the greatest potential to be affected are bull trout (entrainment through diversion flow at Dam 7D), arctic grayling (entrainment through diversion flow at

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	expected to affect fish movements. - reservoir filling may indirectly affect migratory movements (less ability to follow in-water chemical cues, currents, etc). ***Background:*** ***Rainbow Trout*** *– show limited movement, and reside primarily between PC Dam and Cache Creek. Some use of Maurice and Lynx creeks for spawning and rearing. (AMEC & LGL, 2008b)* ***Bull trout*** *– Significant portion from Halfway River (57% of tagged fish in 1996-1999 study) migrate to Peace River mainstem and spend ~ 70% of their time in the Peace River. They rarely enter other tributaries. Of those migrating to the Peace, 29% were found below the Moberly confluence, 56% were found above the Halfway River, and the rest were between those two areas (AMEC & LGL, 2008a). Some bull trout undertake extensive movements - spawn (and rear) in the Halfway River, then move to the Pine river to forage. There is also a group within the Pine River that rears and forages primarily in the Pine river, and spawns in the Burnt River. (AMEC & LGL, 2008b).* ***Arctic Grayling*** *– Distinct Peace River, Pine River and Halfway River groups are likely, with the latter two group remaining within their respective rivers throughout the year (AMEC & LGL, 2008 a & b). Spawning migrations by the Peace River group occur into the Moberly River under the ice in early spring. They then return to the Peace River mainstem for remainder of year. About 20% of the spring migrants passed the upstream inundation limit within the Moberly River (AMEC & LGL, 2008c). Limited use of Beatton River also possible (AMEC & LGL, 2008b).* ***Mountain Whitefish*** *– Broadly distributed in Peace River (PC Dam to Alberta) with relatively little movement between the mainstem and tributaries even during spawning period. Limited spawning migrations into lower reaches of Halfway, Moberly and Pine rivers. (AMEC & LGL, 2008b)* ***Walleye*** *– Two groups of walleye identified. One group (~50% of fish tracked) exhibited distinct spring spawning movement into and out of Beatton River, and utilized Peace River mainstem between Beatton and Moberly rivers outside the spawning season. Second group remained within Peace River mainstem below Beatton mouth into Alberta with no*					4A). - no significant difference for reservoir clearing or filling.	Dam 7G) and rainbow trout (entrainment through diversion flow at Dam 7A & 7B). - no significant difference for reservoir clearing or filling.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	distinct seasonal movements, although one individual travelling extensively (>600 km) (AMEC & LGL, 2008b).						
Lower trophic level communities (plankton, benthos and macrophytes)	- construction of cofferdams, the dam and powerhouse will eliminate benthic organisms and macrophyte communities within the footprint of the work area. No affect predicted on plankton communities as they mostly arise from upstream sources, with short downstream passage times that would no facilitate population growth. ***Background*** *- No current information on benthic community – expect it to be flowing-water community dominated by mayfies (Ephemeroptera), stoneflies (Plecoptera), caddis flies (Trichoptera).*	- no significant change from Site C	- no significant change from Site C	- footprint of two dams would result in more loss of benthic community and macrophytes.	- footprint of three dams would result in more loss of benthic community and macrophytes.	- footprint of four dams would result in more loss of benthic community and macrophytes.	- footprint of seven dams would result in more loss of benthic community and macrophytes.
Rare and listed species	No COSEWIC (federal) listed species in project area. Spottail shiner is red-listed, while bull trout, goldeye and pearl dace are blue-listed in BC (AMEC & LGL, 2008d). ***Spottail Shiner -*** construction of cofferdams, the dam and powerhouse is not expected to significantly affect spottail shiners, although any approaching the diversion tunnel would be entrained and passed downstream with no opportunity to return - reservoir clearing and filling are not expected to significantly affect spottail shiner. ***Background:*** ***Spottail Shiner*** *- A common and abundant minnow throughout Canada from Ontario to Alberta and into the northern US, and is at the western limit of its distribution range in the Peace River system. Its habitat is typically lakes or large rivers, and is an important forage species in many systems*	- no significant change from Site C	- no significant change from Site C	- slightly greater potential to affect bull trout due to a second work area/dam within the Peace River. No significant change from Site C for spottail shiner, goldeye or pearl dace.	- increasingly greater potential to affect bull trout due to a third work area/dam within the Peace River. No significant change from Site C for spottail shiner, goldeye or pearl dace.	- increasingly greater potential to affect bull trout due to a fourth work area/dam within the Peace River, and significant potential for Halfway River fish to be entrained and passed downstream by the diversion flow at Dam 4B with limited opportunity to return to the Halfway River. No significant change from Site C for spottail shiner, goldeye or pearl dace.	- increasingly greater potential to affect bull trout due to a seventh work area/dam within the Peace River, and significant potential for Halfway River fish to be entrained and passed downstream by the diversion flow at Dam 7D with limited opportunity to return to the Halfway River. No significant change from Site C for spottail shiner, goldeye or pearl dace.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	(S&C, 1985). During small fish sampling programs in 2006 (Mainstream, 2009), spottail shiner comprised 5.3% of the Peace River sample and a few (0.2%) were collected in the Halfway River. In the Peace River they were most prevalent between Cache Creek and the BC-Alberta border. ***Bull trout*** - construction of cofferdams, the dam and the powerhouse would prevent those bull trout that travel between Pine and Halfway rivers from returning to the Halfway River after passing through the diversion tunnel. - reservoir clearing could increase erosion and sediment inputs, but is expected to have minimal effects overall. - reservoir filling will change habitat conditions throughout the length of the river system and in the mouths of affected tributaries, but this is unlikely to significantly affect bull trout as spawning/rearing areas are in the headwaters of the Halfway and Pine river systems (both of which are unaffected by this process), and foraging/refuge habitat areas will be increased. ***Goldeye -*** construction of cofferdams, the dam and powerhouse is not expected to affect goldeye, although any approaching the diversion tunnel would be entrained and passed downstream - reservoir clearing and filling are not expected to adversely affect goldeye. ***Background*** *- Within Canada, goldeye is widely distributed from northwestern Ontario*						

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	to Alberta, into the Peace River drainage in BC, and into the northern US. Its typical habitat is quiet, turbid water of large rivers and connected waterbodies, using deep water habitat for overwintering (S&C, 1989). In the project area, goldeye were reported downstream of Taylor during studies in 1989 and 1990 (RL&L, 1991a,1991b) and 9 fish were collected between Lynx Creek and Peace Canyon Dam during community index sampling in 2001 (P&E, 2002), but none throughout the project area since. ***Pearl Dace -*** construction of cofferdams, the dam and powerhouse is not expected to affect pearl dace as they are rare in the project area and unlikely to be in the Peace River mainstem (see Background for habitat preference) - reservoir clearing and filling are not expected to affect pearl dace. ***Background*** *– widely distributed in Canada from the Maritime provinces to Alberta (S&C, 1989). Typically a minnow of cool, clear headwater streams, beaver ponds, and/or bog drainage streams, ponds and small lakes. ARL (1991) reported the capture of pearl dace in Lynx Creek during 1989 surveys. No collections reported since then.*						
Aquatic Habitat							
- Spawning and rearing habitat							
Peace River	- initial construction activities (cofferdams, tunnels, dam and powerhouse) will directly affect ~22 ha of potential spawning habitat within the footprint of those facilities. Fluctuating daily flows (from upstream facility releases) are expected to result in daily water level fluctuations of up to 12 m upstream of cofferdams and tunnels with	- generally similar to site C - initial construction activities (cofferdams, tunnels, dam and powerhouse) will directly affect ~17 ha of potential spawning habitat within the footprint of those facilities, and daily water level fluctuations will extend ~ 25 km upstream. This area is not critical spawning habitat, but	- generally similar to site C - initial construction activities (cofferdams, tunnels, dam and powerhouse) will affect ~ 135 ha of potential spawning habitat within the footprint of those facilities. Changed flow characteristics (due to diversion structures) will affect a short distance upstream and downstream of	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will affect ~57 ha of potential spawning habitat within the footprint of the two facilities. Changed flow characteristics (due to diversion structures) will affect a short distance upstream and downstream of	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will affect ~ 150 ha of potential spawning habitat within the footprint of the three facilities. Changed flow characteristics (due to diversion structures) will affect a short distance upstream and downstream	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will affect ~ 200 ha of potential spawning habitat within the footprint of those facilities. Changed flow characteristics (due to diversion structures) will affect a short distance	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will affect ~ 350 ha of potential spawning habitat within the footprint of the seven facilities. Changed flow characteristics (due to diversion

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	changes extending as far upstream as Cache Creek (~ 25 km). This area is not critical spawning habitat, but may be used by mountain whitefish, sucker and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back channel and nearshore spawning habitat (used by northern pike and other cool-water species) and/or rearing habitat (used by northern pike and other cool-water species) along ~85 km of the river. This may also affect mountain whitefish, arctic grayling and other species that use the Peace River for spawning. - reservoir filling will inundate ~85 km of spawning and rearing habitat utilized by mountain whitefish, nortern pike, arctic grayling and other sport and non-sport fish species. ***Background*** *- Mountain whitefish spawn and rear throughout the mainstem of the river, while northern pike use the vegetated off-channels for spawning and rearing. Bull trout and rainbow trout use the Peace River for rearing (AMEC, 2008). Arctic grayling may also utilize spawning habitat in the Peace River mainstem between Cache Creek and Beatton River (i.e. >80% of tagged fish in 2007 stayed in this area throughout spring spawning period) (AMEC & LGL, 2008b).*	may be used by mountain whitefish, suckers and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back-channel and nearshore spawning and rearing habitat along ~79-81.5 (C1 or C2) km of the river. This may affect mountain whitefish, northern pike, arctic grayling and other species that use the Peace River for spawning. - reservoir filling will inundate ~79-81.5 (C1 or C2) km of spawning and rearing habitat utilized by mountain whitefish, northern pike, arctic grayling and other sport and non-sport fish species.	the site. This area is not critical spawning habitat, but may be used by mountain whitefish, suckers and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back-channel and nearshore spawning and rearing habitat along ~73 km of the river. This may affect mountain whitefish, arctic grayling and other species (arctic grayling) that use the Peace River for spawning. - reservoir filling will inundate ~73 km of spawning and rearing habitat utilized by mountain whitefish, northern pike, arctic grayling and other sport and non-sport fish species.	the site. This area is not critical spawning habitat, but may be used by mountain whitefish, suckers and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back-channel and nearshore spawning and rearing habitat along ~85 km of the river. This may affect mountain whitefish, arctic grayling and other species (arctic grayling) that use the Peace River for spawning. - reservoir filling will inundate ~85 km of spawning and rearing habitat utilized by mountain whitefish, northern pike, arctic grayling and other sport and non-sport fish species.	of the site. This area is not critical spawning habitat, but may be used by mountain whitefish, suckers and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back-channel and nearshore spawning and rearing habitat along ~85 km of the river. This may affect mountain whitefish, arctic grayling and other species (arctic grayling) that use the Peace River for spawning. - reservoir filling will inundate ~85 km of spawning and rearing habitat utilized by mountain whitefish, northern pike, arctic grayling and other sport and non-sport fish species.	upstream and downstream of the site. This area is not critical spawning habitat, but may be used by mountain whitefish, suckers and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back-channel and nearshore spawning and rearing habitat along ~85 km of the river. This may affect mountain whitefish, arctic grayling and other species (arctic grayling) that use the Peace River for spawning. - reservoir filling will inundate ~85 km of spawning and rearing habitat utilized by mountain whitefish, northern pike, arctic grayling and other sport and non-sport fish species.	structures) will affect a short distance upstream and downstream of the site. This area is not critical spawning habitat, but may be used by mountain whitefish, suckers and/or arctic grayling. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect back-channel and nearshore spawning and rearing habitat along ~85 km of the river. This may affect mountain whitefish, arctic grayling and other species (arctic grayling) that use the Peace River for spawning. - reservoir filling will inundate ~85 km of spawning and rearing habitat utilized by mountain whitefish, northern pike, arctic grayling and other sport and non-sport fish species.
Moberly River	- initial construction activities	- construction activities	- construction activities	- initial construction	- initial construction	- initial construction	- initial construction

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	(cofferdams, tunnels, dam and powerhouse) may affect spawning habitat in the Moberly River (due to ponding/fluctuations upstream of the cofferdam). - reservoir clearing along the Moberly has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning and rearing habitat downstream of the clearing activities. This could affect mountain whitefish, arctic grayling and northern pike. - reservoir filling will inundate approximately 11.6 km of spawning and rearing habitat utilized by arctic grayling and other fish species. ***Background*** *- Moberly River used by arctic grayling and mountain whitefish for spawning and rearing, as well as northern pike (AMEC, 2008). Also noted that it likely contributes more to annual recruitment than any other tributary upstream of Site C (AMEC & LGL, 2008b).*	(cofferdams, tunnels, dam and powerhouse, reservoir clearing and filling) at Site C1 or C2 will not affect existing spawning habitat for arctic grayling, mountain whitefish and any other Peace River fish species that use the Moberly River for spawning.	(cofferdams, tunnels, dam and powerhouse, reservoir clearing and filling) at Site C1 or C2 will not affect existing spawning habitat for arctic grayling, mountain whitefish and any other Peace River fish species that use the Moberly River for spawning.	activities (cofferdams, tunnels and diversion channels, dam and powerhouse) have similar potential to affect spawning habitat in the Moberly River. - reservoir clearing has less potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning habitat downstream of the clearing activities (due to ~ 40% smaller cleared area). - reservoir filling will inundate approximately 7.8 km of spawning habitat utilized by arctic grayling and other fish species.	activities (cofferdams, diversion channels, dam and powerhouse) has less potential to affect spawning habitat in the Moberly River (less water level fluctuation due to flow diversion). - reservoir clearing has less potential than Site C or Low C and 7b to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning habitat downstream of the clearing activities. - reservoir filling will inundate approximately 3.8 km of spawning habitat utilized by arctic grayling and other fish species.	activities (cofferdams, diversion channels, dam and powerhouse) has less potential to affect spawning habitat in the Moberly River (less water level fluctuation due to flow diversion). - reservoir clearing has less potential than Site C to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning habitat downstream of the clearing activities. - reservoir filling will inundate approximately 2.8 km of spawning habitat utilized by arctic grayling and other fish species.	activities (cofferdams, diversion channels, dam and powerhouse) has less potential to affect spawning habitat in the Moberly River (less water level fluctuation due to flow diversion). - reservoir clearing has less potential than Site C to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning habitat downstream of the clearing activities. - reservoir filling will inundate approximately 1.1 km of spawning habitat utilized by arctic grayling and other fish species.
Wilder Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) at Site C and associated water level fluctuations could affect spawning or rearing habitat in Wilder Creek. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and potentially adversely affect any spawning habitat	- no significant change from Site C	- fluctuating daily water levels from cofferdam immediately downstream of creek mouth likely to adversely affect spawning/rearing habitat	- no significant change from Site C for initial construction activities. -reservoir clearing and filling will have less potential impact due to lower FSL.	- less potential change in water level from initial construction activities. -reservoir clearing and filling will have less potential impact due to lower FSL.	- less potential change in water level from initial construction activities. -reservoir clearing and filling will have less potential impact due to lower FSL.	- less potential change in water level from initial construction activities. -reservoir clearing and filling will have less potential impact due to lower FSL.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	downstream of the clearing activities (no rearing habitat in the creek due to minimal summer flow). - reservoir filling will inundate approximately ~2.9 km of creek length and could adversely affect any species that utilize this creek during the spring when flows are adequate. ***Background*** *- Unlikely to be of use for fall spawning species due to lack of flow. Potential for spring spawning when flows are adequate (AMEC & LGL, 2008d).*						
Cache Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not affect any spawning or rearing habitat in Cache Creek. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning or rearing habitat downstream of the clearing activities. - reservoir filling will inundate approximately 11.5 km of spawning and rearing habitat potentially utilized by mountain whitefish, arctic grayling and cyprinid species. ***Background*** *- Ample spawning gravel and some good off-channel habitat is present in the lower reach within the inundation area (AMEC & LGL, 2008d). Juvenile mountain whitefish and YOY arctic grayling have been found in the creek, as well as numerous cyprinids (RRCS, 1978; ARL, 1991a). Red Creek enters Cache Creek approximately 6.5 km upstream of the Peace River junction. Creek has poor water quality (excessive iron deposits - water is red), and habitat is of poor quality (AMEC & LGL, 2008d).*	- no significant change from Site C	--fluctuating daily water levels from cofferdam immediately downstream of Wilder Creek mouth has more potential to adversely affect spawning/rearing habitat	- no significant change from Site C for initial construction activities. -reservoir clearing and filling will have less potential impact due to lower FSL.	- less potential change in water level from initial construction activities (diversion channel used at dam 3b instead of tunnel). -reservoir clearing and filling will have less potential impact due to lower FSL.	- less potential change in water level from initial construction activities (diversion channel used at dam 4c instead of tunnel). -reservoir clearing and filling will have less potential impact due to lower FSL.	- no significant change from Site C for initial construction activities(diversion channel used at dam 7e instead of tunnel). -reservoir clearing and filling will have less potential impact due to lower FSL.
Halfway River	- initial construction activities (cofferdams, tunnels, dam and	- no significant change from Site C	- no significant change from Site C	- similar to Site C in terms of potential effects of	- less potential change in water level from initial	- less potential change in water level from initial	- less potential change in water level

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	powerhouse) should not physically affect spawning or rearing habitat. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning and rearing habitat downstream of the clearing activities for mountain whitefish, bull trout, arctic grayling, rainbow trout and other forage/non-sport species. - reservoir filling will inundate approximately 15.5 km of spawning and rearing habitat and will reduce the suitability of that habitat for those functions. ***Background*** *- Ample good quality spawning gravel was present in lower reaches as well as off-channel habitats with cover (AMEC & LGL, 2008d). Halfway River known to provide spawning and rearing habitat for mountain whitefish, bull trout, arctic grayling and rainbow trout (AMEC, 2008).*			cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~45% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (8.6 km vs 15.5 km for Site C).	construction activities. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~50% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (7.8 km vs 15.5 km for Site C).	construction activities. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~40% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (9.8 km vs 15.5 km for Site C).	from initial construction activities. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~85% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (4.2 km vs 15.5 km for Site C).
Farrell Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not physically affect spawning or rearing habitat. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning and rearing habitat downstream of the clearing activities for arctic grayling, rainbow trout or longnose sucker. - reservoir filling will inundate approximately 3.6 km of	- no significant change from Site C	- no significant change from Site C	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (~80% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (1.1 km vs 3.6 km for Site C).	- no significant change from Site C	- no significant change from Site C	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (<0.1 ha) - lower level of effects anticipated from reservoir filling due to smaller inundation length (0.9 km vs 3.6 km for Site C).

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	spawning and rearing habitat and will reduce the suitability of that habitat for those functions. ***Background*** *- Ample spawning gravel is present within the inundation area and above. Off-channel habitats are present mostly in the upper reach, but were aggraded and lacked flow during the fall 2005 survey (AMEC & LGL, 2008d). Farrell creek is used by arctic grayling, rainbow trout and longnose suckers for spawning, and one juvenile mountain whitefish was found (RRCS, 1978; ARL, 1991a & 1991b).*						
Lynx Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not physically affect spawning or rearing habitat. - reservoir clearing has the potential to increase the input of fine sediments (due to erosion within cleared areas) and adversely affect spawning and rearing habitat downstream of the clearing activities for rainbow trout, longnose sucker and various cyprinids. - reservoir filling will inundate approximately 1.2 km of the lower creek and will reduce the suitability of that habitat for spawning and rearing. ***Background*** *- Rainbow trout, arctic grayling and longnose suckers utilize the creek for spawning and rearing. Juvenile rainbow trout were collected, and various cyprinids are found in glide and riffle habitats (AMEC, 2008). Spawning gravel quantity was fair within and above inundation area, but was of general poor quality due to excessive fines. Beaver dams in the upper reach provided additional pool habitat but would have been a barrier to upstream fish movements (AMEC & LGL, 2008d).*	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- similar to Site C in terms of potential effects of cofferdam, dam and powerhouse. - less potential effect from reservoir clearing due to lower FSL and smaller cleared area (<90% smaller) - lower level of effects anticipated from reservoir filling due to smaller inundation length (0.4 km vs 1.2 km for Site C).
Maurice Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C in terms of construction

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	physically affect spawning or rearing habitat. - clearing and filling will inundate ~ 0.3 km of creek mouth and is not expected to effect existing spawning and rearing habitat utilized by rainbow trout, arctic grayling and longnose sucker (limit of upstream movement is a falls 4.1 km from Peace River – AMEC, 2008). ***Background*** *- An important spawning and rearing area for rainbow trout. Also used for spawning by longnose sucker. Mountain whitefish juveniles also observed rearing in pool and glide habitats (AMEC, 2008). Similar to Lynx Creek, but wider and more bedrock controlled. More favourable rearing habitat in lower reach due to more and better quality pools, more boulders in riffles and good overhead cover. Gravel quantity and off-channel habitat better in the upper reach above the inundation area (AMEC & LGL, 2008d).*						activities. - reservoir filling for this option will inundate less of Maurice Creek and have less potential effect.
- Foraging and/or refuge habitat							
Peace River	- initial construction activities (cofferdams, tunnels, dam and powerhouse) will directly affect ~ 50 ha of potential foraging and/or refuge habitat within the footprint of those facilities. Changed flow characteristics (due to diversion structures) will affect up to 25 km of river uptream of the site, making it less suitable for foraging and/or refuge. - reservoir clearing is unlikely to significantly affect foraging and/or refuge habitats used by sport and non-sport species along ~85 km of the river. - reservoir filling will inundate ~85 km of foraging and/or	- no significant change from Site C with respect to initial construction activites and reservoir clearing - reservoir filling will inundate ~79-81.5 (C1 or C2) km of foraging and/or refuge habitat and may make it less suitable for the species found within the river system.	- no significant change from Site C with respect to initial construction activites and reservoir clearing - reservoir filling will inundate ~73 km of foraging and/or refuge habitat and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will affect approximately twice the foraging and/or refuge habitat as Site C due to the footprint of the two facilities. Changed flow characteristics (due to diversion structures) will alter habitat characteristics for a short distance upstream and downstream of the site. - reservoir filling will inundate ~85 km of foraging and/or refuge habitat and may make it less suitable for the species found within the	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will affect approximately three times the foraging and/or refuge habitat as Site C due to the footprint of the two facilities. Changed flow characteristics (due to diversion structures) will alter habitat characteristics for a short distance upstream and downstream of the site. - reservoir filling will inundate ~85 km of foraging and/or refuge habitat and may make it less suitable for the species	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will affect approximately four times the foraging and/or refuge habitat as Site C due to the footprint of the two facilities. Changed flow characteristics (due to diversion structures) will alter habitat characteristics for a short distance upstream and downstream of the site. - reservoir filling will inundate ~85 km of foraging and/or refuge habitat and may make it less suitable for the	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will affect approximately seven times the foraging and/or refuge habitat as Site C due to the footprint of the two facilities. Changed flow characteristics (due to diversion structures) will alter habitat characteristics for a short distance upstream and downstream of the site.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	refuge habitat and may make it less suitable for the species found within the river system. ***Background*** *- Existing habitat between Peace Canyon dam and Pine River confluence consists of ~20 km^2 of run/glide, ~3 km^2 of riffle, 0.65 km^2 of pool, 0.31 km^2 of bar and 0.01 km^2 of debris accumulation. Average depth at runs and riffles ranges from 3-4 m, with depth of deep holes increasing upstream towards PCD (max. depth 5-7.6 m below Cache Creek, increasing to ~ 24 m in a deep hole below PCD). Very little cover and shoreline mostly armoured with large particles (cobble/small boulder) (AMEC & LGL, 2008d). Mainstem from Peace Canyon Dam to Alberta border provides foraging habitat for all species and summer/winter refuge for species that use smaller tributaries for spawning and rearing (AMEC, 2008; AMEC & LGL, 2008d)*			river system.	found within the river system.	species found within the river system.	- reservoir filling will inundate ~85 km of foraging and/or refuge habitat and may make it less suitable for the species found within the river system.
Moberly River	- water level changes (due to flow diversion) during initial construction activities (cofferdams, tunnels, dam and powerhouse) may affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 11.6 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system. ***Background*** *- Moberly River is noted to be of adequate size and flow volume to provide foraging and refuge areas throughout most of the year (AMEC, 2008), and has the highest diversity of habitat of all the tributaries surveyed during fall 2005. Its gentle gradient and broad floodplain resulted in a diversified mix of main channel, tertiary channel and off-channel habitats interspersed with islands and gravel bars, particularly at meanders (AMEC & LGL, 2008d). River is characterized as a moderate size, low gradient and meandering, cobble-embedded channel with a fairly broad floodplain comprised of gravel bars (many of them vegetated) and various tertiary channels, typically at meanders. In the lower 10 km of the main channel, the proportion of pool habitat and pool frequency was rated as poor,*	- no effect on Moberly River	- no effect on Moberly River	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will have less effect on foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 7.8 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will have less effect on foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 3.8 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will have less effect on foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 2.8 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will have less effect on foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 1.2 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	the quality of holding pools for fish was rated as poor, and the overall proportion of wood and overhead cover was poor. Good quality habitat with adequate wood cover was present off-channel (AMEC & LGL, 2008d).						
Wilder Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) may affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 2.9 km of creek mouth and may improve foraging and/or refuge habitat ***Background** - A small stream consisting mainly of riffles and runs with a heavily aggraded channel, high percentage of fines in channel substrate, minimal surface flow and no useful fish habitat during low flow periods. Pools in lower reach have a good amount of wood and a high proportion of overhead cover, but no off-channel habitat. (AMEC & LGL, 2008d).* *Foraging/refuge potential limited during summer and winter seasons due to low flows and associated shallow depths and temperature extremes (AMEC, 2008).*	- no significant change from Site C	- fluctuating daily water levels from cofferdam immediately downstream of creek mouth likely to adversely affect foraging/refuge habitat	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) may affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 2.0 km of creek mouth and may improve foraging and/or refuge habitat.	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will have less effect on foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 0.8 km of creek mouth and may improve foraging and/or refuge habitat.	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) will have less effect on foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 0.6 km of creek mouth and may improve foraging and/or refuge habitat.	- fluctuating daily water levels from cofferdam immediately downstream of creek mouth likely to adversely affect foraging/refuge habitat - reservoir filling will inundate 0.6km of creek mouth and may improve foraging and/or refuge habitat.
Cache Creek and Red Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not significantly affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 11.5 km of creek mouth and may improve foraging and/or refuge habitat. ***Background** - Habitat consists of riffles lacking in boulder cover and runs constituting extensive lengths of stream with silted beds and virtually no cover for fish. A good amount of pool habitat, although pools are shallow. As holding habitat for fish, pools were of poor quality, but did have moderate amounts of woody debris and other forms of cover, and may provide useful holding habitat at higher flows (AMEC &*	- no significant change from Site C	- fluctuating daily water levels from cofferdam immediately downstream of Wilder Creek mouth likely to adversely affect spawning/rearing habitat	- no change from Site C, initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) should not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 6.7 km of creek mouth and may improve foraging and/or refuge habitat.	- less potential change in daily water levels from initial construction activities (diversion channel used at dam 3b instead of tunnel). - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 6.2 km of creek mouth and may improve foraging and/or refuge habitat.	- less potential change in daily water levels from initial construction activities (cofferdams, diversion channels, dam and powerhouse) just downstream of creek mouth (dam 4c) - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 4.3 km of creek mouth and may improve foraging and/or refuge habitat.	- less potential change in daily water levels from initial construction activities (cofferdams, diversion channels, dam and powerhouse) immediately downstream of creek mouth (dam 7e) - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 3.1 km of creek mouth and may improve foraging and/or refuge habitat.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	LGL, 2008d). Some good off-channel habitat present in the lower reach. Red Creek (a tributary of Cache Creek entering approximately 6.5 km upstream of the Peace River junction) has poor water quality (excessive iron deposits) and poor habitat quality and minimal cover (AMEC & LGL, 2008d). Foraging/refuge potential generally limited during summer and winter seasons due to low flows and associated shallow depths and temperature extremes (AMEC, 2008).						
Halfway River	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 15.5 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system. ***Background** - a large river that extends well into the Rocky Mountains with fast flowing conditions and a low percentage of fine (<10%) within the lower 28 km, and adequate size and flow to provide foraging and refuge areas throughout the year AMEC, 2008). Riffles comprise broad areas of moderate water depth, while pools were quite deep with some cover and runs typically consisted of extensive lengths of deep water with virtually no suitable cover for fish. The river has the least diversity of habitat of all tributaries surveyed during fall 2005 (AMEC & LGL, 2008d). The proportion and frequency of occurrence of pools was rated poor, with none qualifying as suitable holding habitat for fish. The proportions of wood and overhead cover were also poor. Off-channel habitats with cover were present (AMEC & LGL, 2008d).*	- no significant change from Site C	- no significant change from Site C	- initial construction activities (cofferdams, tunnels and diversion channels, dam and powerhouse) should not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 8.6 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) not expected to physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 7.8 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) at dam 4B has the potential to affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 9.8 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) at dam 7d has the potential to affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 4.2 km of foraging and/or refuge habitat, and may make it less suitable for the species found within the river system.
Farrell Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) should not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C - reservoir filling will inundate 1.1 km of creek mouth and may improve foraging and/or refuge habitat.	- increased potential for daily water level fluctuations during initial construction activities at dam 3b (diversion channel used instead of tunnel) affecting foraging and	- increased potential for daily water level fluctuations during initial construction activities at dam 4a (diversion channel used instead of tunnel) affecting foraging	- less potential for daily water level fluctuations during initial construction activities at dam 7c (diversion channel used instead of

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	clearing. - reservoir filling will inundate 3.6 km of creek mouth and may improve foraging and/or refuge habitat ***Background*** *- the stream consists of a gently sloping gravel/cobble bed with riffles comprising approximately 50% of the total habitat and low percentage of fines. Runs are less common (14%), consisting of extensive shallow sections with little cover for fish. Pool habitat ranged from fair to poor, but generally not suitable as holding areas for larger fish due to the lack of water depth and cover. The lower reach had a greater amount of boulder cover in the riffles. (AMEC & LGL, 2008d).* *Foraging/refuge potential limited during summer and winter seasons due to low flows and associated shallow depths and temperature extremes (AMEC, 2008).*				refuge habitat. - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate the same length of creek mouth and may improve foraging and/or refuge habitat.	and refuge habitat. - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate the same length of creek mouth and may improve foraging and/or refuge habitat.	tunnel). - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 0.9 km of creek mouth and may improve foraging and/or refuge habitat.
Lynx Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) will not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 1.2 km of creek mouth and may improve foraging and/or refuge habitat. ***Background*** *- a small creek characterized by moderate gradient (~2%) and reasonable habitat in riffles, but high percentage of silt deposits in pools and runs. The proportion and frequency of pool habitat in each reach is minor, and rated poorly for fish holding habitat due to insufficient water depth and woody cover (AMEC & LGL, 2008d).* *Foraging/refuge potential limited during summer and winter seasons due to low flows and associated shallow depths and temperature extremes (AMEC, 2008).*	- no significant change from Site C	- no significant change from Site C	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) at dam 7b has the potential to affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 1.2 km of creek mouth and may improve foraging and/or refuge habitat.	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 1.2 km of creek mouth and may improve foraging and/or refuge habitat.	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) will not physically affect foraging and/or refuge habitat, nor is any significant effect anticipated from reservoir clearing. - reservoir filling will inundate 1.2 km of creek mouth and may improve foraging and/or refuge habitat.	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) at dam 7b has the potential to affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - reservoir filling will inundate 0.6 km of creek mouth and may improve foraging and/or refuge habitat.
Maurice Creek	- initial construction activities (cofferdams, tunnels, dam and powerhouse) will not physically affect foraging and/or refuge habitat, nor is any significant effect	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- no significant change from Site C	- initial construction activities (cofferdams, diversion channels, dam and powerhouse) at dam 7a has the

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	anticipated from reservoir clearing. - reservoir filling will inundate ~ 1.1 km of creek mouth and may improve foraging and/or refuge habitat. ***Background*** *- Similar in watershed size to Lynx Creek, but wider and more bedrock controlled. Habitat characteristics more favourable in lower reach due to more and better quality pools, more boulders in riffles and good overhead cover. (AMEC & LGL, 2008d). Foraging/refuge potential limited during summer and winter seasons due to low flows and associated shallow depths and temperature extremes (AMEC, 2008).*						potential to affect foraging and/or refuge habitat - no significant effect anticipated from reservoir clearing. - less inundation of creek mouth (0.2 km)
In-stream flow aspects	- initial construction activities (cofferdams, tunnels, dam and powerhouse) will not affect Peace River flow as diversion tunnels will bypass and maintain flows. - no changes to river flows during reservoir clearing - reservoir filling will take 62 days at a constant rate of 431 m^3/s. If undertaken during low flow periods, more time will be required. Assumed that minimum flow requirement would remain in effect during filling. ***Background*** *- Flow in the Peace River mainstem is constant and reasonably consistent as a result of releases from Williston reservoir (some diurnal fluctuations in response to power demand). Minimum flow established at 283 m^3/s (10,000 cfs). With the exception of the Moberly and Halfway rivers, late summer/early fall base flows in other tributaries are very low, with the most extreme conditions occurring in Wilder, Red, and Cache creeks.*	- no significant change from Site C as minimum flow rule in effect, which will maintain flow into downstream reach	- reservoir filling anticipated to take ~ 55 days, but no effect anticipated as minimum flow rule will maintain downstream flow	- diversion channels will maintain Peace River flows - reservoir filling anticipated to take ~ 44 days for Low C and ~ 21 days for 7B, but no effect anticipated as minimum flow rule will maintain downstream flow	- diversion channels will maintain Peace River flows - reservoir filling anticipated to take ~ 78 days in total (26 for 3A, 30 for 3B and 22 for 3C), but no effect anticipated as minimum flow rule will maintain downstream flow	- diversion channels will maintain Peace River flows - reservoir filling anticipated to take ~ 86 days in total (25 for 4A, 22 for 4B, 22 for 4C, and 17 for 4D), but no effect anticipated as minimum flow rule will maintain downstream flow	- diversion channels will maintain Peace River flows - reservoir filling anticipated to take ~ 75 days in total (10 for 7A, 12 for 7B, 12 for 7C, 10 for 7D, 12 for 7E, 11 for 7F and 8 for 7G), but no effect anticipated as minimum flow rule will maintain downstream flow
Riparian Habitat/Species							
Wetlands	- one 20 ha wetland area (Watson Slough) near Bear	- same as Site C for Watson Slough, approximately 40%	- same as Site C for Watson Slough, approximately 30%	- Watson Slough not affected, and ~ 40% less	- Watson Slough not affected, and	- Watson Slough not affected approximately	- Watson Slough not affected or any

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	Flats inundated by reservoir filling. No initial construction effects or clearing effects. - approximately 70 ha of wetland affected by transmission corridor	wetland affected along transmission line	more wetland affected along transmission line	wetland affected along transmission line	approximately 20% more wetland affected along transmission line	20% more wetland affected along transmission line	wetland along transmission line
Shoreline vegetation community	- shoreline and island riparian vegetation community will be lost within footprint of structures and work area (~ 500 ha) -shoreline and island communities also lost due to reservoir clearing and filling (~3100 ha of three dominant communities – FM02, AM and SH). ***Background*** *- valley bottom vegetation communities mapped as part of TEM process. Numerous forested islands and gravel bar islands within river, and generally forested shorelines. Predominant community types are cottonwood-spruce-red osier dogwood (FM02), spruce-aspen-step moss (AM) and spruce-horsetail (SH). Willow-horsetail-sedge community (WH) also common on islands.*	- similar to Site C except that Moberly River valley not affected (~12-18% less of dominant habitat types affected).	- similar to Site C except that Moberly River valley not affected and less Peace River valley (~26% less of dominant habitat types affected).	- similar to Site C except that lower dams/FSL result in less area being affected (~23% less of dominant habitat types affected).	- similar to Site C except that lower dams/FSL result in less area being affected (~27% less of dominant habitat types affected).	- similar to Site C except that lower dams/FSL result in less area being affected (~24% less of dominant habitat types affected).	- similar to Site C except that lower dams/FSL result in less area being affected (~56% less of dominant habitat types affected).
Islands/in-water structures	- one island removed at dam site - 3 islands partially submerged, and 27 islands cleared and submerged by the reservoir	- island downstream of Moberly River not affected - 3 islands partially submerged, and 27 islands cleared and submerged by the reservoir	- one island removed at dam site - 3 islands partially submerged, and 23 islands cleared and submerged by the reservoir	- one island removed at Low C and one island removed at 7B - 6 islands partially submerged, and 23 islands cleared and submerged by the reservoirs	- 2 islands removed at dam sites - 4 islands partially submerged, and 5 island cleared and submerged by the reservoirs	- 2 islands removed at dam sites - 4 islands partially submerged, and 25 island cleared and submerged by the reservoirs	- 4 islands removed at dam sites - 19 islands partially submerged, and 8 island cleared and submerged by the reservoirs
Rare and/or listed riparian species and/or communities	*Background - detailed information not available, but preliminary reports (Keystone, 2009b) suggest that three blue-listed plant species are present within the area to be inundated by Site C (two in Watson Slough, one on a gravel bar near dam 7C). More work required to determine distribution and composition of riparian community.*	- similar to Site C except that Moberly River valley not affected (potential for rare species to be within inundation zone of Site C).	- similar to Site C except that Moberly River valley not affected (potential for rare species to be within inundation zone of Site C).	- similar to Site C, but Watson Slough not affected	- similar to Site C, but Watson Slough not affected	- similar to Site C, but Watson Slough not affected	- similar to Site C, but Watson Slough not affected
Terrestrial Environment							

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
Terrestrial Habitat/Vegetation							
Vegetation species/ communities	- initial construction activities, reservoir clearing and filling will result in the loss of the predominant vegetation communities within the river bottom. - transmission line expansion/construction on the south shore will affect ~ 910 ha of upland vegetation communities, which are significantly different than those within the river valley (virtually no FM02 or SH communities, although AM present in substantial amount (~ 40% of reservoir amount). ***Background** – Terrestrial ecosystem mapping has been undertaken within the river corridor to map the various vegetation communities. Predominant community types within the reservoir inundation zone are cottonwood-spruce-red osier dogwood (FM02), spruce-aspen-step moss (AM) and spruce-horsetail (SH).*	- similar to Site C, but Moberly River valley not affected - transmission line area similar (~920 ha) and similar vegetation communities and areas.	- similar to Site C, but Moberly River valley not affected - transmission line area similar (~940 ha) and similar vegetation communities and areas.	- similar to Site C, but lower dams/FSL and more retention of lower side slope habitats - two transmission lines on south shore, but with narrower footprints, resulting in longer length (90 km) but smaller area (680 ha). Similar vegetation communities as Site C.	- similar to Site C, but lower dams/FSL and more retention of lower side slope habitats - three transmission lines on south shore, resulting in longer length (111 km) and greater area (~1325 ha). Similar vegetation communities and areas as Site C.	- similar to Site C, but lower dams/FSL and more retention of lower side slope habitats - four transmission lines on south shore, resulting in longer length (129 km) and greater area (~1540 ha). Similar vegetation communities and areas as Site C.	- similar to Site C, but lower dams/FSL and most retention of river bottom and lower side slope habitats - seven transmission lines on north shore, with a total length of ~105 km and cleared area of ~1250 ha. No disturbance of south shore vegetation communities.
Rare and listed species and/or communities	- initial construction activities, reservoir clearing and filling will inundate species that are within the reservoir footprint. - no information on transmission line species ***Background** – Fifty-six red- or blue-listed plant species and five red- or blue-listed plant communities found in area between Peace Canyon Dam and Alberta border during surveys in 2005 and 2006. Steep, warm aspect slopes are most productive in terms of diversity and number of rare flora, and are mostly out of the development zone (for reservoirs at least). Future studies are required to provide more information (Keystone, 2009b).*	- similar to Site C, except that Moberly River valley unaffected.	- similar to Site C, except that Moberly River valley unaffected.	- similar to Site C, except that lower dams/FSLs and less affect on lower side slope species.	- similar to Site C, except that lower dams/FSLs and less affect on lower side slope species.	- similar to Site C, except that lower dams/FSLs and less affect on lower side slope species.	- similar to Site C, except that lower dams/FSLs and less affect on lower side slope and valley bottom species.
Terrestrial Biota							
Wildlife							
Songbirds	- initial construction activities, reservoir clearing and filling	- better than Site C as Moberly River valley not	- better than Site C as Moberly River valley not	- similar to Site C in terms of effects within Peace River	- similar to Site C in terms of effects within Peace	- similar to Site C in terms of effects within	- least loss of riparian habitat, so least effect

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	will displace songbirds from foraging, refuge and breeding habitat. - transmission line construction is anticipated to have similar effects ***Background*** *- surveys were undertaken in 2005 and 2006 to assess presence and habitat use within the project area. Blue-listed black-throated green warbler and Canada warbler were found within or directly adjacent to the river floodplain. The red-listed Cape May warbler and bay-breasted warbler is associated with mature coniferous stands and upland habitat (possible transmission corridor interaction). Nelson's shar-tailed sparrow and Le Conte's sparrow are associated with herbaceous wetlands (i.e Watson Slough). The blue-listed rusty blackbird was found in wetland and river island habitats. The red-listed Connecticut warbler is typically associated with balsam poplar/spruce islands along the Peace River. Additional survey is required to establish habitat linkages for other rare species (Keystone, 2009b).*	affected.	affected and less Peace River valley affected.	corridor, but less potential effect on Nelson's sharp-tailed sparrow and le Conte's sparrow (i.e. Watson slough not affected) - more potential for effects due to 7B transmission line interconnection (especially for Cape May warbler and bay-breasted warbler).	River corridor, but less potential effect on Nelson's sharp-tailed sparrow and le Conte's sparrow (i.e. Watson slough not affected) - more potential for effects due to 3A and 3B transmission line interconnections (especially for Cape May warbler and bay-breasted warbler).	Peace River corridor, but less potential effect on Nelson's sharp-tailed sparrow and le Conte's sparrow (i.e. Watson slough not affected) - more potential for effect due to 4A, 4B and 4C transmission line interconnections (especially for Cape May warbler and bay-breasted warbler).	on species that heavily utilize the river corridor - less transmission line effect potential due to shorter lengths and passage through developed areas
Raptors	- initial construction activities, reservoir clearing and filling may displace raptors from their preferred foraging habitat and will affect roosting and nesting habitat (large balsam poplars – FM02 unit). - transmission line construction is anticipated to have less effect for those species that orient to water (i.e. osprey, bald eagle, etc). ***Background*** *– Eleven species of diurnal raptors (bald eagle, golden eagle, red-tailed hawk, northern goshawk, northern harrier, sharp-shinned hawk, Cooper's hawk, Osprey, American kestrel, merlin and broad-winged hawk) reported in the core and periphery area during studies in 2005. Twenty-one active bald eagle nests were reported from an aerial survey (LGL, 2006). In 2006, 19 nests were observed in the lower portion of the river channel and on islands upstream of Site C, with nine being active. All nests were found in large balsam poplar trees (Keystone, 2009b).*	- similar to Site C. Although Moberly River valley unaffected, no data to indicate presence/absence of nests within that area	- similar to Site C. Although Moberly River valley unaffected, no data to indicate presence/absence of nests within that area	- similar to Site C in terms of effects within Peace River corridor, but more potential for effect due to 7B transmission line interconnection.	- similar to Site C in terms of effects within Peace River corridor, but more potential for adverse effects due to 3A and 3B transmission line interconnections.	- similar to Site C in terms of effects within Peace River corridor, but more potential for adverse effects due to 4A, 4B and 4C transmission line interconnections.	- similar to Site C in terms of effects within Peace River corridor. Less potential for adverse effects due to transmission line interconnections as shorter and through developed areas.
Owls	- initial construction activities,	- better than Site C (~ 12 %	- better than Site C (~ 23 %	- better than Site C (~ 11 %	- better than Site C (~ 17 %	- better than Site C (~ 15	- better than Site C (~

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	reservoir clearing and filling may displace owls from their preferred foraging habitat and may affect roosting and nesting habitat (large balsam poplars – FM02 unit). - transmission line construction will have similar effects. ***Background** – six species of owls documented during studies in 2006, including northern saw-whet (most common), great horned and barred (both relatively abundant), and short-eared, boreal and great gray owls. Nesting habitat is typically the limiting factor for owl distribution, with large balsam poplars the ideal nesting tree for great gray, great horned and gray owls due to the large tree size and appropriate limb configuration (owls take over stick nests constructed by other birds of prey) (Keystone, 2009b).*	less FM02 area affected, mostly within Moberly River valley)	less FM02 area affected, mostly within Moberly River valley and Peace River valley below dam site)	less FM02 area affected, mostly due to lower dams and FSL) - more potential transmission line effects due to interconnection for 7B	less FM02 area affected, mostly due to lower dams and FSL). - more potential transmission line effects due to interconnections for 3A and 3B.	% less FM02 area affected), mostly due to lower dams and FSL. - more potential transmission line effects due to interconnections for 4A 4B and 4C	39 % less FM02 area affected), mostly due to lower dams and FSL. - limited transmission line effects as shorter and through developed areas.
Bats	- no significant effect anticipated from initial construction activites - reservoir clearing and filling could remove roosting habitat within the inundation area. -transmission line construction expected to have fewer effects as less preferred habitat. ***Background** – Nine bats species potentially in Peace River area. All are insectivores and roost in trees, although some may utilize other habitat (buildings, rock crevices and/or cliffs). Six species (little brown myotis, long-legged myotis and northern myotis, hoary bat, silver-haired bat and big brown bats) collected during preliminary surveys in 2005 and 2006, and confirmed to be reproducing in the area. Balsam poplar stands are heavily used for roosting, while wetlands and slow moving creeks support the greatest degree of foraging activity. Northern myotis is blue-listed in BC. (Keystone and Kingbird, 2009a & b).*	- slightly better than Site C (balsam poplar within forested slopes along Moberly River not affected)	- significantly better than Site due to less impact (25-30% less) to balsam poplar stands (TEM – FM02 – Cottonwood-spruce-red osier dogwood community)	- similar to Site C, but more potential for transmission line effects.	- similar to Site C, but more potential for transmission line effects.	- similar to 2 and 3 dam alternative, but more potential for transmission line effects.	- better than all other options due to lower FSLs of the series of reservoirs and less impact on balsam poplar stands due to less clearing within the river valley. - less potential for transmission line effects (shorter lengths and passing through developed areas).
Butterflies	- initial construction activities, reservoir clearing and filling may displace butterflies from their preferred habitat areas. - transmission line	No rating – insufficient data	No rating – insufficient data	No rating – insufficient data	No rating – insufficient data	No rating – insufficient data	No rating – insufficient data

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	expansion/construction will have similar effects. ***Background*** *- Twelve blue-listed butterfly species (of 16 potential) were found in the project area during 2006 surveys. Habitat suitability ratings are being prepared to correlate life stages with habitat, particularly river associated habitat (Keystone, 2009b).*						
Waterfowl and Shorebirds	- initial construction activities, reservoir clearing and filling may displace waterfowl and shorebirds from their preferred foraging habitat and will affect refuge and breeding habitat (particularly those that utilize back channels, such as dabbling ducks). - transmission line expansion/construction will have limited effects (few wetland areas) ***Background*** *- Forty-two species of waterfowl recorded on the river during 2006, with most use during fall migrations (3-4 times those recorded during other times of year). Five blue-listed species were encountered during 2006 surveys, being surf scoter, sandhill crane, great blue heron, California gull and Caspian tern, with no breeding noted (mainly fall observations). Canada goose and mallard were the most common waterfowl observed, while Franklin's gull was the most common gull. Species found mainly on the main river channel include gulls, Canada geese, common loons, common mergansers, spotted sandpiper and surf scoter. Species found mainly in back-channel habitat include green-winged teal, northern shoveler, northern pintail, ring-necked duck and trumpeter swan. Generally, gulls were found on open gravel bars along the main river channel, diving ducks preferred the fast flowing, main channel, and dabbling ducks preferred the slow flowing or stagnant back channels. Wetlands used primarily in spring (Keystone, 2009b).*	- similar to Site C, but Moberly River not affected. - approx. 40% less wetland area affected along transmission route.	- similar to Site C, but Moberly River not affected and less Peace River valley affected. - approx. 30% more wetland area affected along transmission route.	- similar to Site C in terms of amount of Peace River valley affected, but Watson Slough not affected - approx. 40% less wetland areas affected along transmission route.	- similar to Site C in terms of amount of Peace River valley affected, but Watson Slough not affected - approx. 20% more wetland areas affected along transmission route.	- similar to Site C in terms of amount of Peace River valley affected, but Watson Slough not affected - approx. 20% more wetland areas affected along transmission route.	- better than all other options due to lower dams/FSLs and less effect on riparian habitat within the river valley. - no significant transmission line effects.
Beavers	- initial construction activities and reservoir clearing may displace beavers from their preferred foraging habitat. -reservoir filling will inundate	- similar to Site C, but colonies in the Moberly River not affected.	- similar to Site C, but colonies in the Moberly River and lower Peace River not affected.	- similar to Site C.	- similar to Site C.	- similar to Site C.	- less effect anticipated than Site C.

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	houses/tunnels and food caches. - transmission line expansion/construction will have limited effects (few wetland areas) ***Background** – A survey of lodges in 2005 found 67 active and 60 inactive in the river reach from Hudson Hope to the Moberly River. Assuming 5 beavers/colony, these counts result in a population estimate of 335 animals, which is similar to the population estimate from a previous survey in 1990 (380 animals) (Keystone, 2009b).*						
Amphibians	- initial construction activities, reservoir clearing and filling may displace amphibians from their preferred foraging habitat and will affect refuge and breeding habitat. - transmission line expansion/construction will have limited effects (few wetland areas) ***Background** – Five species of amphibians were found in project area during surveys in 2005 and 2006, including long-toed salamander, western toad, boreal chorus frog, Columbia spotted frog and wood frog. Western toad, wood frogs, and boreal chorus frog was recorded in river back channel sites. Amphibians were also detected at Watson Slough. Amphibians are sensitive to development as they are aquatic breeders that rely on wetlands, ponds, and/or slow water river back-channel habitat for breeding (Keystone, 2009b).*	- similar to Site C, but Moberly River valley not affected - approx. 40% less wetland areas affected along transmission route.	- similar to Site C, but Moberly River valley not affected and less Peace River valley affected - approx. 30% more wetland areas affected along transmission route.	- similar to Site C in terms of amount of Peace River valley affected, but Watson Slough not affected - approx. 40% less wetland areas affected along transmission route.	- similar to Site C in terms of amount of Peace River valley affected, but Watson Slough not affected - approx. 20% more wetland areas affected along transmission route.	- similar to Site C in terms of amount of Peace River valley affected, but Watson Slough not affected - approx. 20% more wetland areas affected along transmission route.	- better than all other options due to lower dams/FSLs and less effect on riparian habitat within the river valley. - no significant transmission line effects.
Ungulates	- initial construction activities and reservoir clearing may displace ungulates from their preferred foraging/refuge habitat within the riparian area and on river islands. -reservoir filling will inundate river shoreline and islands and result in the loss of moose calving areas on islands. - transmission line	- similar to Site C, except that Moberly River valley not affected	- similar to Site C, except that Moberly River valley not affected and less Peace River valley affected.	- similar to Site C in terms of amount of river bottom affected, but less south and north aspect slope affected. - more forested area affected along transmission route for 7B, although not critical habitat.	- similar to Low C/7B in terms of amount of river bottom, and south and north aspect slopes affected. - more forested area affected along transmission route for 3A and 3B, although not critical habitat.	- similar to Low C/7B in terms of amount of river bottom, and south and north aspect slopes affected. - more forested area affected along transmission route for 4A, 4B and 4C, although not critical habitat.	- most islands retained and least amount of river bottom and south and north aspect slopes affected by reservoir clearing and filling. - more potential for work area footprint and transmission line effects on south

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	expansion/construction will have limited effects ***Background** – Moose, deer and elk were surveyed in 2006 to determine their abundance and distribution. Compared to 1991 surveys, numbers of moose were similar in all areas (river bottom, south aspect and north aspect slopes). Deer numbers were similar on north aspects and river bottom, but lower on south aspect slopes. Elk numbers have increased, and were mostly present on south aspect slopes and the river bottom*						aspect slopes along the north side of the river, which are preferred wintering areas for moose, deer and elk.
Other species/taxa	*Harlequin ducks - non-breeding adults were found on the river during the mid-1970s, but have not been seen since. Require fast flowing waters with good benthic production and adjacent island habitat for nesting/loafing (Keystone, 2009b). Furbearers – Fishers are blue-listed and were the target of 2006 furbearer investigations, but none were observed (possible tracks). Large balsam poplar trees within the river valley are important reproductive and resting habitat for fisher. Other species encountered included marten, lynx, otter, mink, unknown weasel, red squirrel, snowshoe hare, coyote and wolf (Keystone, 2009b).*	- similar to Site C, except that Moberly River valley not affected	- similar to Site C, except that Moberly River valley not affected	- similar to Site C	- similar to Site C	- similar to Site C	- better than others due to lower dams/FSL and more retention of island habitat/large balsam poplars.
Rare and listed wildlife species and/or communities	- initial construction activities, reservoir clearing and filling may displace rare species from their preferred foraging habitat and may affect roosting and nesting habitat. - transmission line expansion/construction will have similar effects ***Background** - Fourteen red- or blue-listed wildlife species were found within the project area during surveys in 2005 and 2006. They were found along the river bottom and upper slopes along the Peace River corridor and in the lower portion of the Moberly River valley. Species detected included western toad, California gull, Caspian tern, great blue heron, sandhill crane, surf scoter, black-throated green warbler, Canada warbler, Connecticut warbler, Nelson's sharp-tailed sparrow, rusty blackbird, broad-winged hawk, peregrine falcon and short-eared owl (Keystone, 2009b).*	- better than Site C as Moberly River valley not affected	- better than Site C and C1 or C2 as Moberly River valley not affected and less Peace River valley affected	- similar to Site C, but more potential for transmission line effects.	- similar to Site C, but more potential for transmission line effects.	- similar to Site C, but more potential for transmission line effects.	- better than all other options due to lower dams/FSLs and less clearing for the series of reservoirs within the river valley. - less potential for transmission line effects (shorter lengths and passing through developed areas).
OPERATIONS **-** maintain reservoir level within 1.8 m of							

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
FSL - maintain flows >10,000 cfs - emergency flow releases (spilling) - maintain facilities and transmission line corridors							
Aquatic Environment							
Aquatic habitat and fauna							
Reservoir Habitat characteristics (shoreline erosion, sedimentation, nutrients, and temperature regime)	- reservoir habitat characteristics will be significantly different than the pre-development situation (as noted below). After reservoir creation, chemical and biological changes will occur as it matures. - operation of the facility has the potential to effect shorelines (erosion, vegetation) and benthic production within the operating zone. - emergency spilling could reduce water levels up to 11.8 m (to 450 m elevation), resulting in loss of habitat (depth, volume and surface area) and increased turbidity/suspended solids due to exposure of previously inundated shorelines. Background – the Site C reservoir will be ~ 85 km in length, range up to 50 m in depth and cover an area of ~9300 ha, with ~ 300 km of perimeter shoreline and 21 km of shoreline around islands. The area of the islands will be	- shorter length (~80 km), and smaller area (~8300-8600 ha), but generally similar to Site C. Exclusion of Moberly River not significant in terms of reservoir habitat diversity and/or characteristics.	- shorter length (~73 km), and smaller area (~7700 ha), but generally similar to Site C. Exclusion of Moberly River not significant in terms of reservoir habitat diversity and/or characteristics.	- lower dams and smaller reservoirs for Low C/7B will have ~ 20% less aquatic habitat (based on surface area) than Site C. Low C reservoir characteristics are expected to be similar to Site C due to significant depth (~36 at dam) and similar underwater habitat, while 7B will be very riverine. Low C volume and flushing rate predicted to be ~ 50% of Site C, which will result in a greater degree of downstream export of nutrients than Site C and possibly reduced primary production potential. 7B volume ~ 95% less than Site C and flushing rate is ~ 1 day, limiting potential for significantly enhanced primary production, but maintaining 'riverine' characteristics and associated production of benthic organisms adapted to flowing water environments (i.e. mayflies, stoneflies, etc). Export of nutrients and/or	- lower dams and smaller reservoirs for 3A, 3B and 3C will have ~ 20% less aquatic habitat (based on surface area) than Site C. Individual reservoir are shallower (~17 m at dams), and will have a greater range of habitat characteristics (particularly more shallow water habitat) compared to Site C. Reservoir volumes and flushing rates are 10-20% of Site C, which will result in a significantly greater degree of downstream export of nutrients than Site C and reduced primary production potential. Upstream portions of each reservoir will be relatively deep (5+ m) and provide little opportunity for the production of benthic organisms adapted to flowing water environments (i.e.mayflies, stoneflies, etc). Export of nutrients and/or organisms from 3A to 3B to 3C is	- lower dams and smaller reservoirs for 4A, 4B, 4C and 4D will have ~ 20% less aquatic habitat (based on surface area) than Site C. Individual reservoir are shallower (~12-14 m at dams), and will have a greater range of habitat characteristics (particularly more shallow water habitat) compared to Site C. Reservoir volumes and flushing rates are 5-10% of Site C, which will result in a significantly greater degree of downstream export of nutrients than Site C and reduced primary production potential. Upstream portions of each reservoir will be relatively deep (5+ m) and provide little opportunity for the production of benthic organisms adapted to flowing water environments (i.e.	- lower dams and smaller reservoirs for 7A to 7G will have ~ 40% less aquatic habitat (based on surface area) than Site C. Individual reservoir are shallower (~6-7 m at dams), and will have a greater range of habitat characteristics (significantly more shallow water habitat) compared to Site C. Reservoir volumes and flushing rates are 1-2% of Site C and not significantly different than the pre-development situation. This will result in continual downstream export of nutrients fro reservoir to reservoir, and little planktonic primary production potential. Upstream portions of each reservoir will

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	~ 96 ha. The flushing time is predicted to be ~ 21 days, which will result in a low velocity flow regime and the majority of suspended material (organic or inorganic) settling out within the reservoir length. Erosion of fine sediments at the water-land interface is anticipated (due to wind generated wave action) along much of the new shoreline until stable gradient and/or hardening is achieved. Emergent and submergent vegetation is likely to be limited within the operating range (1.8) due to water level fluctuations and/or active erosion. Inundation of tributary mouths and valleys will provide sheltered back-water habitats that are less affected by wind/wave action, which may be suitable for aquatic vegetation growth. Coarse river bottom sediments will be increasingly overlain with deposited materials, resulting in fine-grained, organic bottom sediment that will be colonized by organisms adapted to that environment (burrowing mayflies, chironomids, etc). Decomposition of organic materials within flooded lands provides a surge of nutrients that passes upwards through the aquatic community, and may last from 5-20 years depending on the biomass of			organisms from 7B into Low C is expected to result in aquatic production within Low C that is similar to that expected for Site C. Less inundation of tributaries (~ 30-70% less distance), resulting in more retention of flowing water environments and aquatic habitat diversity. - similar effects for emergency spilling	expected to result in less aquatic production as expected for Site C. Less inundation of tributaries (~ 30-50% less distance for most, except for Farrell Creek which is the same as Site C), resulting in more retention of flowing water environments and aquatic habitat diversity . - similar effects for emergency spilling	mayflies, stoneflies, etc). Export of nutrients and/or organisms from 4A to 4B to 4C to 4D is expected to result in less aquatic production than expected for Site C. Less inundation of tributaries (~ 20-60% less distance for most, except for Farrell Creek which is the same as Site C), resulting in more retention of flowing water environments and aquatic habitat diversity. - similar effects for emergency spilling	maintain 'riverine' characteristics and associated production of benthic organisms adapted to flowing water environments (i.e. mayflies, stoneflies, etc). Export of nutrients and/or organisms from 7A to 7G is expected to result in similar aquatic production as Site C due to greater diversity of habitats. Less inundation of tributaries (~ 10-40% less distance for most), resulting in more retention of flowing water environments. - similar effects for emergency spilling

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	flooded vegetation, the magnitude of the water level change and other factors. This period of trophic upsurge is often followed by a variable length period (3 to 30 years) of reduced production of benthic invertebrates and fish (Hall et al., 1999). A similar pattern of nutrient concentration occurred within Williston Reservoir, which was considered in the low production 'oligotrophic' range in 1999 (Stockner and Langston, 2000).						
Reservoir fish community (composition, abundance, growth and health)	- long term installation and operation of the facility is expected to change the fish community as noted below, due to the habitat, foraging, spawning and rearing requirement of each species. - emergency spilling would be expected to increase entrainment, but would be a short term effect. Background - Kokanee are noted to be expanding in Williston Reservoir (Wood & Blackman, 2008), are present in Dinosaur reservoir (Blackman et al., 2003), and will eventually pass downstream into Site C and are expected to colonize and do well in the new reservoir. Bull trout are present within the river, utilize Halfway River for spawning/rearing and are expected to do well in the reservoir.	- similar to Site C	- similar to Site C	- increased potential for adverse effects on rainbow trout due to potential to be entrained at Dam 7B and passed out of their preferred spawning area, however, better habitat characteristics for mountain whitefish. - no significant difference for other major species.	- shorter distance between dams provides less habitat for species that range widely such as bull trout and arctic grayling. - slightly better than 2 dam option for rainbow trout, but worse than Site C. - deep water (5+ m) environments at the base of each dam provides limited spawning habitat, and expected to adversely affect mountain whitefish - less favourable for lake whitefish than Site C	- shorter distance between dams provides less habitat for species that range widely such as bull trout and arctic grayling. - slightly better than 2 & 3 dam option for rainbow trout, but worse than Site C. - deep water (5+ m) environments at the base of each dam provides limited spawning habitat, and expected to adversely affect mountain whitefish - less favourable for lake whitefish than Site C - dam immediately downstream of Halfway River creates significant potential to entrain fish exiting the river and pass them into the subsequent reservoir (habitat loss	- shorter distance between dams provides less habitat for species that range widely such as bull trout and arctic grayling. - worse than all other options for rainbow trout. - improved spawning habitat potential for mountain whitefish (shallow water environment below each dam) - less favourable for lake whitefish than all other options - dam immediately upstream and downstream of Halfway River creates significant potential to entrain fish exiting the river

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	Rainbow trout utilize Maurice Creek and potentially other upper reach creeks for spawning/rearing and are expected to do well in the new reservoir. Mountain whitefish are the most abundant fish in the river system, completing all life stages in the mainstem and also utilizing the Moberly and Halfway rivers for spawning and rearing. Their abundance is expected to decline after reservoir formation due to loss of riverine habitat. Lake whitefish are expected to increase in the new reservoir. Arctic grayling utilize the Moberly River and possibly the Peace River mainstem for spawning/rearing. Their abundance is expected to decline after reservoir formation. Walleye are largely found below Site C, utilizing the Beatton River for spawning and rearing. No change is expected.					and potential turbine mortality)	and pass them into the subsequent reservoir (habitat loss and potential turbine mortality) and limits their habitat
Entrainment and turbine mortality	Background – Six 150 MW vertical shaft Francis turbines. Turbine mortality expected to be less than 20% (depending on size of fish, number of blades, etc). Significant potential to entrain fish that exit the Moberly River into the reservoir and pass them downstream.	- same units but slightly lower head. Similar entrainment and mortality potential as Site C e	- same units but slightly lower head. Similar entrainment and mortality potential as Site C	- entrainment potential increased as two structures in river, although assume approach velocities will be the same - lower head at Low C decreases the potential for turbine mortality - additional smaller units at 7B likely to offset above noted benefit. - Propeller units typically	- entrainment potential further increased as three structures in river, although assume approach velocities will be the same - lower head at each dam decreases the potential for turbine mortality - additional of more units within the river system increases the potential for direct or indirect mortality	- entrainment potential further increased as four structures in river, although assume approach velocities will be the same - lower head at each dam decreases the potential for turbine mortality - additional of more units within the river system increases the potential for	- entrainment potential further increased as seven structures in river, although assume approach velocities will be the same - lower head at each dam decreases the potential for turbine mortality - additional of more

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
				have higher fish survival than Francis units (EPRI, 1992).	if fish pass successive facilities.	direct or indirect mortality if fish pass successive facilities.	units within the river system increases the potential for direct or indirect mortality if fish pass successive facilities.
Upstream fish movement and/or migrations	Trap and truck proposed.	Trap and truck proposed.	Trap and truck proposed.	Trap and truck proposed for Low C and7B	Trap and truck proposed at each site, multiple dams will may upstream passage more difficult.	Trap and truck proposed at each site, multiple dams will may upstream passage more difficult.	Fishways at each facility will provide unrestricted fish passage.
Downstream habitat (erosion & sediment transport, side channels/dewatering, drift organisms, contaminants)	- long term operations has the potential to affect on downstream sediment transport and erosion processes (i.e. back-channel maintenance and/or dewatering) - bedload and suspended sediment transport interrupted by Site C dam (trapped in reservoir) - similar restriction of nutrient flow/drift organisms from reservoir - emergency spilling has potential to erode river channel in proximity to dam and adversely affect aquatic and riparian habitat	- similar to Site C	- similar to Site C	- no significant difference compared to Site C for erosion and transport and side channel maintenance and/or dewatering as river flows controlled by Bennett dam/Williston reservoir and passed through by Peace Canyon and Site Cs flow rate - smaller reservoirs with higher flushing rate with greater potential to export nutrients/organisms into the downstream area. - same for emergency spilling	- no significant difference compared to Site C for erosion and transport and side channel maintenance and/or dewatering as river flows controlled by Bennett dam/Williston reservoir and passed through by Peace Canyon and Site Cs flow rate - smaller reservoirs with higher flushing rate with greater potential to export nutrients/organisms into the downstream area. - same for emergency spilling	- no significant difference compared to Site C for erosion and transport and side channel maintenance and/or dewatering as river flows controlled by Bennett dam/Williston reservoir and passed through by Peace Canyon and Site Cs flow rate - smaller reservoirs with higher flushing rate with greater potential to export nutrients/organisms into the downstream area. - same for emergency spilling	- no significant difference compared to Site C for erosion and transport and side channel maintenance and/or dewatering as river flows controlled by Bennett dam/Williston reservoir and passed through by Peace Canyon and Site Cs flow rate - smaller reservoirs with higher flushing rate with greater potential to export nutrients/organisms into the downstream area. - same for emergency spilling
Lower trophic level communities (plankton, benthos and macrophytes)	- a robust plankton community is expected to develop in Site C reservoir in response to reservoir formation and associated nutrient releases from flooding of terrestrial soils and decaying vegetation. - the reservoir benthic community is likely to consist of organisms that prefer soft	- similar to Site C	- similar to Site C	- Low C expected to be similar to Site C, although lower volume and higher flushing rate (50% faster) will provide less opportunity for primary production. Benthic community expected to be similar to Site C - 7B has a very quick flushing rate (~ 1 day) and	- lower dams with smaller reservoirs and higher flushing rates (10-20% of Site C rate) will provide less opportunity for primary production. Upstream portion of each reservoir will maintain more 'riverine' characteristics and	- lower dams with smaller reservoirs and higher flushing rates (5-10% of Site C rate) will provide less opportunity for primary production. Upstream portions of each reservoir will maintain more 'riverine' characteristics and	- lower dams with smaller reservoirs and higher flushing rates (1-2% of Site C rate) will provide less opportunity for primary production. Upstream portions of each reservoir will maintain more

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	sediments, such as chironomids, oligochaete works, round worms and zooplankton that are associated with the sediment/water interface. - no additional changes due to emergency spilling or facility maintenance Background - zooplankton community of Williston Reservoir in 1999 was considered a diverse assemblage, with 15 species, dominated by copepods and cladocerans. Biomass averaged 56% copepods and 44% cladocerans (Wilson and Langston, 2000). Transfer of these organisms downstream into the Site C reservoir is anticipated. Benthic community sampling downstream of the Site C dam in the Peace River in 1976 collected oligochaetes, mayflies, nematodes, beetles and chironomids (RRCS, 1978). The reservoir benthic community is likely to consist of organisms that prefer soft sediments, such as chironomids, oligochaete works, round worms and zooplankton that are associated with the sediment/water interface (Perrin, 1996). Some retention of riverine community in reach immediately below Peace Canyon dam.			will retain riverine plankton and benthic community characteristics.	associated production of benthic organisms adapted to flowing water environments (i.e.mayflies, stoneflies, etc).	associated production of benthic organisms adapted to flowing water environments (i.e.mayflies, stoneflies, etc).	'riverine' characteristics and associated production of benthic organisms adapted to flowing water environments (i.e.mayflies, stoneflies, etc).

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
Fish mercury concentrations (results transferred to Wildlife and Social for inclusion into health assessments)	- production and uptake of methyl mercury into aquatic organisms expected due to inundation of river valley organic matter (humus, leaf litter, organic soils, etc), resulting in short term peak and slow decline over long term as system reaches equilibrium. - no additional changes due to emergency spilling or facility maintenance **Bull trout** - Mean mercury concentration elevated (0.68 ppm) in Finlay Reach of Williston Reservoir in 1980. No significant difference in mean size-adjusted Hg concentration among Peace, Parsnip and Finlay reaches in 1988 (0.83 ppm) and no decline since 1980. **Lake whitefish** – size-adjusted Hg concentration in Williston higher in 1988 (0.24 ppm) than in 1980 (0.13 ppm). 1988 concentrations similar to large reservoirs in Manitoba and Quebec, and significantly higher than found in reference lakes. **Burbot** – size adjusted concentration for Parsnip reach of Williston of 0.41 ppm (below 0.5 ppm guideline). **Rainbow trout** – size adjusted concentration below 0.5 ppm. Primarily insectivore with low potential to accumulate Hg. **Kokanee** – no size/Hg	- inundation area slightly smaller (~10%), but net effect expected to be similar to Site C	- inundation area ~20% smaller, but net effect expected to be similar to Site C	- inundation area ~20% smaller, but net effect expected to be similar to Site C	- inundation area ~20% smaller, but net effect expected to be similar to Site C	- inundation area ~20% smaller, but net effect expected to be similar to Site C	- inundation area ~40% smaller, and higher flow velocity through reservoirs (less potential for methyl mercury formation). Less effect expected than for Site C or other alternatives

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
	relationship and very low in Williston Peace reach (0.04 ppm). Primarily insectivore with low potential to accumulate Hg. (EVS, 1999).						
Rare and listed species	- reservoir environment and normal facility operations not expected to adversely affect spottail shiner as it is typically a species of lakes or large rivers. Bull trout are not expected to be adversely affected as spawning/rearing habitat not affected, and adequate foraging opportunities expected in large reservoir environment. Pearl dace is typically a minnow of cool, clear headwater streams, beaver ponds, and/or bog drainage streams, ponds and small lakes. Preferred habitat will remain in tributary streams/rivers. Typical goldeye habitat is quiet, turbid water of large rivers and connected waterbodies with deep water habitat used for overwintering, which will be found in the reservoir environment. - emergency spilling could evacuate individuals near dam from the reservoir into the downstream reach. Background - Spottail shiner is red-listed, while bull trout, goldeye and pearl dace are blue-listed in BC (AMEC & LGL, 2008d).	- similar to Site C	- similar to Site C	- similar to Site C	- more partitioning of habitat into short river section, which is expected to provide fewer benefits to bull trout - similar to Site C for other listed species	- more partitioning of habitat into short river section, which is expected to provide fewer benefits to bull trout - similar to Site C for other listed species	- more partitioning of habitat into short river section, which is expected to adversely affect bull trout - similar to Site C for other listed species
Riparian							

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
Habitat/Species							
Shoreline vegetation community	- formation and operation of the reservoir is expected to eventually result in a relatively stable riparian zone vegetation community due to the small operating range. Complex shoreline vegetation communities may develop along low aspect shorelines in sheltered embayments (as is present near Halfway/Peace junction; AIM, 2000), consisting of the community transition from spikerush to horsetail to sedges to bulrush to spearwart to grasses and sedges and finally willows and cottonwoods at the highest elevation (AIM, 2000). Reservoir formation will result in ~300 km of shoreline around the periphery of the reservoir and ~21 km of shoreline around islands	- similar to Site C, with ~260 km of reservoir shoreline and ~20 km of island shoreline.	- similar Site C, with ~240 km of reservoir shoreline and ~20 km of island shoreline.	- better than Site C, with more low gradient shoreline available and ~260 km of reservoir shoreline and ~40 km of island shoreline.	- better than Site C, with more low gradient shoreline available and ~240 km of reservoir shoreline and ~27 km of island shoreline.	- better than Site C, with more low gradient shoreline available and ~240 km of reservoir shoreline and ~28 km of island shoreline.	- significantly better than site C, with more low gradient shoreline available in river bottom ~260 km of reservoir shoreline and ~170 km of island shoreline.
Islands/in-water structures	- three islands present at the upper end of the reservoir near Peace Canyon dam, with an area of ~ 96 ha. - normal operations, maintenance and emergency spilling will not affect these islands	- similar to Site C, islands area is ~ 95 ha	- similar to Site C, islands area is ~ 95 ha	- similar to Site C - island area is 58.5 ha	- similar to Site C, area of islands ~ 51 ha	- similar to Site C, area of islands ~ 57 ha	- 19 islands present, with total combined area of ~ 429 ha
Rare and/or listed species and/or communities	- insufficient information to assess.						
Terrestrial Environment							

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
Vegetation species/ communities	- existing vegetation communities in close proximity to reservoir shoreline may change to more "riparian" type community over long term due to higher groundwater levels and local changes to micro-climate. Forest communities beyond this "edge" area (± 100 m) unlikely to be affected by normal and/or emergency reservoir operations or maintenance. -transmission line maintenance activities will not affect surrounding vegetation communities.	- similar to Site C	- similar to Site C	- similar to Site C	- similar to Site C	- similar to Site C	- less loss of vegetation communities and greater potential for recovery
Wildlife	- changes in habitat availability due to reservoir formation and operation has the potential to affect ungulates that utilize islands for calving/rearing. - relatively stable water levels during project operation is not expected to adversely affect beavers - large reservoir area with sheltered embayments and tributary mouths will favour diving ducks, but will be less favourable for dabbling ducks and shorebirds - loss of specific nesting trees and roosting habitat may adversely affect raptors, owls, and bats until replacement habitat develops. -methylmercury has the potential to affect species that prey on reservoir fish	- similar to Site C	- similar to Site C, but reservoir area ~ 20% smaller and slightly less Methylmercury accumulation potential	- similar to Site C, but reservoir area ~ 20% smaller and slightly less Methylmercury accumulation potential	- similar to Site, but reservoir area ~ 20% smaller and slightly less Methylmercury accumulation potential C	- similar to Site C but reservoir area ~ 20% smaller and slightly less Methylmercury accumulation potential	- less effect on wildlife than other options due to lower dams/FSLs - reservoir area ~ 40% less than other options, providing less Methylmercury accumulation potential

Environmental Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Option			
				Low C and 7b	3 dam	4 dam	7 dam
Rare and listed species and/or communities	- insufficient information to assess						

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Appendix D

Socio-Economic Environment Matrix

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Site C Evaluation of Alternatives

Socio-economic Environment Aspects

Socio-Economic Environment

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
CONSTRUCTION -Cofferdams, tunnels and burrow/disposal areas -Dam and powerhouse construction -Hwy 29 relocation, bridges and access roads -Transmission lines - Reservoir Clearing -Reservoir Filling							
Land Use and Land Tenure							
Land Use	-~9513.6 ha impacted + 22.3 km Hwy relocated -9313.6 ha land needed for reservoir -200 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 1 dam. -22.3 km of Hwy 29 to be relocated and 4 bridges needed.	-~8520.9 (C1) or 8768.4 (C2) ha impacted + 22.3 km Hwy relocated -8320.9(C1) or 8568.4 (C2) ha land needed for reservoir -200 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 1 dam. -22.3 km of Hwy 29 to be relocated	-~8007.7 ha impacted + 22.3 km Hwy relocated -7677.7 ha land needed for reservoir -330 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 1 dam. -22.3 km of Hwy 29 to be relocated	-~7968.7 ha impacted + 18.1 km Hwy relocated -7668.7 ha land needed for reservoir -300 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 2 dams. -18.1 km of Hwy 29 to be relocated	-~7840.41 ha impacted + 13.24 km Hwy relocated -7372.41 ha land needed for reservoir -468 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 3 dams. -13.24 km of Hwy 29 to be relocated	-~8099.7 ha impacted + 11.77 km Hwy relocated -7379.7 ha land needed for reservoir -720 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 4 dams. -11.77 km of Hwy 29 to be relocated	-~6497.2 ha impacted + 9.76 km Hwy relocated -much less land inundated, and much of upper terraced area will be preserved -previously abandoned back channels will be re-watered. -reduced impact on land use and accessibility[10] -5657.2 ha land needed for reservoir -840 ha of land removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse for 7 dams. -9.76 km of Hwy 29 to be relocated
Land Tenure	-515 ha private land impacted -3544.01 ha of Crown land will be inundated by reservoir -515.05 ha private land will be inundated by reservoir	-Roughly same amount of private land impacted -2995.11 ha of Crown land will be inundated by reservoir -515.05 ha private land will be inundated by reservoir	-Roughly same amount of private land impacted -2575.11 ha of Crown land will be inundated by reservoir -498.25 ha private land will be inundated by reservoir	-Moderately less private land impacted -2480.42 ha of Crown land will be inundated -260.15 ha private land will be inundated by reservoir	-Slightly less private land impacted -2134.59 ha of Crown land will be inundated by reservoir -415.43 ha private land will be inundated by reservoir	-Slightly less private land impacted -2140.17 ha of Crown land will be inundated by reservoir -413.73 ha private land will be inundated by reservoir	-Significantly less private land impacted -1027.3 ha of Crown land will be inundated by reservoir -144.99 ha of private land will be inundated by reservoir

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
Resource Use							
Agricultural Lands	-Agricultural lands affected by the Site C reservoir are approx. 1218 ha. - 678 & 176.07 ha of cultivated and grazing lands will be inundated by reservoir -41 and 101.64 ha of cultivated and grazing lands impacted by Transmission Lines (TL). -98.8 and 120.79 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -disruption to labor supply and traffic during construction	-Similar to Site C, with 1183 ha affected - 672 & 176.07 ha of cultivated and grazing lands will be inundated by reservoir - 41.4 and 100.36 ha of cultivated and grazing lands impacted by TL. -194.3 and 0 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -disruption to labor supply and traffic during construction	-Similar to Site C, but less agricultural lands lost for transmission and facility footprint (997 ha total) - 672 & 176.07 ha of cultivated and grazing lands will be inundated by reservoir - 41 and 22.34 ha of cultivated and grazing lands impacted by TL. -86.6 and 0 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -disruption to labor supply and traffic during construction	-Less effect to cultivated and grazing lands from reservoirs, similar for TLs (842 ha total) - 478 & 26.69 ha of cultivated and grazing lands will be inundated by reservoir - 37.7 and 34.62 ha of cultivated and grazing lands impacted by TL. -143.5 and 120.79 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -slightly less disruption to labor supply and traffic during construction due to longer construction period and less intense construction activity.	-Less effect to cultivated and grazing lands from reservoirs, similar for TLs, and considerably more for facility footprint (1030 ha) - 497 & 19.63 ha of cultivated and grazing lands will be inundated by reservoir - 42 and 100.2 ha of cultivated and grazing lands impacted by TL. -191.7 and 178.8 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -slightly less disruption to labor supply and traffic during construction due to longer construction period and less intense construction activity.	-Less effect to cultivated and grazing lands from reservoirs, similar for TLs, but much more for facility footprint (1305 ha total) - 492 & 27.39 ha of cultivated and grazing lands will be inundated by reservoir - 46 and 100.2 ha of cultivated and grazing lands impacted by TL. -483.6 and 156.2 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -slightly less disruption to labor supply and traffic during construction due to longer construction period and less intense construction activity.	-Least effect due to reservoir formation, but more effect due to transmission lines to connect to north shore transmission corridor and facility footprints. (1222 ha total) - 270 & 1.74 ha of cultivated and grazing lands will be inundated by reservoir - 259 and 97 ha of cultivated and grazing lands impacted by TL. -589.7 and 4.8 ha cultivated and grazing land impacted by access roads, dam site and related facilities. -less disruption to labor supply and traffic during construction due to longer construction period and less intense construction activity.
Forestry Lands	-Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. - 852.53 ha of Timber Harvesting Land Base lost from future production -9313.6 ha of reservoir clearing needed and 910 ha cleared for TL. -roughly half of flooded	-Somewhat less Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. -717.22 ha of Timber Harvesting Land Base lost from future production -8320.9 (C1) or 8568.4 (C2) of reservoir clearing	-Moderately less Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. - 662.60 ha of Timber Harvesting Land Base lost from future production -7677.7 ha of reservoir clearing needed and 921	-Moderately less Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. -570.50 ha of Timber Harvesting Land Base lost from future production -7668.7 ha of reservoir clearing needed and 676	-Roughly same Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. -832.69 ha of Timber Harvesting Land Base lost from future production -7372.41 of reservoir clearing needed and 1325	-Very slightly more Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. -899.53 ha of Timber Harvesting Land Base lost from future production -7379.7 ha of reservoir clearing needed and 1538	-Significantly less Contributing and Partially Contributing Timber Harvesting Land Base lost from future production. - 164.62 ha of Timber Harvesting Land Base lost from future production -5657.2 ha of reservoir clearing needed and 1251

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	area forest land. [9]	needed and 938 ha cleared for TL (for C2)	ha cleared for TL	ha cleared for TL	ha cleared for TL	ha cleared for TL	ha cleared for TL on north shore (mostly private or BC Hydro owned)
Oil & Gas	-Some oil and gas fields impacted, 1 well impacted. -1 O&G well inundated --1619.17 ha of O&G fields impacted by reservoir - 173.48 ha of O&G fields impacted by TL Total = 1793 ha -4023.14 ha Petroleum titles impacted by reservoir -769.63 ha Petroleum titles impacted by TL Total = 4793 ha	-Moderately less O&G fields impacted -1 O&G well inundated (5b) --1098.73 ha of O&G fields impacted by reservoir - 200.42 ha of O&G fields impacted by TL Total = 1299 ha -3190.91 ha Petroleum titles impacted by reservoir -797.66 ha Petroleum titles impacted by TL Total = 3989 ha	-Significantly less O&G fields impacted -1 O&G well inundated (5b) -507.65 of O&G fields impacted by reservoir - 219.92 ha of O&G fields impacted by TL Total = 728 ha -2575.42 ha Petroleum titles impacted by reservoir -806.89 ha Petroleum titles impacted by TL Total = 3382 ha	-Moderately less O&G fields impacted -1 O&G well inundated (5b) --1295.04 ha of O&G fields impacted by reservoir - 92.96 ha of O&G fields impacted by TL Total = 1388 ha -3212.28 ha Petroleum titles impacted by reservoir -553.42 ha Petroleum titles impacted by TL Total = 3766 ha	-Moderately less O&G fields impacted -1 O&G well inundated (5b) --1047.99 ha of O&G fields impacted by reservoir - 378 ha of O&G fields impacted by TL Total = 1426 ha -2780.69 Petroleum titles impacted by reservoir - 1222.6 ha Petroleum titles impacted by TL Total = 4003 ha	-Moderately less O&G fields impacted -1 O&G well inundated (5b) --1029.18 ha of O&G fields impacted by reservoir - 412.9 ha of O&G fields impacted by TL Total = 1442 ha -2599.42 Petroleum titles impacted by reservoir - 1397.5ha Petroleum titles impacted by TL Total = 3997 ha	-Significantly less O&G fields impacted -1 O&G well inundated (5b) --733.53 ha of O&G fields impacted by reservoir - 280 ha of O&G fields impacted by TL Total = 1014 ha -2249.31 Petroleum titles impacted by reservoir - 809.3 ha Petroleum titles impacted by TL Total = 3059 ha
Mining & Aggregates	-Some loss of mining and aggregate resources -3 gravel pits will be inundated. -1 private aggregate pit inundated -18.8 mm^3 of fill required	-Slightly less effect on mining and aggregates -1 gravel pit will be inundated. -1 private aggregate pit inundated -21.8 mm^3 of fill required	-Slightly less effect on mining and aggregates -2 gravel sites will likely be affected -1 private aggregate pit inundated -15.6 mm^3 of fill required	-Slightly less effect on mining and aggregates -1 gravel pit will be inundated. -1 private aggregate pit inundated -19.04 mm^3 of fill required	-Moderately less effect on mining and aggregates -no gravel sites impacted -1 private aggregate pit inundated -mm^3 of fill required not available	-Moderately less effect on mining and aggregates -no gravel sites impacted -1 private aggregate pit inundated -mm^3 of fill required not available	-Significantly less effect on mining and aggregates -no gravel sites impacted -private aggregate pit not inundated -mm^3 of fill required not available
Irrigation	-7 water licenses impacted. Likely changes to water quality due to river-to-lake transformation difficult to predict.	-7 water licenses impacted. Likely changes to water quality due to river-to-lake transformation difficult to predict.	-7 water licenses impacted. Likely changes to water quality due to river-to-lake transformation difficult to predict.	-6 water licenses impacted. Likely changes to water quality due to river-to-lake transformation difficult to predict.	-7 water licenses impacted. Likely changes to water quality due to river-to-lake transformation difficult to predict.	-7 water licenses impacted. Likely changes to water quality due to river-to-lake transformation difficult to predict.	-4 water licenses impacted (almost half as many). Likely less change to water quality, though difficult to predict.
Transportation & Infrastructure							
Roads and Traffic	-Deterioration of existing road surfaces due to construction traffic	-Deterioration of existing road surfaces due to construction traffic	-Deterioration of existing road surfaces due to construction traffic	-Deterioration of existing road surfaces due to construction traffic	-Deterioration of existing road surfaces due to construction traffic	-Deterioration of existing road surfaces due to construction traffic	-Deterioration of existing road surfaces due to construction traffic

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	(workers, delivery vehicles and material transfers) over 7 years -Increased traffic anticipated along small portion of the road over 7 years.	(workers, delivery vehicles and material transfers) over roughly 7 years. -Increased traffic anticipated along slightly longer portion of road. -More haul road use for disposal.	(workers, delivery vehicles and material transfers) over roughly 7 years. -Increased traffic anticipated along slightly longer portion of road than C1/C2	(workers, delivery vehicles and material transfers) over slightly more than 7 years. -Increased traffic anticipated along longer road (FSJ to past Farrell Creek)	(workers, delivery vehicles and material transfers) over moderately more than 7 years. -Increased traffic anticipated along longer stretch of road (FSJ to Farrell Creek)	(workers, delivery vehicles and material transfers) over moderately more than 7 years. -Increased traffic anticipated along longer stretch of road (FSJ to Farrell Creek)	(workers, delivery vehicles and material transfers) over significantly more than 7 years (depending on sequencing). -Increased traffic anticipated along longest stretch of road (FSJ to past Hudson's Hope) in order to construct seven separate facilities
Transmission Line Interconnections	-Minimal disturbance to supply -1 interconnection with existing BCH transmission line	-Minimal disturbance to supply -1 interconnections with existing BCH transmission line	-Minimal disturbance to supply -1 interconnections with existing BCH transmission line	-Slightly more potential for disturbance to supply -2 interconnections with existing BCH transmission line	-Slightly more potential for disturbance to supply -3 interconnections with existing BCH transmission line	-Moderately more potential for disturbance to supply -4 interconnections with existing BCH transmission line	-Significantly more potential for disturbance to supply -7 interconnections with existing BCH transmission line
Public Health & Safety							
Fugitive Dust Emissions	One site, so less impact. Better mitigation and enforcement potential.	One site, so less impact. Better mitigation and enforcement potential.	One site, so less impact. Better mitigation and enforcement potential.	2 sites, so slightly larger potential to affect more people. Longer construction period.	3 sites, so larger potential to affect more people. Longer construction period and more geographically spread out.	4 sites, so larger potential to affect more people. Longer construction period and more geographically spread out.	Seven sites, so greater potential to affect more people. Long construction period, more geographically spread out.
Noise	-As above	-As above	-As above	-As above	-As above	-As above	-As above
Worker safety	-One site. -Heavy equipment, underground work, near water required.	-One site. -Slightly longer road travel, increased potential for traffic accidents.	-One site. -Slightly longer road travel, increased potential for traffic accidents	-2 sites. -Moderately longer road travel, so slightly increased potential for accidents	-3 sites. -Moderately longer road travel, so moderately increased potential for accidents	-4 sites. -Moderately longer road travel, so moderately increased potential for accidents	-7 sites. -Moderately longer road travel, so significantly increased potential for accidents
Public Safety	-~2000 person workforce -Heavier traffic along small portion of the road over 7 years. -Greater potential for large-scale emergencies related to downstream flooding, dam problems.	-~2000 person workforce -Heavier traffic along slightly longer portion of road over roughly 7 years. -Greater potential for large-scale emergencies related to downstream	-~2000 person workforce -Heavier traffic along slightly longer portion of road than C1/C2 over roughly 7 years. -Greater potential for large-scale emergencies related to downstream	-Slightly greater than ~2000 person workforce -Heavier traffic along longer road (FSJ to past Farrell Creek) over slightly more than 7 years. -Slightly less potential for large-scale emergencies	-Moderately greater than ~2000 person workforce -Heavier traffic along longer stretch of road (FSJ to Farrell Creek) over more than 7 years. -Moderately less	-Moderately greater than ~2000 person workforce -Heavier traffic along longer stretch of road (FSJ to Farrell Creek) over more than 7 years. -Moderately less potential for large-scale	-Significantly greater than ~2000 person workforce (depending on sequencing) -Heavier traffic along longest stretch of road (FSJ to past Hudson's Hope) over significantly

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
		flooding, dam problems. -More haul road activity for disposal	flooding, dam problems.	related to downstream flooding, dam problems.	potential for large-scale emergencies related to downstream flooding, dam problems.	emergencies related to downstream flooding, dam problems.	more than 7 years (depending on sequencing). -Significantly less potential for large-scale emergencies related to downstream flooding, dam problems.
Recreational Users Safety	-No significant risk to recreational users' safety. Flow level relatively even. -One dam site, so mitigation measures can be effective. -Shoreline stability: Reservoir creating 319km shoreline that could be prone to local instability and erosion during reservoir clearing and filling.	-No significant risk to recreational users' safety. Flow level relatively even. -One dam site, so mitigation measures can be effective. -Assumed slightly less shoreline erosion effect based on less length of reservoir shoreline created.	-No significant risk to recreational users' safety. Flow level relatively even. -One dam site, so mitigation measures can be effective. -Assumed slightly less shoreline erosion effect based on less length of reservoir shoreline created.	-Slightly more risk to recreational users safety. Flow level relatively even. -Two dam sites, requiring more mitigation measures. -Assumed similar potential shoreline erosion effect as C3, based on similar length of reservoir shoreline created.	-Slightly more risk to recreational users safety. Flow level relatively even. -Three dam sites, requiring more mitigation measures. Shallower water a slight risk for boaters and canoeists. -Assume moderately less potential shoreline erosion effect based on lower cascade reservoir depth and less length of reservoir shoreline.	-Slightly more risk to recreational users safety. Flow level relatively even. -Four dam sites, requiring more mitigation measures. Shallower water a slight risk for boaters and canoeists. -Assume moderately less potential shoreline erosion effect based on lower cascade reservoir depth and less length of reservoir shoreline.	-More risk to recreational users safety. Flow level relatively even. -Seven dam sites, requiring more mitigation measures. Shallower water a slight risk for boaters and canoeists. -Assume slightly more potential shoreline erosion effects based on more length of reservoir shoreline created, although lower reservoirs may reduce potential for shoreline instabilities on steep slopes. -Boaters and canoeists would have to become used to the new dangers of many flooded islands and bars, many of which would be inundated up to a meter or less. [10]
Culture & Heritage							
Archaeology Sites	-50 known sites disturbed or damaged (TEM) -~9513.6 ha land disturbed	Slightly fewer sites disturbed or damaged -45 known sites disturbed or damaged (TEM) -~8520.9 (C1) or 8768.4 (C2) ha land disturbed	Slightly fewer sites disturbed or damaged -42 known sites disturbed or damaged (TEM) ~8030 ha land disturbed	Moderately fewer sites disturbed or damaged -30 known sites disturbed or damaged (TEM) -~7968.7 ha land disturbed	Moderately fewer sites disturbed or damaged -34 known sites disturbed or damaged (TEM) -~7822.4 ha land disturbed	Moderately fewer sites disturbed or damaged -31 known sites disturbed or damaged (TEM) -~7899.7 ha land disturbed	Significantly fewer sites disturbed or damaged -21 known sites disturbed or damaged (TEM) -~6357.2 ha land disturbed

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
Cultural Resources	-66-67 buildings will be impacted	-65-66 buildings will be impacted	-66-67 buildings will be impacted	-34-35 buildings near to flood line, likely to be impacted	-49-50 buildings will likely be impacted	-47-48 buildings will likely be impacted	-13 building will be inundated or impacted
Recreation & Tourism							
Fishing	-Fishing opportunities affected -1 flow diversion and coffer dam will block fish passage. -Increase in demand for fishing from 2000 person construction workforce over 7 yrs -7 yrs worth of limited access to fishing during construction	-Fishing opportunities affected similar to Site C -1 flow diversion and coffer dam will block fish passage. -Increase in demand for fishing from ~2000 person construction workforce over ~7 years yrs Construction -~7 yrs worth of limited access to fishing during construction	-Fishing opportunities affected similar to Site C -1 flow diversion and coffer dam will block fish passage. -Increase in demand for fishing from ~2000 person construction workforce over ~7 years yrs -~7 yrs worth of limited access to fishing during construction	-More potential to disrupt fishing activities with 2 sites -2 flow diversions and coffer dams will block fish passage. -Increase in demand for fishing from more than 2000 person construction workforce over more than 7 yrs -Slightly more than 7 yrs worth of limited access to fishing during construction	-More disruption to fish community and more potential to disrupt fishing activities with 3 construction sites -3 flow diversions and coffer dams will block fish passage. -Increase in demand for fishing from moderately more than 2000 person construction workforce over more than 7 yrs -Moderately more than 7 yrs worth of limited access to fishing during construction	-More disruption to fish community and more potential to disrupt fishing activities with 4 construction sites -4 flow diversions and coffer dams will block fish passage. -Increase in demand for fishing from moderately more than 2000 person construction workforce over more than 7 yrs -Moderately more than 7 yrs worth of limited access to fishing during construction	-More disruption to fish community and more potential to disrupt fishing activities with 7 construction sites -7 flow diversions and coffer dams will block fish passage. -If cascade includes fishways, lower mortality of fish so greater fish populations. BUT boating impeded by series of dams. -Increase in demand for fishing from significantly more than 2000 person construction workforce over more than 7 yrs (depending on sequencing) -Significantly more than 7 yrs worth of limited access to fishing during construction (depending on sequencing)
Hunting	-7369.32 ha hunting zone land impacted. 7 yrs reduced access. -6459.11 ha hunting zones impacted by reservoir -910.23 ha hunting zones impacted by TL -Temporary loss of access to some areas	-Slightly less hunting zone impacted (6688.97 ha). Similar time reduced access. -5750.71 ha hunting zones impacted by reservoir -938.26 ha hunting zones impacted by TL -Temporary loss of	-Moderately less hunting zone impacted (6262.71 ha). Similar time reduced access. -5342.17 ha hunting zones impacted by reservoir -920.54 ha hunting zones impacted by TL -Temporary loss of	-Moderately less hunting zone impacted (6219.29 ha). Slightly longer time reduced access. -5543.31 ha hunting zones impacted by reservoir -675.98 ha hunting zones impacted by TL -Temporary loss of	-Slightly less hunting zone impacted (6691.52 ha). Moderately longer time reduced access. -5366.25 ha hunting zones impacted by reservoir -1325.27 ha hunting zones impacted by TL -Temporary loss of	-Slightly less hunting zone impacted (6998.54 ha). Moderately longer time reduced access. -5460.50 ha hunting zones impacted by reservoir -1538.04 ha hunting zones impacted by TL -Temporary loss of	-Significantly less hunting zone impacted (4867.51). Moderately longer time reduced access. -4243.36 ha hunting zones impacted by reservoir -624.15 ha hunting zones impacted by TL

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	during 7 yrs construction -Total area affected represents 0.6% of total area licensed to the 4 guide outfitters. (No hunting zone on and adjacent to the Peace River, so likely around 0.3%) [12]	access to some areas during ~7 yrs construction	access to some areas during ~7 yrs construction	access to some areas during slightly more than 7 yrs construction	access to some areas during moderately more than 7 yrs construction	access to some areas during moderately more than 7 yrs construction	-Temporary loss of access to some areas during more than 7 yrs construction (depending on sequencing)
Trapping and Guiding	-Trapping areas affected by reservoir and TL (10228.92 ha) -Traplines impacted: TR0735T004; TR0732T004: TR0732T003. -9318.69 ha trapline area impacted by reservoir -910.23 ha trapline area impacted by TL	-Slightly less trapping area impacted (9511.46 ha) -Traplines impacted: TR0735T004: TR0732T004: TR0732T003. -8573.20 ha trapline area impacted by reservoir -938.26 ha trapline area impacted by TL	-Moderately less trapping area impacted (8602.67 ha) -Traplines impacted: TR0735T004: TR0732T004: TR0732T003. -7682.13 ha trapline area impacted by reservoir -920.54 ha trapline area impacted by TL	-Moderately less trapping area impacted (8348.89 ha) -Traplines impacted: TR0735T004: TR0732T004: TR0732T003. -7672.91 ha trapline area impacted by reservoir -675.98 ha trapline area impacted by TL	-Moderately less trapping area impacted -Traplines impacted TR0735T004: TR0732T004: TR0732T003. -7376.50 ha trapline area impacted by reservoir -1325.27 ha trapline area impacted by TL	-Moderately less trapping area impacted -Traplines impacted TR0735T004: TR0732T004: TR0732T003. -7383.82 ha trapline area impacted by reservoir -1538.04 ha trapline area impacted by TL	-Significantly less trapping area impacted -Traplines impacted TR0735T004: TR0732T004: TR0732T003. -5660.55 ha trapline area impacted by reservoir -1250.91 ha trapline area impacted by TL
Recreational Boating and Navigation	-Limited boating/navigation access during 7 yrs construction	-Limited boating/navigation access during ~7 yrs construction, but Moberley still in tact.	-Limited boating/navigation access during ~7 yrs construction, but Moberley still in tact.	-Limited boating/navigation access during slightly more than 7 yrs construction	-Limited boating/navigation access during moderately more than 7 yrs construction	-Limited boating/navigation access during moderately more than 7 yrs construction	-Limited boating/navigation access during significantly more than 7 yrs construction (depending on sequencing)
Recreational Sites	-Recreational sites lost, and limited public access during construction. -44.50 ha recreational sites lost -9 recreational sites lost (TEM) -7 yrs of limited public access during construction	-Similar to C3. -44.50 ha recreational sites lost -8 recreational sites lost (TEM) -~7 yrs construction	-2 fewer recreational sites lost than C3. -38.36 ha recreational sites lost -7 recreational sites lost (TEM) -~7 yrs of limited public access during construction	-Slightly less loss of recreational sites. -42.94 ha recreational sites lost -9 recreational sites lost (TEM) -More than 7 yrs of limited public access during construction	-Slightly less loss of recreational sites. -42.77 ha recreational sites lost -9 recreational sites lost (TEM) -More than 7 yrs of limited public access during construction	-Slightly less loss of recreational sites. -41.72 ha recreational sites lost -8.5 recreational sites lost (TEM) -More than 7 yrs of limited public access during construction	-Significantly less loss of recreational sites. -16.29 ha recreational sites lost - scenic view of river maintained -7 recreational sites lost (TEM) -More than 7 yrs of limited public access during construction

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
Proposed Protected Areas	-6356.64 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -0 ha impacted by TL	-5676 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -47.61 ha impacted by TL	-4933.97 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -27.11 ha impacted by TL	-5805.96 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -13.64 ha impacted by TL	-5584.43 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -92.42 ha impacted by TL	-5596.55 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -91.22 ha impacted by TL	-4664.35 ha of proposed Peace River Boudreaux Lake Protected Area impacted by reservoir -0 ha impacted by TL
Viewscapes and Area Aesthetics	-Large reservoir means loss of islands and vegetated terraces. -Large amount of Hwy to be relocated away from river -Reduced scenic view of river	-Large reservoir means loss of islands and vegetated terraces. -Large amount of Hwy to be relocated away from river -Reduced scenic view of river	-Large reservoir means loss of islands and vegetated terraces. -Slightly less Hwy to be relocated away from river than C3/2/1 -Reduced scenic view of river	-2 larger reservoirs so loss of islands and vegetated terraces. -Less Hwy to be relocated away from river than Wilder option -Reduced scenic view of river	-3 dam facilities and TLs would impact viewscapes and area aesthetics BUT vegetated terraces will remain slightly less unflooded -Less Hwy to be relocated away from river than 2-Dam option -Scenic view of river more maintained, but declined visual quality due to dams.	-4 dam facilities and TLs would impact viewscapes and area aesthetics BUT vegetated terraces will remain slightly less unflooded -Less Hwy to be relocated away from river than 3-Dam option -Scenic view of river more maintained, but declined visual quality due to dams.	-7 dam facilities and TLs would impact viewscapes and area aesthetics BUT vegetated terraces will remain unflooded -Least amount of Hwy to be relocated away from river -Scenic view of river maintained, but declined visual quality due to dams.
Tourism	-Increased traffic anticipated along small portion of the road over 7 years. -Larger tourism benefit from single large dam	-Increased traffic anticipated along slightly longer portion of road over ~7 years. -Larger tourism benefit from single large dam	-Increased traffic anticipated along slightly longer portion of road than C1/C2 over ~7 years. -Larger tourism benefit from single large dam	-Increased traffic anticipated along longer road (FSJ to past Farrell Creek) over slightly more than 7 years. -Slightly less tourism draw from two dams.	-Increased traffic anticipated along longer stretch of road (FSJ to Farrell Creek) over moderately more than 7 years. -Slightly less tourism draw from three dams.	-Increased traffic anticipated along longer stretch of road (FSJ to Farrell Creek) over moderately more than 7 years. -Slightly less tourism draw from four dams.	-Increased traffic anticipated along longest stretch of road (FSJ to past Hudson's Hope) over significantly more than 7 years (depending on sequencing) -Less tourism draw from seven dams.
Employment and Economic Opportunities							
Labour Requirements & Impacts	-Shorter construction period and heavy influx, so bigger pressure on wages, increased business costs, potential skills shortage, and greater slump afterwards -2015 workers during peak of construction (year 4) [9] -7 year construction period [9]	-Shorter construction period and heavy influx, so bigger pressure on wages, increased business costs, potential skills shortage, and greater slump afterwards -~2000 person workforce -~7 years construction period	-Shorter construction period and heavy influx, so bigger pressure on wages, increased business costs, potential skills shortage, and greater slump afterwards -~2000 person workforce -~7 years construction period	Longer construction period and slightly less heavy influx, so slightly less pressure on wages, slightly less increased business costs, slightly less potential skills shortage, and slightly less slump afterwards ->2000 person workforce ->2000 years construction period	Longer construction period and slightly less heavy influx , so moderately less pressure on wages, moderately less increased business costs, moderately less potential skills shortage, and moderately less slump afterwards ->2000 person workforce ->7 years construction	Longer construction period and slightly less heavy influx , so moderately less pressure on wages, moderately less increased business costs, moderately less potential skills shortage, and moderately less slump afterwards ->2000 person workforce ->7 years construction	Long construction period and less heavy influx, so less pressure on wages, less increased business costs, less potential skills shortage, and less slump afterwards -55 months per site; sequentially, simultaneously, or in groups -Would likely be around

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	-Estimated 25% local hires [14]				period	period	16 yrs development[10]
Construction Services & Infrastructure	-Construction work force up to 2000 will require housing and associated facilities -Increase in transient workforce, large strain on local community: boom and bust.	-Increase in transient workforce, large strain on local community: boom and bust.	-Increase in transient workforce, large strain on local community: boom and bust.	-Slightly more stable work force, slightly less short-term strain on community.	-Moderately more stable work force, slightly less short-term strain on community.	-Moderately more stable work force, slightly less short-term strain on community.	-More stable work force, slightly less short-term strain on community.
Community Services & Infrastructure							
Community Services & Infrastructure	-2000 person workforce over 7 years, so boom and bust impact. -Increased short-term need for additional community services	-~2000 person workforce over ~7 years, so big boom and bust impact. -Increased short-term need for additional community services	-~2000 person workforce over ~7 years, so big boom and bust impact. -Increased short-term need for additional community services	-~2000+ person workforce over slightly more than 7 years, so slightly less boom and bust impact. -Slightly less need for additional community services, yet period of influx is longer	-More than 2000 person workforce over moderately more than 7 years, so moderately less boom and bust impact. -Less need for additional community services, yet period of influx is moderately longer	-More than 2000 person workforce over moderately more than 7 years, so moderately less boom and bust impact. -Less need for additional community services, yet period of influx is moderately longer	-More than 2000 person workforce over significantly more than 7 years (depending on sequencing), so significantly less boom and bust impact. -Less need for additional community services, yet period of influx is significantly longer
Economic Development & Finances	-7 yrs construction period, so more difficult for local government planning, local companies to access larger/shorter contracts -Increased public expenditures over 7 years -Loss of 1194.93 ha taxable land base (private land and BCH owned/leased land)	- ~7 yrs construction period, so more difficult for local government planning, local companies to access larger/shorter contracts -Increased public expenditures over ~7 years -Loss of 1189.35 ha taxable land base	-~7 yrs construction period, so more difficult for local government planning, local companies to access larger/shorter contracts -Increased public expenditures over ~7 years -Loss of 1172.55 ha taxable land base	-More than 7 construction period, so slightly longer period, slightly less difficult for local government planning. Local companies have slightly better access to contracts. -Increased public expenditures over more than 7 years. -Loss of 640.4 ha taxable land base	-More than 7 construction period, so moderately longer period, less difficult for local government planning. Local companies have slightly better access to contracts. -Increased public expenditures, but moderately less drastic, over more than 7 years. -Loss of 805.56 ha taxable land base	-More than 7 construction period, so moderately longer period, less difficult for local government planning. Local companies have slightly better access to contracts. -Increased public expenditures, but moderately less drastic, over >7 years. -Loss of 780.42 ha taxable land base	-Well over 7 year construction period, so significantly longer period, less difficult for local government planning. Local companies have slightly better access to contracts. -Increased public expenditures, but significantly less drastic, over well over 7 years. -Loss of 383.44 ha taxable land base
First Nations							
Traditional Lands and Uses	-~9313.6 ha land disturbed: removal of vegetation, loss of traditional activities	-Slightly improved due to no flooding of Moberly River valley and associated changes	-Slightly improved due to no flooding of Moberly River valley and associated changes	-Somewhat better than Site C due to lower dam (less flooded area within Peace corridor and	-Somewhat better than Site C due to lower dam (less flooded area within Peace corridor and	-Somewhat better than Site C due to lower dam (less flooded area within Peace corridor and	-Moderately better than Site C due to lower dam (less flooded area within Peace corridor and

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	-Impacts on traditional land usages (hunting, fishing) due to increased recreational usage of river with enhanced access and reduced wildlife habitat[2] -Loss of big game habitat (ex. moose) -Likely change in potential fish community in reservoir, while maintaining downstream populations.	to fish and wildlife communities. -~8520.9 (C1) or 8768.4 (C2) ha land disturbed: removal of vegetation and loss of traditional activities -Less wildlife habitat flooded (ie Moberley R. and section of Peace R. between upstream and downstream dam sites not flooded) which moderately benefits elk, dear, beaver, etc. [1] -Slightly less loss of big game habitat (ex. moose) -Impacts on traditional land usages (hunting, fishing) due to increased recreational usage of river with enhanced access (new TL temp road) and reduced wildlife habitat[2] -Likely change in potential fish community in reservoir, while maintaining downstream populations.	to fish and wildlife communities -~8007.7 ha land disturbed: removal of vegetation and loss of traditional activities -Less wildlife habitat flooded (ie Moberley R. and section of Peace R. between upstream and downstream dam sites not flooded) which affects elk, dear, beaver, etc. [1] -Slightly less loss of big game habitat (ex. moose) -Impacts on traditional land usages (hunting, fishing) due to increased recreational usage of river with enhanced access (new TL temp road) and reduced wildlife habitat[2] -Likely change in potential fish community in reservoir, while maintaining downstream populations.	Moberly River) -~7968.7 ha land disturbed: removal of vegetation and loss of traditional activities -Likely to reduce potential fish numbers in reservoir, while maintaining downstream populations, but fish stocks not heavily utilized by FN. [1] -Loss of big game habitat (ex. moose) -Impacts on traditional land usages (hunting, fishing) due to increased recreational usage of river with enhanced access (2 new TL temp roads) and reduced wildlife habitat[2] -Likely change in potential fish community in reservoir, while maintaining downstream populations.	Moberly River) -~7840.41 ha land disturbed: removal of vegetation and loss of traditional activities -More significant loss of land and greater access in South Bank for TL -Likely to reduce potential fish numbers in reservoir, while maintaining downstream populations. -Loss of big game habitat (ex. moose) -Slightly less recreational use of river expected, but enhanced access (3 new TL temp roads). -Likely change in potential fish community in reservoir, while maintaining downstream populations.	Moberly River) -~8099.7 ha land disturbed: removal of vegetation and loss of traditional activities -More significant loss of land and greater access in South Bank for TL -Likely to reduce potential fish numbers in reservoir, while maintaining downstream populations. -Loss of big game habitat (ex. moose) -Slightly less recreational use of river expected, but enhanced access (4 new TL temp roads). -Likely change in potential fish community in reservoir, while maintaining downstream populations.	Moberly River) -~6497.2 ha land disturbed: removal of vegetation and loss of traditional activities -Least change to existing fish community in river, while maintaining downstream populations. -Moderately less loss of big game habitat (ex. moose) -Slightly less recreational use of river expected, but enhanced access (7 new TL temp roads). -Least change to big game habitat (ex. moose)
Economic Opportunities	-7 year construction period. -Significant land clearing needed.	-Similar construction period. Slightly less land clearing needed. -Moderately more excavation needed.	-Similar construction period. Slightly less land clearing needed.	-Slightly longer construction period. Slightly less land needing clearing. One extra road to build.	-Moderately longer construction period. Slightly less land needing clearing. 2 extra roads to build.	-Moderately longer construction period. Slightly less land needing clearing. 3 extra roads to build.	-Significantly longer construction period. Significantly less land needing clearing. 6 extra roads to build.
Public Interest & Quality of Life	-2000 workers over 7 yrs, so short-term influx (impacting neighborhood safety, local benefits, short-term pressure on community services/infrastructure)	-~2000 workers over ~7 yrs, so short-term influx (impacting neighborhood safety, local benefits, short-term pressure on community services/infrastructure)	-~2000 workers over ~7 yrs, so short-term influx (impacting neighborhood safety, local benefits, short-term pressure on community services/infrastructure)	-More than 2000 workers over slightly more than 7 yrs, so slightly less short-term influx (impacting neighborhood safety, local benefits, short-term pressure on community	-More than 2000 workers over more than 7 yrs, so moderately less short-term influx (impacting neighborhood safety, local benefits, short-term pressure on community	-More than 2000 workers over more than 7 yrs, so moderately less short-term influx (impacting neighborhood safety, local benefits, short-term pressure on community	-Significantly more than 2000 workers over well over 7 yrs (depending on sequencing), so significantly less short-term influx (impacting neighborhood safety,

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	-More microclimate changes, biggest reservoir footprint, but lowest dam/facilities footprint -Methylmercury will increase in initial years after impoundment, but will decline over time.	-Slightly less microclimate changes, slightly smaller reservoir footprint, but lowest dam/facilities footprint -Methylmercury will increase in initial years after impoundment, but will decline over time.	-Slightly less microclimate changes, slightly smaller reservoir footprint, but lowest dam/facilities footprint -Methylmercury effects will be slightly less based on smaller extend of inundated lands.	services/infrastructure) -Slightly less microclimate changes, slightly smaller reservoir footprint, and higher dam/facility footprint. -Smaller extent of inundated lands will result in lower relatively methylmercury levels.	services/infrastructure) -Moderately less microclimate changes, smaller reservoir footprint, and higher dam/facility footprint. -Smaller extent of inundated lands will result in lower relatively methylmercury levels.	services/infrastructure) -Moderately less microclimate changes, smaller reservoir footprint, and higher dam/facility footprint. -Smaller extent of inundated lands will result in lower relatively methylmercury levels.	local benefits, short-term pressure on community services/infrastructure) -Significantly less microclimate changes, significantly smaller reservoir footprint, and significantly higher dam/facility footprint. -Significantly smaller extent of inundated lands will result in lower relatively methylmercury levels.
OPERATIONS - maintain level near FSL - maintain flows >10,000 cfs -maintain facilities and TL corridors							
Land Use	-Expected increase in fog, dew, and relative humidity as a result of reservoir presence and operations -9,313.6 ha reservoir area	-Expected slightly less increase in fog, dew, and relative humidity as a result of reservoir presence and operations -8320.9 (C1) or 8568.4 (C2) ha reservoir area	-Expected moderately less increase in fog, dew, and relative humidity as a result of reservoir presence and operations -7677.7 ha reservoir surface area	-Expected moderately less increase in fog, dew, and relative humidity as a result of reservoir presence and operations -7668.7 ha reservoir surface area	-Expected moderately less increase in fog, dew, and relative humidity as a result of reservoir presence and operations -7372.41 ha reservoir surface area	-Expected moderately less increase in fog, dew, and relative humidity as a result of reservoir presence and operations -7379.7 ha reservoir surface area	-Expected significantly less increase in fog, dew, and relative humidity as a result of reservoir presence and operations -5657.2 ha reservoir surface area
Groundwater & Water Wells	-Potential increase to local groundwater in proximity to reservoir and potential improvement to future well water supply	-Potential effects assumed similar to C3 based on similar C1 or C2 reservoir surface area (within 20% of C3), depth and volume (within 14% of C3)	-Potential effects assumed similar to C3 based on similar reservoir surface area (within 20% of C3), depth and volume (within 25% of C3).	-Assumed less influential effect to local groundwater conditions since Low C3 reservoir will be lower in elevation, smaller area (18% less than C3) and smaller volume (48% less than C3) compared to C3.	-Assumed less influential effect to local groundwater conditions since cascade reservoirs will be lower in elevation, smaller area (21% less than C3) and smaller volume (63% less than C3) compared to C3.	-Assumed less influential effect to local groundwater conditions since cascade reservoirs will be lower in elevation, smaller area (21% less than C3) and smaller volume (68% less than C3) compared to C3.	-Assumed less influential effect to local groundwater conditions since cascade reservoirs will be lower in elevation, smaller area (39% less than C3) and smaller volume (88% less than C3) compared to C3.
Recreation and Tourism							
Recreational Fishing	-Large reservoir with good potential to develop recreational fishery for kokanee, bull trout, lake	-Similar to Site C for reservoir, but better for downstream fishery as Moberly River not	-Similar to Site C for reservoir, but better for downstream fishery as Moberly River not	-Similar to Site C in terms of Low C reservoir, but 7B reservoir will remain	-Smaller reservoirs will break river into isolated segments and may separate adult fish from	-Smaller reservoirs will break river into isolated segments and may separate adult fish from	-Series of small reservoirs with fast flushing rate and moderate flow velocities

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
	whitefish and possibly rainbow trout. Spawning and rearing habitat available in tributary streams. -Arctic grayling and mountain whitefish likely to decline from current levels due to habitat changes (spawning and foraging).	affected. -Less effect on spawning/foraging areas for Arctic grayling and mountain whitefish.	affected. -Less effect on spawning/foraging areas for Arctic grayling and mountain whitefish.	more riverine and may provide better conditions for mountain whitefish in that reservoir and below the Low C dam. -Faster flushing rate will improve passage of nutrients and organisms into downstream reach, and potentially provide better recreational fishing.	their preferred spawning/rearing areas if they pass through the dam(s) into the next downstream reach (i.e. bull trout). -Faster flushing rate will improve passage of nutrients and organisms into downstream reach, and potentially provide better recreational fishing in that area.	their preferred spawning/rearing areas if they pass through the dam(s) into the next downstream reach (i.e. bull trout). -Faster flushing rate will improve passage of nutrients and organisms into downstream reach, and potentially provide better recreational fishing in that area.	(more riverine character) will break river into numerous isolated segments. Not preferred habitat for bull trout as limits their foraging/refuge habitat to short sections and likely to get separated from preferred spawning/rearing habitat in Halfway River. -Similar potential effects for rainbow trout. Mountain whitefish expected to do better in this alternative.
Hunting, Trapping and Guiding	-Likely decline in big game populations and beavers -Likely rise in water fowl populations, but potentially less access[2]	-Likely decline in big game populations and beavers -Likely rise in water fowl populations, but potentially less access[2]	-Likely decline in big game populations and beavers -Likely rise in water fowl populations, but potentially less access[2]	-Likely decline in big game populations and beavers -Likely rise in water fowl populations, but potentially less access[2]	-Likely decline in big game populations and beavers -Likely rise in water fowl populations, but potentially less access[2]	-Likely decline in big game populations and beavers -Likely rise in water fowl populations, but potentially less access[2]	-Moderately less decline in big game populations and beavers. -Less likely rise in water fowl populations [2]
Recreational Boating and Navigation	-One barrier to upstream travel -Loss of river environment, gain of lake environment -Enhanced boating access up the Moberley.	-One barrier to upstream travel -Loss of river environment, gain of lake environment	-One barrier to upstream travel -Loss of river environment, gain of lake environment	-2 barriers to upstream travel -Loss of river environment, gain of lake environment -Enhanced boating access up the Moberley.	-3 barriers to upstream travel -Loss of river environment, gain of lake environment	-4 barriers to upstream travel -Loss of river environment, gain of lake environment	-7 barriers to upstream travel -More potential to retain flowing water recreational pursuits at top end of each reservoir -Boating compromised, recreational opportunities less favorable. [10] -Loss of primitive recreation site immediately downstream of the barrage of 7b. [10]
Scenic Viewscapes and Tourism Potential	-Reduced scenic view of river, enhanced lake view -Dam & reservoir to become new attraction	-Reduced scenic view of river, enhanced lake view -Dam & reservoir to become new attraction	-Reduced scenic view of river, enhanced lake view -Dam & reservoir to become new attraction	-Reduced scenic view of river, enhanced lake view	-Reduced scenic view of river, enhanced lake view	-Reduced scenic view of river, enhanced lake view	-Scenic view of river maintained

Socio-Economic Parameter	Site C (original C3)	Site C1 or C2	Wilder Creek (near 7f)	Cascade Options			
				Low C and 7b	3 dam	4 dam	7 dam
Employment and Economic Opportunities							
Employment	-Positive effect on local economy -Operators and maintenance personnel for one dam facility	-Positive effect on local economy -Operators and maintenance personnel for one dam facility	-Positive effect on local economy -Operators and maintenance personnel for one dam facility	-Slightly greater positive effect on local economy -Operators and maintenance personnel for two dam facilities	-Moderately greater positive effect on local economy -Operators and maintenance personnel for three dam facilities	-Moderately greater positive effect on local economy -Operators and maintenance personnel for four dam facilities	-Significantly greater positive effect on local economy -Operators and maintenance personnel for seven dam facilities
Local & Regional Economic Development	-Completed project to be exempt from municipal and provincial taxes (per provincial policy for Peace River projects), but will pay grants-in-lieu for 900MW installed capacity. -Loss of revenues to province and municipalities from conversion of land base to project and reservoir lands (i.e. 9,313.6 ha reservoir and footprint of remainder of project) -Some economic benefits from purchases, demand for local services/products	-Similar to Site C, but smaller land base, so less loss of taxes to municipalities and province -Grants-in-lieu for 863-878MW installed capacity.	-Similar to Site C, but smaller land base, so less loss of taxes to municipalities and province -Grants-in-lieu for 781MW installed capacity.	-Slightly improved relative to Site C due to smaller land base and less loss of municipal and provincial taxes -Grants-in-lieu for 859MW installed capacity.	-Slightly improved relative to Site C due to smaller land base and less loss of municipal and provincial taxes -Grants-in-lieu for 841MW installed capacity.	-Slightly improved relative to Site C due to smaller land base and less loss of municipal and provincial taxes -Grants-in-lieu for 826MW installed capacity.	-Smallest land base used for project, so least loss of taxes to municipalities and province -Grants-in-lieu for 705MW installed capacity.
Public Interest & Quality of Life	-9,313.6 ha reservoir area, so impacts on local climate change -1218 ha cultivated and grazing land lost -50 known heritage sites disturbed or damaged	-8320.9 (C1) or 8568.4 (C2) ha reservoir area, so slightly less impact on local climate change -1183 ha cultivated and grazing land lost -Slightly fewer sites disturbed or damaged	-7677.7 ha reservoir surface area, so moderately less impact on local climate change -997 ha cultivated and grazing land lost -Slightly fewer sites disturbed or damaged	-7668.7 ha reservoir surface area, so moderately less impact on local climate change -842 ha cultivated and grazing land lost -Moderately fewer sites disturbed or damaged	-7372.41 ha reservoir surface area, so moderately less impact on local climate change -1030 ha cultivated and grazing land lost - Moderately fewer sites disturbed or damaged	-7379.7 ha reservoir surface area, so moderately less impact on local climate change -1305 ha cultivated and grazing land lost - Moderately fewer sites disturbed or damaged	-5657.2 ha reservoir surface area, so moderately less impact on local climate change -1222 ha cultivated and grazing land lost - Significantly fewer sites disturbed or damaged

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All non-referenced data is from consolidated GIS information from BC Hydro, prepared and provided by Klohn Crippen Berger.

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[10] Klohn Crippen Consultants Ltd and SNC-Lavalin Inc, *Preseasibility Study for a Cascae of Low Consequence Structures as an Alternative to Site C*. January 2003.
[11-14] Lions Gate Consulting; Robinson Consulting and Associates Ltd; Peak Solutions Consulting Inc.; and JK Solutions Ltd; Socio-Economic Baseline and Preliminary Effects Assessment Methodology, Site C Project, June 2009:
[11] Volume A: Introduction and Methodology
[12] Volume B: Land and Resource Uses
[13] Volume C: Economic Issues
[14] Volume D: Community, Social and Health Issues
[15] Estimates for land area removed for cofferdams, tunnels, burrow/disposal sites, dam, and powerhouse are based maps with footprint layouts:
C3: **200 ha**
C2 (or C1): **200 ha**
Wilder: **330 ha**
2 Dam Option: 7b (100) + C3 (200) = **300 ha**
3 Dam Option: 156 ha (3A) x 3 = **468 ha**
4 Dam Option: 180 x 4 = **720 ha** (it seems like 4A is 152ha + an additional amount, coming to ~180ha)
7 Dam Option: 120 x 7 = **840 ha** (it seems like the 7dam footprint is 100ha + an additional amount, coming to ~120ha)
[16] Review of Site C Climate Impacts. Stanton E. Tuller. March 1991.

Appendix E

Engineering Comparative Matrix

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Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
A Functionality							
A1 Dam Safety Factors							
Reservoir Evacuation Capability	Spillway and powerhouse can be used to draw reservoir down. Drawdown level limited by spillway sill El. 446.5 and submergence at power intakes to El. 449 to El. 445 (75% to 67% of gross head) depending on inflow.	Spillway and powerhouse can be used to draw reservoir down. Drawdown level limited by spillway sill El. 446.5 and submergence at power intakes to El. 449 to El. 445 (74% to 66% of gross head) depending on inflow. Similar to Base Case	Spillway and powerhouse can be used to draw reservoir down. Drawdown level limited by spillway sill El. 446.5 and submergence at power intakes to El. 449 to El. 445 (71% to 62% of gross head) depending on inflow. Similar to Base Case.	The sill level of the three sluices at Site 7b are at the river bed so this reservoir can be almost completely drained. The water depth at the spillway required to pass the minimum flow from Peace Canyon Dam would be about 3 m. At Site C3 the spillway and powerhouse can be used to draw reservoir down. Drawdown level limited by spillway sill El. 431.4 and submergence at power intakes to El. 434 to El. 430 (64% to 53% of gross head) depending on inflow. Somewhat better than Base Case.	The sill level of the spillway at each site is at the river bed so all three reservoirs can be almost completely drained. The water depth at the spillway required to pass the minimum flow from Peace Canyon Dam would be about 4 m. Moderately better than Base Case.	The sill levels of the spillway at each site is at the river bed so all four reservoirs can be almost completely drained. The water depth at the spillway required to pass the minimum flow from Peace Canyon Dam would be about 4 m. Moderately better than Base Case.	The sill levels of the spillway at each site is at the river bed so all seven reservoirs can be almost completely drained. Significantly better than Base Case.
Time to Evacuate Reservoir The spillways for all of the alternates would be designed to pass the PMF and would have a discharge capacity at the maximum normal reservoir level several times the powerhouse discharge. Therefore, the spillway and powerhouse discharges would probably have to be limited to avoid problems in the reservoir due to rapid drawdown and to mitigate effects of high flows downstream from the furthest downstream dam. Actual times to evacuate the reservoirs would generally be longer	The spillway and powerhouse have sufficient capacity to draw the reservoir down to the lowest level in less than six days depending on inflow.	The reservoir volume is 10% less than at Site C and the spillway and powerhouse have the same capacity, therefore the time to evacuate the reservoir would be approximately 10% less than at Site C. Similar to Base Case	The reservoir volume is 25% less than at Site C and the spillway and powerhouse have the same capacity, therefore the time to evacuate the reservoir would be approximately 25% less than at Site C. Similar to Base Case	The reservoir impounded by the upstream dam at Site 7b could be drawn down to the lowest level in about one day provided that the discharge from Peace Canyon Dam was reduced to the minimum flow. The reservoir impounded by the downstream dam at Site C3 could be drawn	The reservoirs impounded by dams 3a and 3c could be drawn down to the lowest level in about 18 hours and the reservoir impounded by dam 3b could be drawn down in about 36 hours. The time to evacuate all three reservoirs would be about three days. Moderately better than Base Case.	The times to evacuate the reservoirs would vary from 12 hours from dam 4d to 24 hours for dam 4b. The time to evacuate all three reservoirs would be about three days. Moderately better than Base Case.	The reservoirs would be so small compared to the spillway that each reservoir could be evacuated in a few hours and the whole cascade could be evacuated in a day and a half. Significantly better than Base Case.

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
than the capability. The evacuation times quoted assume that the discharge from Peace Canyon Dam is reduced to the minimum flow to facilitate evacuation. The times quoted do not take into account ice effects.				down to the lowest level in about three days. Somewhat better than Base Case.			
Hydrological All alternates would be designed to pass the PMF. Inability to pass inflows due to insufficient spillway capacity or equipment malfunction has been a leading cause of dam failures. This category rates the relative reliability of the alternate to pass high inflows.	Gated spillway – six gates.	Gated spillway – six gates. Similar to Base Case	Gated spillway – six gates. Similar to Base Case	The dam at 7b has a free overflow spillway in addition to the three gated sluices. The free overflow spillway adds redundancy and does not rely on mechanical equipment. The dam at C3 has a six gated spillway similar to the Base Case. Somewhat better than Base Case.	Three gated spillways – higher risk of gate malfunction due to large number of spillway gates (26 gates). Somewhat worse than Base Case.	Four gated spillways – higher risk of gate malfunction due to large number of spillway gates (74 gates). Somewhat worse than Base Case.	Seven gated spillways – highest risk of gate malfunction due to the very large number of spillway gates (183). Moderately worse than Base Case.
Landslide Risks The Peace River Valley has a history of landslides and slope instability. This category compares the relative vulnerability of each alternate to landslides.	The crest level of the earthfill dam at Site C has been selected to provide sufficient freeboard so that the dam would not be overtopped by the wave generated by the largest and fastest conceivable landslide moving into the reservoir. The left bank of the river valley at Site C will be stabilized by flattening the overburden slope to 1H:4V. The left bank slopes between Tea Creek and Site C are currently moving and slumping.	The crest levels of the earthfill dams at Site C1 and C2 were selected in the 2006 study to provide sufficient freeboard so that the dam would not be overtopped by the wave generated by the largest and fastest conceivable landslide moving into the reservoir Site C1 and C2 are located in the section of the Peace River between Tea Creek and the Moberly River. The south side of the current valley is a relatively flat, vegetated slope formed	The crest level of the earthfill dam at Wilder Creek was selected to provide sufficient freeboard so that the dam would not be overtopped by the wave generated by the largest and fastest conceivable landslide moving into the reservoir. The Wilder Creek site is located upstream of Tea Creek where a terrace is located on each bank just above dam crest level. The slope above the left bank terrace was formed by a series of slides and earth flows in the	The slopes upstream of Dam 7b are in the more competent Gates Formation and no landslides that could affect the safety of the dam are expected upstream from dam 7b. The crest level of the lower earthfill dam at Site C was selected to provide sufficient freeboard so that the dam would not be overtopped by the wave generated by the largest and fastest conceivable landslide moving into the reservoir. The reservoir level would	Dam 3b is close to the 70 million m^3 Cache Creek slide which occurred in the late 1700's. Although it is possible that the slide or a portion of it occurred rapidly, it could have been formed by a series of relatively slow slumps and mudflows. There is no evidence of slide debris reaching the opposite bank. Inundation of the toe of the slide debris may cause further movement. Moderately better than Base Case.	Dam 4b is close to the slide area at Attachie. Although the slide area is well above reservoir level the proximity to the dam is a concern. While the dam would be designed to prevent overtopping by a landslide generated wave there is uncertainty about the size of the slide and wave that could occur. The 1973 slide blocked the Peace River and the landslide dam subsequently breached. Breach of a similar landslide dam in the future would pose a hazard to dam 4b due to	Dam 7d is close to the slide area at Attachie. Although the slide area is well above reservoir level the proximity to the dam is a concern. While the dam would be designed to prevent overtopping by a landslide generated wave there is uncertainty about the size of the slide and wave that could occur. The 1973 slide blocked the Peace River and the landslide dam subsequently breached. Breach of a similar landslide dam in the future would pose a hazard to dam 7d due to

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
	Most of the movement appears to be associated with a white clay layer near El. 432, which forms a boundary between disturbed rock above and undisturbed rock below. This clay layer is about 22 m above the riverbed at Site C and 30 m below the proposed reservoir level. Filling of the reservoir will increase water pressures in the clay layer and shale bedrock and result in increased movement in some currently active slopes; however, these movements are not expected to have an adverse affect on the safety of the dam.	for the most part by inactive slumps and river terraces. One of the flat slopes appears to be formed by colluvium from a landslide in the shale. The north side of the valley is steeper, less vegetated and is actively eroding and slumping. Many of the slumps seem to be associated with the white clay layer. At Sites C1 and C-2 the left bank rises steeply for nearly 230 m to the plateau at about El. 640. The lower part of the right bank has a relatively flat slope to El. 490 and then rises steeply to the plateau at about El. 625. At these two axes the valley walls would be up to 170 m above the crest of the dam. The left slope at Site C1 is potentially unstable and this unstable area extends high above the dam. It was also noted that. In addition there is considerable slumping on the right bank. At Site C-2 there is a considerable amount of slumped material on the right bank and slopes on both sides of the Peace River could produce large slides, both from the in-situ material and slumped	overburden. The current slope is 4H:1V and it was assumed that no work was required to stabilize the overburden slopes above the dam. Somewhat worse than Base case as no slope stabilization is done.	be 15 m above the white clay layer, approximately one half of the depth for Site C. Therefore, movements in the shale slopes in the Tea Creek section and other areas upstream would be less than with Site C. Moderately better than Base Case.		its proximity. Significantly worse than Base Case.	its proximity. Significantly worse than Base Case.

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
		material. Development at either Site would require major excavations to stabilize the slopes. The 2006 report was based on earlier work on Site C and has not been updated for the higher MDE. Updating the design for the current MDE would significantly increase the cost. Construction of the dam at either of these sites where the slopes are considerably higher than at Site C and have signs of instability would not be prudent. Moderately worse than the Base Case.					
Seismic All dams would be designed for the MDE which is the 10,000 year earthquake based on a seismic hazard assessment. This category rates the relative vulnerability of each alternate to large earthquakes.	Highest dam. Allowances for seismic stability of all structures included in cost estimate. Spillway headworks structure relies on concrete piles. Right bank structures rely on drainage. Some aspects of the seismic design need to be resolved – in particular the expected deformations if any during the MDE and acceptability of analysis methodology and behaviour of piles.	Similar to Site C except that seismic stability of the high slopes could be more problematic. Similar to Base Case.	Similar to Site C. Similar to Base Case.	Less uncertainty about seismic performance of dam 7b on Gates Formation. Lower dam at C3 better due to lower seismic loading. Moderately better than Base Case.	Lower dams better due to lower seismic loading. Not as good as 7b/Low C3 because all three dams are on the Shaftesbury Formation. Somewhat better than Base Case.	Lower dams better due to lower seismic loading. Not as good as 7b/Low C3 because all three dams are on the Shaftesbury Formation. Proximity to Attachie slide and the risk that this poses is a significant issue. Moderately worse than Base Case.	Lowest dams, two on the Gates formation but one close to Attachie. Moderately better than Base Case.
Geological Conditions:	Base Case – best known	Worst alternate for	Slightly worse than Base	Dam 7b on better	Multiple lower dams on	Multiple lower dams on	Lowest dams, two on the

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	**Single Dam Alternates**			**Cascade Alternates**			
	Site C Base Case	**Site C1 or C2**	**Wilder Creek**	**Site 7b and low C3**	**3 dam**	**4 dam**	**7 dam**
• Rebound • Piping • Deformation/Creep Piping potential is less for the lower dams due to less head. Rebound is a significant issue for dams on the Shaftesbury shale and exacerbated by excavation. Less creep likely with lower dam even though all dams designed to the same criteria. More dams = more aggregate risk.	site.	rebound due to the very large volumes of excavation for the structures. May not be possible to manage the long term rebound. Moderately worse than Base Case.	Case for rebound due to somewhat greater depth of excavation on the terrace for the structures – but feasible. No site specific knowledge of geological conditions. Overall similar to Base Case.	geology – lower dam than Base Case on Shaftesbury shale. Conditions at C3 the best understood. Moderately better than Base Case.	shale. Risk of multiple dams offset by lower heads. Similar to Base Case.	shale. Risk of multiple dams offset by lower heads. Somewhat better than Base Case.	Gates Formation and five on the Shaftesbury shale. Best option considering geological conditions. Significantly better than Base Case.
Consequence of Failure	High dam with potentially significant downstream consequences.	High dam with potentially significant downstream consequences. Similar to Base Case.	High dam with potentially significant downstream consequences. Similar to Base Case.	Lower dams. Downstream dam failure not likely if upstream dam fails due to attenuation and large spillway capacity. Consequences of failure of downstream dam less than for Base Case due to smaller volume and head. Moderately better than Base Case.	Lower dams but potential for cascading failures. Similar to Base Case.	Lower dams but potential for cascading failures. Similar to Base Case.	Lowest dams with small reservoirs. Dam break analyses indicates that cascading failures unlikely. Significantly better than Base Case.
Resilience & Robustness		Similar to Base Case.	Similar to Base Case.	Maximizes the head on the better geology. Has free overflow spillway. Somewhat better than Base Case.	Multiple gates and other equipment. Moderately worse than Base Case.	Multiple gates and other equipment. Moderately worse than Base Case.	Very large number of gates and other equipment. Significantly worse than Base Case.
A2 Life Cycle Factors							
Operation & Maintenance	Single conventional powerhouse with six units and spillway with six radial gates. Operation and maintenance requirements typical for a	Single conventional powerhouse with six units and spillway with six radial gates. Operation and maintenance requirements no different	Single conventional powerhouse with six units and spillway with six radial gates. Operation and maintenance requirements no different	Two powerhouses each with six units – increased maintenance requirements due to greater number of units. (Note that propeller units	Three powerhouses each with six units – increased maintenance requirements due to greater number of units. (Note that propeller units	Four powerhouses each with six units – increased maintenance requirements due to greater number of units. (Note that propeller units	Seven powerhouses with a total of 116 small units – increased maintenance requirements due to greater number of units. These would be the only

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
	large project.	to Site C apart from potential increased requirements due to surveillance, maintenance and remedial work on high slopes. Similar to Base Case.	to Site C. Similar to Base Case.	at 7b would be larger diameter than the Francis units at Site C). Three gate spillway at 7b and six gate spillway at low C3 - increased maintenance requirements due to greater number of gates. Greater operating and maintenance staff required due to two facilities. Moderately worse than Base Case.	would be larger diameter than the Francis units at Site C). Increased maintenance requirements due to 26 spillway gates. Greater operating and maintenance staff required due to three facilities. Significantly worse than Base Case.	would be larger diameter than the Francis units at Site C). Increased maintenance requirements due to 74 spillway gates. Greater operating and maintenance staff required due to four facilities. Significantly worse than Base Case.	S turbines in the BC Hydro system. Increased maintenance requirements due to 183 spillway gates. Greater operating and maintenance staff required due to four facilities. Significantly worse than Base Case.
Operating Flexibility	Single powerhouse easy to integrate with system and to operate in conjunction with PCN and GMS to meet fluctuating energy and power demands of the system.	Single powerhouse easy to integrate with system and to operate in conjunction with PCN and GMS to meet fluctuating energy and power demands of the system. Similar to Base Case.	Single powerhouse easy to integrate with system and to operate in conjunction with PCN and GMS to meet fluctuating energy and power demands of the system. Similar to Base Case.	Two powerhouses less easy to integrate. Significantly worse than Base Case.	Three powerhouses less easy to integrate. Significantly worse than Base Case.	Four powerhouses less easy to integrate. Significantly worse than Base Case.	Seven powerhouses difficult to integrate. Significantly worse than Base Case.
Personnel safety during operation All projects would follow the same safety by design standards to reduce the risks to personnel to as low as reasonably practical, however increasing the number of facilities would increase the risk.	Single large facility with normal operation and maintenance requirements.	Single large facility with normal operation and maintenance requirements. Similar to Base Case.	Single large facility with normal operation and maintenance requirements. Similar to Base Case.	Two large powerhouses with twice the number of units than in the Base Case. Double the number of planned unit outages and therefore more confined space entry and other potentially hazardous operations. Somewhat worse than Base Case.	Three large powerhouses with three times the number of units than in the Base Case. Triple the number of planned unit outages and therefore more confined space entry and other potentially hazardous operations. Moderately worse than Base Case.	Four large powerhouses with four times the number of units than in the Base Case. Quadruple the number of planned unit outages and therefore more confined space entry and other potentially hazardous operations. Moderately worse than Base Case.	Seven powerhouses with a total of 116 small units, significantly more unit outages and exposure to potentially hazardous operations. BC Hydro currently has 80 generating units at 30 hydroelectric facilities – this alternate would more than double the number of units in the BC Hydro system. Significantly worse than Base Case.
Potential for Environmental	One large facility.	One large facility.	One large facility.	Two large facilities with	Three large facilities.	Four large facilities.	Seven large facilities.

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Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	**Site C1 or C2**	**Wilder Creek**	**Site 7b and low C3**	**3 dam**	**4 dam**	**7 dam**
Incidents All projects would be designed to the same environmental standards to reduce the risks to the environment from oil spills etc to as low as reasonably practical, however increasing the number of facilities would increase the risk.		Similar to Base Case.	Similar to Base Case.	oil and other hazardous materials increases the risk of spills and other accidents that could affect the environment. Somewhat worse than Base Case.	Moderately worse than Base Case.	Moderately worse than Base Case.	Significantly worse than Base Case.
Generation Reliability The generation reliability is largely a function of the number of units – a single unit outage at a six unit plant will remove 17% of the capacity potentially constraining the operation of 3500 MW of capacity at GMS and PCN, whereas the loss of a single unit in a cascade project has less of an impact.	One large facility with six units.	One large facility with six units. Similar to Base Case.	One large facility with six units. Similar to Base Case.	Two large facilities with 12 units. Somewhat better than Base Case.	Three large facilities with 18 units. Somewhat better than Base Case.	Four large facilities with 24 units. Moderately better than Base Case.	Seven facilities with 116 small units. Moderately better than Base Case.
B Physical Risks - Effecting Design and Construction							
B1 Geological							
Certainty	Extensive investigations including laboratory and in-situ tests have been done to understand the site conditions. Some testing still required to provide more information on bedding plane pore pressure response to construction of the dam, dynamic strength of bedding planes, swelling characteristics of shale and sources of impervious material.	Several holes drilled at C1. Bedrock assumed to be the same as Site C. Complex site due to colluvium and landslide debris. A little knowledge. Considerable uncertainty of geological conditions relative to Base Case.	Site reconnaissance undertaken – no drilling or other investigations undertaken. Concern that Wilder Creek is topographically different to other creeks in the valley – is there a significant geological feature here? Evidence of a number of separate debris flows and slides on left bank. Access road at toe of old slide – will this reactivate? Significant uncertainty about the geological conditions relative to Base Case.	Outcrops of good rock visible at site 7b. Topography suggests sound rock. Gates Formation better than Shaftesbury. Rock conditions assumed to be the same as at PCN. Depth to rock in river bed unknown. Presence of near horizontal well layers likely. Site C3 well known – same site as Base Case. A bit more uncertainty about the geological conditions than for Base Case.	Conditions at site 3a and 3b unknown. Assumed to be similar to Site C. Site 3c same location as Base Case therefore same level of certainty as Base Case. Significant uncertainty about the geological conditions relative to Base Case.	Conditions at site 4a, 4b and 4c unknown. Assumed to be similar to Site C. Site 4d same location as Base Case therefore same level of certainty as Base Case. Significant uncertainty about the geological conditions relative to Base Case.	Outcrops of good rock visible at sites 7a and 7b. Topography suggests sound rock. Gates Formation better than Shaftesbury. Rock conditions assumed to be the same as at PCN. Depth to rock in river bed unknown. Presence of near horizontal weak layers likely. Site 7c, 7d, 7e and 7f unknown. Assumed to be similar to Site C. Site 7g same location as Base Case therefore same level of certainty as Base Case.

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
							Significant uncertainty about the geological conditions relative to Base Case.
Slope Stability This section addresses slope stability issues at the site. Reservoir slope stability issues are addressed in the following section on shoreline impacts.	Slope stability issues at site expressly addressed in cost estimate.	Dam would be located in Tea Creek to Site C section - affect of slope instability in Tea Creek section on dam not included in estimates. Assumed that the same overburden slopes could be used as for the Base Case – but not updated for the new MDE which could have significant affect on cost and arrangement. Significantly worse than Base Case.	Cost estimate assumes that no slope stabilization would be required. Concern that access road will have to cross landslide debris – this may cause instability. Suspected geological feature at Wilder Creek may case slope stability problems close to dam. Worse than Base Case.	No known significant slope stability issues at 7b and not expected due to better rocks of the Gates Formation. Foundations for structures will be 15 m lower therefore excavated slopes will be 15 m higher – more potential for slope stability issues? Slightly worse than Base Case.	Conditions at site 3a and 3b unknown. Assumed to be similar to Site C. Site 3c same location as Base Case therefore conditions known. Cost estimate based on assumption that slope stabilization requirements for 3a and 3b will be the similar to site 3c. Proximity of 3b to Cache Creek slide debris a concern - may add to the cost of development at this site. Worse than Base Case.	Conditions at sites 4a, 4b and 4c unknown. Assumed to be similar to Site C. Site 4d is same location as Base Case therefore conditions known. Cost estimate based on assumption that slope stabilization requirements for 4a, 4b and 4c will be the similar to site 4d. Proximity of 4d to Attachie slide a concern - may add to the cost of development at this site. Significantly worse than Base Case.	Based on an examination of aerial photographs slope instability may be a problem at the following locations: • left bank at 7b; • left bank at 7d; • right bank at 7e; and • left bank at 7g. No allowances for slope stabilization were made in the cost estimate. Proximity of 4d to Attachie slide a concern - may add to the cost of development at this site. Significantly worse than Base Case.
Shoreline Impacts	At locations of historic very large slides (Attachie and Cache Creek) failure surfaces are above reservoir level. Some slide debris may be reactivated by increased water level. Between Tea Creek and Site C the rate at which the shale slopes are currently moving may increase. Slumps may occur. Rapid slides not expected.	Reservoir slope stability as for Base Case except that dam would be located in Tea Creek to Site C section therefore less stability issues in this section of reservoir. Shorter shoreline (40 km shorter C1 and 33 km shorter C2) therefore less erosion and beaching. Less flooding due to smaller reservoir area than Base Case (993 km^2 smaller C1 and 746 km^2	Reservoir slope stability as for Base Case except that dam would be located upstream of Tea Creek therefore there would be no changes to stability issues in this section of river. Shorter shoreline (56 km) therefore less erosion and beaching. Less flooding as reservoir 1636 km^2 smaller than Base Case.	No known significant slope stability issues upstream of 7b. Lower reservoir level for C3 will result in lower movements in Tea Creek section as the increase in head on the white clay layer in the shale will be one half of that for the Base Case. Lower reservoir level means that less overburden and colluvium will be submerged by	Lower reservoir level for 3c will be below the white clay layer in the shale in the Tea Creek section therefore no change in slope stability. Lower reservoir levels means that much less overburden and colluvium will be submerged by reservoir so there should be lower frequency of overburden slides than for Base Case. Shorter shoreline (57 km)	Lower reservoir level for 4d will be below the white clay layer in the shale in the Tea Creek section therefore no change in slope stability. Lower reservoir levels means that significantly less overburden and colluvium will be submerged by reservoir so there should be lower frequency of overburden slides than for Base Case.	Lower reservoir level for 7g will be below the white clay layer in the shale in the Tea Creek section therefore no change in slope stability. Lower reservoir levels means that significantly less overburden and colluvium will be submerged by reservoir so there should be lower frequency of overburden slides than for Base Case.

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Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
	Increased frequency of small slides expected in areas of the reservoir where colluvium or overburden is at or below reservoir level. Erosion and beaching will occur around 298 km shoreline and will be greatest where overburden and colluvium are exposed at reservoir level. Reservoir area 9314 km^2 floods land, islands and river. Raises groundwater levels around shoreline. Creates potential for landslide generated waves in reservoir.	smaller C2). Less groundwater impacts due to shorter shoreline. No change to landslide generated wave potential as the potentially fast landslides capable of producing waves rare upstream. Somewhat better than Base Case.	Less groundwater impacts due to shorter shoreline. No change to landslide generated wave potential as the potentially fast landslides capable of producing waves rare upstream. Somewhat better than Base Case.	reservoir so there should be lower frequency of overburden slides than for Base Case. Shorter shoreline (40 km) and lower reservoir level meaning less overburden and colluvium will be at reservoir level therefore less erosion and beaching. Less flooding as reservoir 1645 km^2 smaller than Base Case. Less groundwater impacts due to shorter shoreline and lower C3 reservoir level. Lower landslide generated wave potential due to lower C3 reservoir level. Moderately better than Base Case.	and lower reservoir levels mean less overburden and colluvium will be at reservoir level therefore less erosion and beaching. Less flooding as reservoir 1942 km^2 smaller than Base Case. Less groundwater impacts due to shorter shoreline and lower reservoir levels. Lower landslide generated wave potential due to lower reservoir levels. Moderately better than Base Case.	Shorter shoreline (61 km) and lower reservoir levels mean less overburden and colluvium will be at reservoir level therefore less erosion and beaching. Less flooding as reservoir 1934 km^2 smaller than Base Case. Less groundwater impacts due to shorter shoreline and lower reservoir levels. Lower landslide generated wave potential due to lower reservoir levels. Significantly better than Base Case.	Shorter shoreline (39 km) and lower reservoir levels mean less overburden and colluvium will be at reservoir level therefore less erosion and beaching. Less flooding as reservoir 3657 km^2 smaller than Base Case. Less groundwater impacts due to shorter shoreline and lower reservoir levels. Lower landslide generated wave potential due to lower reservoir levels. Significantly better than Base Case.
Foundation Conditions	Complex due to the characteristics of the Shaftesbury shale.	Same as Base Case.	Same as Base Case.	7b on the better rocks of the Gates Formation and C3 same as Base Case. Somewhat better than Base Case.	Same as Base Case.	Same as Base Case.	7a and 7b on the better rocks of the Gates Formation and remainder the same as Base Case. Somewhat better than Base Case.
Rebound Conditions	Preliminary rebound estimates have been done and conceptual measures for accommodating the rebound have been incorporated into the cost estimate. A considerable amount of more work is	Excavation depths for the structures at C1 or C2 are considerably greater than at Site C. Significantly worse than Base Case.	Excavation depths for the structures at Wilder Creek are somewhat greater than at Site C. Somewhat worse than Base Case.	Rebound not expected to be an issue at 7b. Excavation depths for the structures at C3 are 15 m greater than at Site C. Moderately worse than Base Case.	Lower dams with some excavations in the shale. Somewhat better than Base Case.	Lower dams with less excavation in the shale. Moderately better than Base Case.	Lower dams with minimal excavation in the shale. Significantly better than Base Case.

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
	required to finalize the details including sampling, testing and analysis.						
B2 Design							
Level of Design Development	Well developed layout. Some parts previously deigned to tender ready level (such as diversion works, access road and bridge and camps). Layout and dimensioning of right bank structures does not take into account: preliminary estimates of rebound and rebound mitigation; and measures required to accommodate larger MDE. Cost estimate includes allowances for conceptual measures for addressing rebound and MDE.	Overview study based on Site C layout. Field reconnaissance undertaken and geological sections produced based on some drilling. Topographically and geologically unsuitable site. Significant changes could result if design was advanced. Significantly less advanced design than Base Case.	Overview study based on Site C layout. Field reconnaissance undertaken and geological sections produced from reconnaissance. Topographically suitable site with some significant geological uncertainties. Topographical similarities with Site C means that many of the layouts from Site C likely to apply equally. Some changes could result if the design was advanced. Moderately less advanced design than Base Case.	7b layout based on designs for similar projects. Good site topographically and geologically. Relatively straightforward site. Significant changes in layout not expected if design advanced. Low C3 based on and similar to Site C – many of the layouts from Site C likely to apply equally. Moderately less advanced design than Base Case.	Layouts based on desk study for dam 3c – assumed that topographically and geologically similar sites exist at 3a and 3b but no confirmatory reconnaissance or other work done. Significantly less advanced design than Base Case.	Layouts based on desk study for dam 4d – assumed that topographically and geologically similar sites exist at 4a, 4b and 4c but no confirmatory reconnaissance or other work done. Significantly less advanced design than Base Case.	Pre-feasibility study layouts fairly well developed. Some significant issues remain such as the reliance on tensioned rock anchors for stability. Moderately less advanced design than Base Case.
Dam	Well developed earthfill dam design – well known foundation conditions.	Earthfill dam assumed the same as Site C – considerable colluvium in foundation would have to be excavated – uncertain foundation conditions. Moderately worse than Base Case.	Earthfill dam assumed the same as Site C – unknown foundation conditions. Somewhat worse than Base Case.	Concrete dam at 7b – unknown depth to competent rock – potential for weak layers in foundation. Low C3 - earthfill dam design – known foundation conditions. Somewhat worse than Base Case.	Earthfill dam assumed the same as Site C – considerable colluvium unknown foundation conditions. Significantly worse than Base Case.	Earthfill dam assumed the same as Site C – considerable colluvium unknown foundation conditions. Significantly worse than Base Case.	Concrete dams at sites 7a and 7b on Gates Formation - unknown depth to competent rock – potential for weak layers in foundation. Concrete dams at sites 7c, 7d, 7e and 7f on Shaftesbury Formation - unknown foundation conditions. Dam 7g at Site C - well known foundation

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
							conditions. All dams rely on post tensioned anchors for static and seismic stability. Moderately worse than Base Case.
Discharge Facilities	Conventional gated chute spillway with stilling basin – special measures required for seismic stability and to accommodate rebound require further development. Spillway at upper limit of precedent of unit discharge.	Similar to Site C except that potential rebound more severe. Moderately worse than Base Case.	Same as Base Case. Neutral relative to Base Case	Dam 7b has three conventional gated sluices plus overflow spillway. Dam C3 moderately worse rebound than Base Case. Neutral relative to Base Case	Similar to Site C except that low head precludes use of an ogee crest. Lower efficiency crest requires wider spillway. Spillway sills at river bed level therefore potential problems with sediment passing through spillways downstream of halfway River. Approach channel not well defined. Hydraulics of spillways not well defined. Considerable changes would be expected as design advanced. Moderately worse than Base Case.	Similar to Site C except that low head precludes use of an ogee crest. Lower efficiency crest requires wider spillway. Spillway sills at river bed level therefore potential problems with sediment passing through spillways downstream of halfway River. Approach channel not well defined. Hydraulics of spillways not well defined. Considerable changes would be expected as design advanced. Moderately worse than Base Case.	Barrage spillways. Spillway sills at river bed level therefore potential problems with sediment passing through spillways downstream of halfway River. Hydraulics of spillways not well defined. Some changes would be expected as design advanced. Somewhat worse than Base Case
Generating Facilities	Conventional intakes with very large diameter steel penstocks and conventional powerhouse – special measures required for seismic stability and to accommodate rebound require further development.	Similar to Site C except that provision potential rebound more severe. Moderately worse than Base Case.	Same as Base Case. Neutral relative to Base Case	Dam 7b has conventional close coupled powerhouse – no penstocks and minimal rebound. Dam C3 moderately worse rebound than Base Case. Neutral relative to Base Case	Conventional intakes with very large diameter steel penstocks and conventional powerhouse – likely have similar issues with seismic stability as Site C – in addition potential for sediment problems at intakes downstream of Halfway River. Somewhat worse than	Conventional intakes with very large diameter steel penstocks and conventional powerhouse – likely have similar issues with seismic stability as Site C – in addition potential for sediment problems at intakes downstream of Halfway River. Somewhat worse than	Integral intakes and powerhouses. Intakes sill at river bed level therefore potential for sediment problems at intakes downstream of Halfway River. Neutral relative to Base Case

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
					Base Case	Base Case	
Other Aspects	Well developed river diversion scheme.	Assumed that diversion scheme would be similar to Base Case, however the amount of colluvium in river bed could require significant modification to that scheme and there would be a significantly higher risk of a slope failure during diversion causing problems. Significantly worse than Base Case.	Assumed that diversion scheme would be similar to Base Case. Proximity of Wilder Creek to the site is a minor concern. Somewhat worse than Base Case.	Diversion scheme developed for site 7b but no hydraulic calculations done to confirm. C3 same as Base Case. Somewhat worse than Base Case.	Diversion scheme relies solely on cofferdams to contain the river into one side of the channel during construction of the major structures. No detailed planning or hydraulic calculations have been done – substantial changes likely if design advanced. Significantly worse than Base Case.	Diversion scheme relies solely on cofferdams to contain the river into one side of the channel during construction of the major structures. No detailed planning or hydraulic calculations have been done – substantial changes likely if design advanced. Significantly worse than Base Case.	Sites 7a, 7b and 7g would cofferdam the channel on one side of an existing island for construction of the majority of the structures. At sites 7c, 7d, 7e and 7f the majority of the structures would be built on the river bank and then connected to the river. Except for sites 7a and 7b in the Gates Formation there is considerable risk of seepage through the alluvium during construction. Detailed calculations have not been done –changes likely if design advanced. Moderately worse than Base Case.
C Construction Factors							
Construction Material	Granular fill and concrete aggregates readily available from terrace deposits and river bed at site. Impervious fill believed to be within 10 km of site on north bank.	Same as Base Case.	Same as Base Case.	Concrete aggregates readily available from terrace deposits and river bed at site. C3 same as Base Case. Somewhat better than Base Case	For dams 3a and 3b assumed that Granular fill and concrete aggregates readily available from terrace deposits and river bed at site. Impervious fill sources not known. 3c the same as the Base Case. Somewhat worse than Base Case.	For dams 4a, 4b and 4c assumed that Granular fill and concrete aggregates readily available from terrace deposits and river bed at site. Impervious fill sources not known. 4d the same as the Base Case. Somewhat worse than Base Case.	Granular fill and concrete aggregates readily available from terrace deposits and river bed at site. Minimal impervious fill required. Somewhat better than Base Case

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Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	**Site C1 or C2**	**Wilder Creek**	**Site 7b and low C3**	**3 dam**	**4 dam**	**7 dam**
Excavation and Relocation of Surplus Excavated Materials	All surplus excavated materials would be relocated along north bank or up on right bank and right bank terrace. Gravel dykes included to contain material and prevent erosion by river during or after construction. Some of the relocated surplus excavated materials will be exposed after construction and will be landscaped. Detailed planning studies completed.	The excavated material that has to be relocated is several times that for the Base Case. The only feasible location is on the top of the plateau and all excavated material has to be hauled up. No detailed studies done. Locations for surplus excavated material would have to be carefully planned to avoid creating problems with the stability of the high valley sides which already have instability problems. Additional excavations may be required to stabilize those slopes. Significantly worse than Base Case.	Less surplus excavated materials than Base Case. Sufficient space for relocation of all excavated materials on the south bank below reservoir level. Moderately better than Base Case.	Relatively small volume of excavation for dam 7b. No detailed studies done for site 7b and assumed that all surplus excavated material could be relocated on site. Unknown how much of the surplus excavated material would be relocated downstream. C3 same as Base Case. Somewhat worse than Base Case.	Total volume of excavation could be larger than Base Case depending on requirements for slope stabilization. No detailed studies done for sites 3a and 3b. Appears to be space for relocation of all surplus excavated material on left and right banks at site and on upper right bank plateau. Site 3c same as Base Case. Moderately worse than Base Case.	Total volume of excavation could be larger than Base Case depending on requirements for slope stabilization. No detailed studies done for sites 4a, 4b or 4c. Appears to be space for relocation of all surplus excavated material on upper right bank plateau at sites 4a and 4b, and placed on left bank at site 4c. Site 4d same as Base Case. Moderately worse than Base Case.	Relatively small volumes of excavation. No detailed studies done. Assumed sufficient space on both banks at dam sites and along river banks behind earthfill dykes where possible. Somewhat better than Base Case.
Accessibility (Road and Rail)	Good road access to north bank from municipal roads in Fort St John. Easy to construct access road and bridge to south bank. Good rail access to existing Septimus siding on CN rail line with easy road access from siding to site.	Existing roads connected to Fort St John are close to the north bank of the site however the instability of the slopes in the Tea Creek section would likely preclude any roads down the valley sides. Most likely road access from north bank would be down the Tea Creek valley, however this valley has large block of sandstone from a failure of the Dunvegan sandstone overlying the shale. Construction of an access road in this valley would be very difficult.	Existing roads connected to Fort St John are close to the north bank of the site. Feasible to construct switchback road from existing roads down to terrace (existing one lane road). However, large excavations would be required to avoid access road from destabilizing existing slope. Road would have to cross large debris fan / slide debris – could cause instability – no allowance in estimate. High level access bridge to south bank terrace due	Further from Fort St John. Easy road access to 7b from Highway 29. Easy access to both banks from highway. Rail shipments would be unloaded at Fort St John and shipped by road. Road and rail access for C3 the same as the Base Case. Somewhat worse than Base Case due to distance from Fort St John.	Sites 3a and 3b further from Fort St John. Easy road access from Highway 29 to north bank from highway to both sites. At site 3a the access bridge to the south bank would connect directly to Highway 29. The south bank access road would run along the toe of the steep high bank. Slope stability problems with south bank access possible. At site 3b a 3 km access road would be	Sites 4a, 4b and 4c further from Fort St John. Easy road access from Highway 29 to north bank from highway for sites 4a and 4b. Site 4c is located about 4 km downstream of where Highway 29 cones down from the plateau in the Cache Creek area. At site 4a the access bridge to the south bank would be connected connect to Highway 29 by a short length of road over easy terrain. The south bank access road would run along the toe	Sites further from Fort St John. Easy road access from Highway 29 to north bank from highway. At site 7a access to the south bank would be directly from Highway 29 – no access bridge would be required. Access bridge and roads required for south bank. Slope stability problems with south bank access possible. Rail shipments would be unloaded at Fort St John and shipped by road.

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Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
		The road to site would have to be constructed along the toe of the unstable slopes which would be problematic. It would be possible to construct a bridge across the Peace River however the road from the bridge to the site would have to be constructed along the toe of the unstable slopes which would be problematic. Further from the rail line than the Base Case – any railhead access road would have to cross the Moberly River. This road would have to be at low level as a high level bridge would not be feasible due to the unstable slopes in the lower part of the Moberly valley. Low level bridge likely to cross the mouth of the Moberly on the gravel fan and then be constructed along the toe of the unstable slopes which would be problematic. More likely that rail shipments would be unloaded at Fort St John and shipped by road. Significantly worse than Base Case.	to high steep river banks. South bank access road easily constructed on terrace. Further from the rail line than the Base Case – any railhead access road would have to cross the Moberly River. This road would have to be at low level as a high level bridge would not be feasible due to the unstable slopes in the lower part of the Moberly valley. Low level bridge likely to cross the mouth of the Moberly on the gravel fan and then be constructed along the toe of the unstable slopes in the Tea Creek section which would be problematic. More likely that rail shipments would be unloaded at Fort St John and shipped by road. Moderately worse than Base Case.		constructed over the debris from the Cache Creek slide to the access bridge is over fairly easy terrain. Slope stability problems with north bank access possible. Rail shipments for sites 3a and 3b would be unloaded at Fort St John and shipped by road. Road and Rail access for 3c the same as the Base Case. Moderately worse than Base Case due to distance from Fort St John and anticipated difficulties accessing south bank.	of the steep high bank. Slope stability problems with south bank access possible. At site 4b a short access road would connect the highway to the access bridge over easy terrain. The south bank access road would run along the toe of the steep high bank. Slope stability problems with south bank access possible. At site 4c access from Highway 29 would be a new road down from the plateau over the steep valley side to the access bridge. The south bank access road would run along the toe of the steep high bank. Slope stability problems with both the north and south bank access possible. Rail shipments to sites 4a, 4b and 4c would be unloaded at Fort St John and shipped by road. Road and Rail access for 4d the same as the base case. Moderately worse than Base Case due to distance from Fort St John and anticipated difficulties accessing south bank at sites 4a, 4b and 4c and difficulty accessing north bank at	Road and Rail access for 7g the same as the base case. Moderately worse than Base Case due to distance from Fort St John and anticipated difficulties accessing south bank.

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
						site 4c.	
Areas for Temporary Works, Camps and Laydown	Large and sufficient areas available on both banks of the river for all temporary facilities required for construction.	The only areas that can be used are on the plateau high above the site. This will add considerably to travel times and reduce overall efficiency of operations. Significantly worse access than the Base Case.	Some space available on the terraces and an upper terrace on the north bank. Less space overall than at Site C – more travel time required. Moderately worse than Base Case.	At 7b there is some space on the island between the two channels and some space on north bank downstream of site. Travel distances somewhat greater. Site C3 is the same as the Base Case. Somewhat worse than Base Case.	At site 3a sufficient space is available on the north bank terrace east of Farrell Creek. No space on the south bank except up on the plateau. At site 3b some space is available on the terrace between Cache Creek and Highway 29. No space on the south bank except up on the plateau. More congested than Base Case. Site 4d the same as the Base Case. Moderately worse than Base Case.	At site 4a sufficient space is available on the north bank terrace east of Farrell Creek. No space on the south bank except up on the plateau. At site 4b space is available on the terrace east of the Halfway River. No space on the south bank except up on the plateau. More congested than Base Case. At site 4c some space is available on the narrow terrace on the north bank downstream. No space on the south bank except up on the plateau. Much more congested than Base Case. Site 4d the same as the Base Case. Moderately worse than Base Case.	At site 7a some space upstream and more downstream on the north bank. No space on the south bank. At site 7b some space 2 km upstream and 1.5 km downstream on the north bank. No space on the south bank. At site 7c space available on the north bank. No space on the south bank. At site 7d space available on the north bank. No space on the south bank. At site 7e space available on the north bank. No space on the south bank. At site 7f space available on both banks. Site 7g the same as the Base Case. Moderately worse than Base Case.
Project Sequencing Due to the size of the system and the generation that could be produced relative to the system, it was considered that it would be advantageous to be able to bring the entire capacity on line as quickly as possible and that the ability to sequence construction and bring the capacity on line in stages would not be an advantage.	If staged development required to match the load growth this could be done by constructing powerhouse for six units and only installing number of units required to match load (e.g. Revelstoke and Mica).	As for Base Case.	As for Base Case.	Both dams could be built together or in sequence. Most likely that the project would start with one dam and the other would commence one or two years later. This would result in a longer construction period than the Base Case. The work would likely be staggered to avoid having	Most likely that the work would be staggered with work starting on each dam in turn, which would result in a longer construction period than the Base Case. Three large powerhouses each with six units physically larger than at Site C. The work would be sequenced so that the	Most likely that the work would be staggered with work starting on each dam in turn. Four large powerhouses each with six units physically larger than at Site C. The work would be sequenced so that the installation, testing and commissioning of the units in both	Most likely that the work would be staggered with work starting on each dam in turn although the civil works are small enough to allow two dams to be constructed concurrently. Seven long powerhouses with a total of 116 units. The work would be sequenced so that the

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	Site C1 or C2	Wilder Creek	Site 7b and low C3	3 dam	4 dam	7 dam
				the same type of work occurring at the same time to avoid straining resources, particularly the skills required for installation, testing and commissioning of the turbines and generators. For example there would be two large powerhouses with a total of 12 units. The work would be sequenced so that the installation, testing and commissioning of the units in both powerhouses would be staggered. Requires more complex planning and has more risk if schedules are not met. Somewhat worse than Base Case.	installation, testing and commissioning of the units in both powerhouses would be staggered. Requires more complex planning and has more risk if schedules are not met. Moderately worse than Base Case.	powerhouses would be staggered. Requires more complex planning and has more risk if schedules are not met. Moderately worse than Base Case.	installation, testing and commissioning of the units in both powerhouses would be staggered. Requires more complex planning and has more risk if schedules are not met. Significantly worse than Base Case.
D Schedule and Cost Certainty							
D1 Schedule Certainty							
Pre-construction	Additional work required can be done in parallel with regulatory stage.	A minimum of two years of very extensive and intensive site investigations required plus additional year for applications and design. Moderately worse than Base Case.	A minimum of two years of very extensive and intensive site investigations required plus additional year for applications and design. Moderately worse than Base Case.	A minimum of one additional year of extensive and intensive site investigations required plus additional year for applications and design for site 7b. C3 same as Base Case. Somewhat worse than Base Case.	A minimum of three years of very extensive and intensive investigations required at sites 3a and 3b plus additional two years for applications and design. Site 3c same as Base Case. Significantly worse than Base Case.	A minimum of three years of very extensive and intensive investigations required at sites 4a, 4b and 4c plus additional two years for applications and design. Site 4d same as Base Case. Significantly worse than Base Case.	A minimum of four years of very extensive and intensive investigations required at sites 7a, 7b, 7c, 7d, 7e and 7f plus additional two years for applications and design. Site 7g same as Base Case. Significantly worse than Base Case.

Site C Evaluation of Alternatives

Comparative Assessment Engineering Matrix

Engineering Parameter	Single Dam Alternates			Cascade Alternates			
	Site C Base Case	**Site C1 or C2**	**Wilder Creek**	**Site 7b and low C3**	**3 dam**	**4 dam**	**7 dam**
Construction	Seven year construction period based on detailed planning.	No detailed planning done. Likely two years longer than Base Case due to greater volumes of excavation. Moderately worse than Base Case.	No detailed planning done – assumed the same as Base Case. Somewhat worse than Base Case.	No detailed planning done. Likely two years longer than Base Case due to sequencing of construction. Significantly worse than Base Case.	No detailed planning done. Likely six years longer than Base Case due to sequencing of construction. Significantly worse than Base Case.	No detailed planning done. Likely eight years longer than Base Case due to sequencing of construction. Significantly worse than Base Case.	No detailed planning done. Likely six years longer than Base Case due to sequencing of construction. Significantly worse than Base Case.
D2 Cost Certainty							
Pre-construction	Required scope of engineering work fairly well known.	Considerable work required – scope likely to change significantly based on findings of investigations. Moderately worse than Base Case.	Considerable work required – scope may change based on findings of investigations. Moderately worse than Base Case.	Site 7b relatively straight forward. C3 same as Base Case. Considerable work required. Somewhat worse than Base Case.	Considerable work required to investigate sites 3a and 3b – scope likely to change based on findings of investigations. Site 3c same as Base Case. Significantly worse than Base Case.	Considerable work required to investigate sites 4a, 4b and 4c – scope likely to change based on findings of investigations. Site 4d same as Base Case. Significantly worse than Base Case.	Considerable work required to investigate six upstream sites - scope likely to change based on findings of investigations. Site 7g same as Base Case. Significantly worse than Base Case.
Construction	Cost based on detailed construction planning and cost estimating with detailed scope and quantities.	Cost estimates at overview level – scope and quantities likely to change significantly. MDE not addressed. Very difficult sites. Significantly worse than Base Case.	Cost estimates at overview level – scope and quantities likely to change. Site topographically superior to C1/C2 and somewhat better than Site C. Moderately worse than Base Case.	Cost estimates for 7b at prefeasibility level – changes in scope and quantities likely. Cost estimates for C3 based on Base Case. Somewhat worse than Base Case.	Cost estimates at overview level – scope and quantities likely to change significantly. Diversion options may have to change. Proximity of Site 3c to Cache Creek slide debris may cause complications. Greater number of dams increases potential for unanticipated foundation problems. Significantly worse than Base Case.	Cost estimates at overview level – scope and quantities likely to change significantly. Diversion options may have to change. Proximity of site 4d to Attachie slide may cause complications. Greater number of dams increases potential for unanticipated foundation problems. Significantly worse than Base Case.	Cost estimates at pre-feasibility level. Reliance on post tensioned anchors (that cannot be tested or replaced) for static stability may not be acceptable for the magnitude of investment. Significantly worse than Base Case.

Appendix F

Terrestrial Ecosystem Mapping

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Terrestrial Ecosystem Mapping (TEM) data and Environmental Theme data

Appendix F contains example mapping of Terrestrial Ecosystem Mapping (TEM) data and environmental theme data layers that was overlaid on 6 orthophoto base tiles developed for the reach from Site C to Peace Canyon Dam.

For example:

- Map F-1 displays the TEM polygons for the area on Tile 1 of 6. For clarity, polygon labels have been omitted from all TEM data example maps in this appendix.

- Map F-7 displays the various Timber Harvest category polygons on Tile 1 of 6 (This is just one example category in the environmental theme data set). A list of all other environmental themes that were evaluated is provided in Appendix A2.

Electronic copies of all TEM data and physical theme data layers for all 6 tiles can be made available on DVD upon request.

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618,000 621,000 624,000 627,000 630,000 633,000

6,234,000

6,231,000

6,228,000

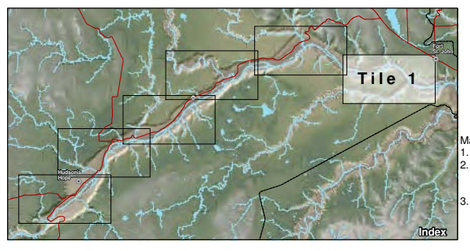
Wilder Creek

Tea Creek

Peace River

Moberly Creek

N



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. TEM data provided by Keystone Engineering. Data produced March 14/22, 2007. Method of collection: Peace River - Airphoto typing, digitizing and field truthing. Fort St. John, Moberly and Lower Halfway River - Digitized hardcopy 1:50,000 maps

Legend

Terrestrial Ecosystem Mapping Polygon

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

Klohn Crippen Berger

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BC hydro

Alternatives Environmental Mapping
Terrestrial Ecosystem Mapping (TEM)
Tile 1 of 6

DATE	OCT, 2009	µ	DWG NO	F-1	R	0

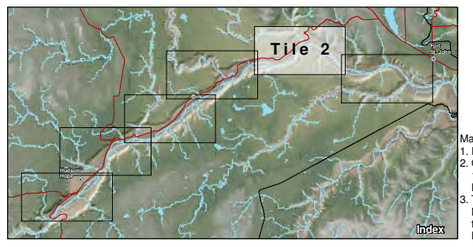
603,000 606,000 609,000 612,000 615,000

6,240,000 6,237,000 6,234,000

Cache Creek

Peace River

N



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. TEM data provided by Keystone Engineering. Data produced March 14/22, 2007. Method of collection: Peace River - Airphoto typing, digitizing and field truthing. Fort St. John, Moberly and Lower Halfway River - Digitized hardcopy 1:50,000 maps

Legend

Terrestrial Ecosystem Mapping Polygon

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

Klohn Crippen Berger
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Alternatives Environmental Mapping
Terrestrial Ecosystem Mapping (TEM)
Tile 2 of 6

DATE	OCT, 2009	µ	DWG NO	F-2	R	0

585,000 588,000 591,000 594,000 597,000 600,000

6,234,000

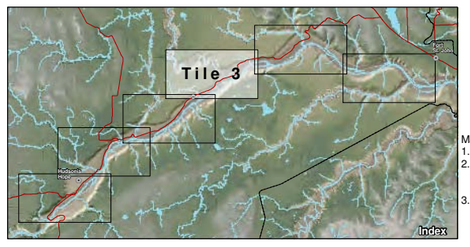
6,231,000

6,228,000

N

Halfway River

Peace River



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. TEM data provided by Keystone Engineering. Data produced March 14/22, 2007. Method of collection: Peace River - Airphoto typing, digitizing and field truthing. Fort St. John, Moberly and Lower Halfway River - Digitized hardcopy 1:50,000 maps

Legend

Terrestrial Ecosystem Mapping Polygon

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

Klohn Crippen Berger

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Alternatives Environmental Mapping
Terrestrial Ecosystem Mapping (TEM)
Tile 3 of 6

DATE	OCT, 2009	µ	DWG NO	F-3	R	0

579,000 582,000 585,000 588,000 591,000

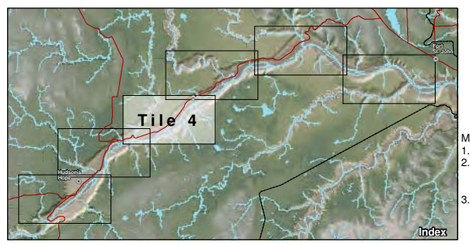
6,225,000

6,222,000

Peace River

Farrell Creek

N



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. TEM data provided by Keystone Engineering. Data produced March 14/22, 2007. Method of collection: Peace River - Airphoto typing, digitizing and field truthing. Fort St. John, Moberly and Lower Halfway River - Digitized hardcopy 1:50,000 maps

Legend

Terrestrial Ecosystem Mapping Polygon

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

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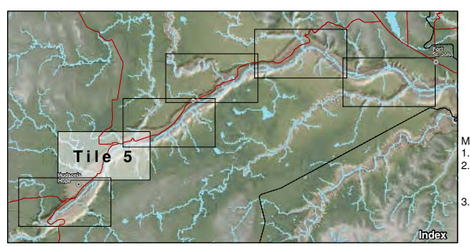
Alternatives Environmental Mapping
Terrestrial Ecosystem Mapping (TEM)
Tile 4 of 6

DATE	OCT, 2009	µ	DWG NO	F-4	R	0



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. TEM data provided by Keystone Engineering. Data produced March 14/22, 2007. Method of collection: Peace River - Airphoto typing, digitizing and field truthing. Fort St. John, Moberly and Lower Halfway River - Digitized hardcopy 1:50,000 maps

Legend

Terrestrial Ecosystem Mapping Polygon

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 — 2.5 km

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Alternatives Environmental Mapping
Terrestrial Ecosystem Mapping (TEM)
Tile 5 of 6

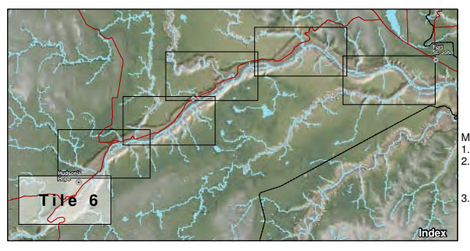
DATE	OCT, 2009	µ	DWG NO	F-5	R	0

558,000 561,000 564,000 567,000 570,000 573,000

6,213,000
6,210,000
6,207,000

N

Peace River



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. TEM data provided by Keystone Engineering. Data produced March 14/22, 2007. Method of collection: Peace River - Airphoto typing, digitizing and field truthing. Fort St. John, Moberly and Lower Halfway River - Digitized hardcopy 1:50,000 maps

Legend

Terrestrial Ecosystem Mapping Polygon

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

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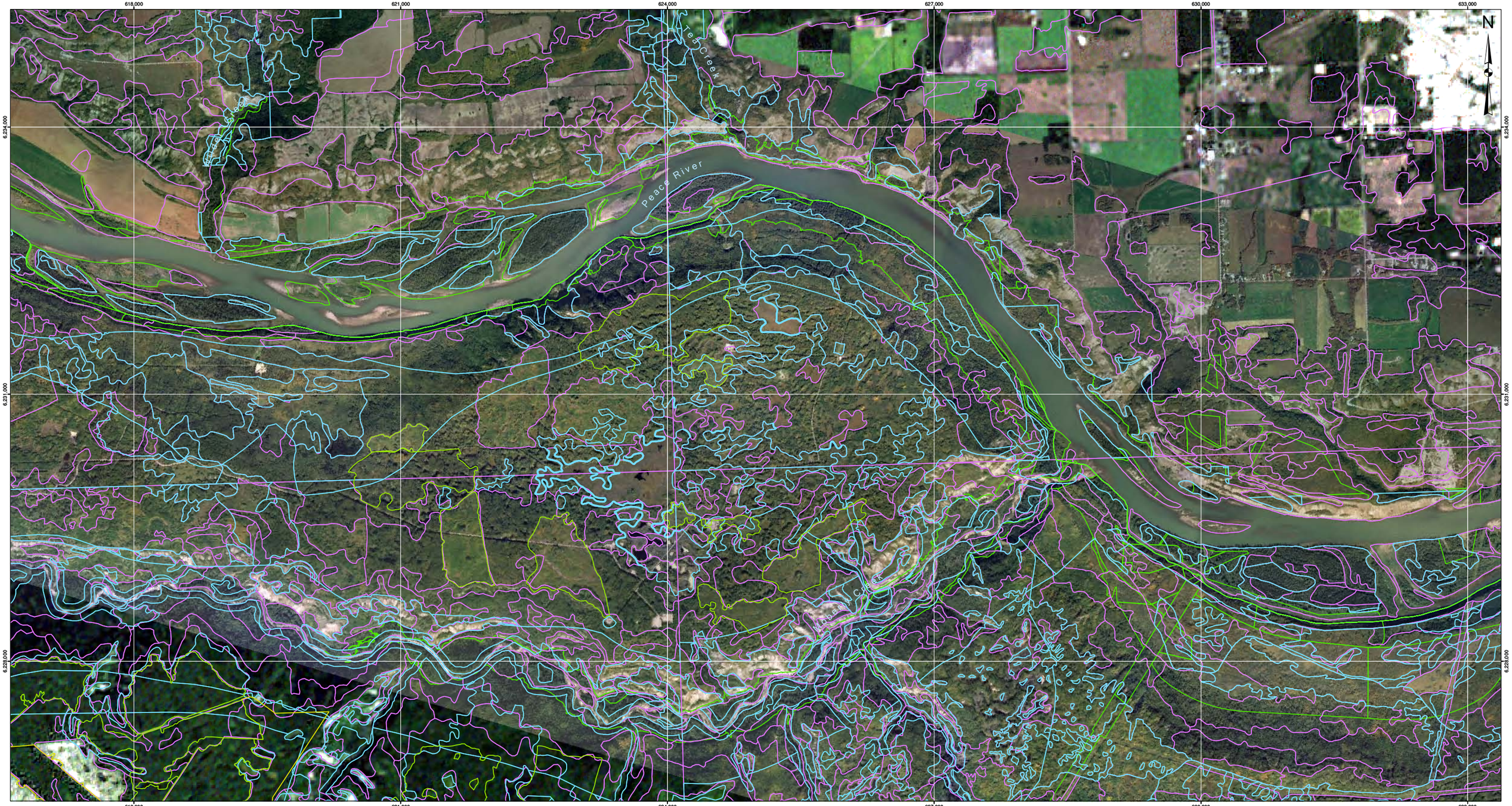
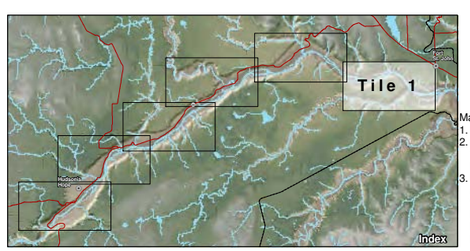
BC hydro

Alternatives Environmental Mapping
Terrestrial Ecosystem Mapping (TEM)
Tile 6 of 6

DATE	OCT, 2009	µ	DWG NO	F-6	R	0





Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. Pulpwood Agreements, Cut Blocks, Community Forests and Woodlots, Forest Cover - Land & Resource Data Warehouse. Old Growth Management Areas, Timber Harvesting Land Base - Integrated Land Management Bureau. Harvest Unit - Industrial Forest Services Ltd. Dec, 2008.

Legend

- Pulpwood Agreements
- Cut Blocks
- Old Growth Management Areas
- Community Forest and Woodlots
- Timber Harvesting Land Base
- Forest Cover
- Harvest Unit

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 — 2.5 km

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BC hydro

Alternatives Environmental Mapping
Timber Harvest
Tile 1 of 6

DATE	OCT, 2009	µ	DWG NO	F-7	R	0

603,000 606,000 609,000 612,000 615,000

6,240,000

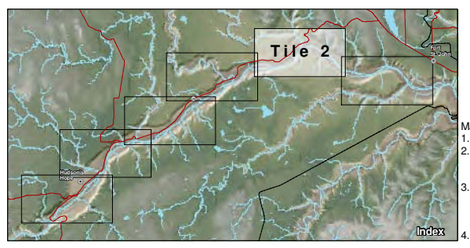
6,237,000

6,234,000

Cache Creek

Peace River

N



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. Property status information represents BC Hydro's current ownership records. Property boundaries shown are the result of computations and adjustment to GPS field observations. The estimate positional accuracy is less than 1.0 metre.
4. Land Act Tenures - Land and Resource Data Warehouse.

Legend

- Crown land
- BC Hydro owned land (leased)
- BC Hydro owned land
- Private land
- Land Act Tenures

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

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Alternatives Environmental Mapping
Land Zoning
Tile 2 of 6

DATE	OCT, 2009	µ	DWG NO	F-8	R	0

585,000 588,000 591,000 594,000 597,000 600,000

6,234,000

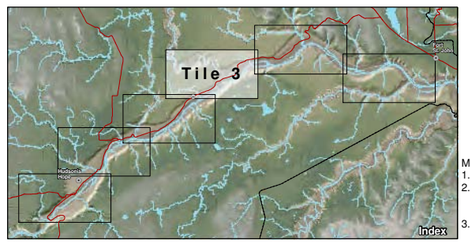
6,231,000

6,228,000

Halfway River

Peace River

N



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. Hunting Zones/Trapline Areas - Land Resource Data Warehouse

Legend

Trapline Areas

Hunting Zones

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

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Alternatives Environmental Mapping
Hunting Zones & Trapline Areas
Tile 3 of 6

DATE	OCT, 2009	µ	DWG NO	F-9	R	0

579,000 582,000 585,000 588,000 591,000

6,225,000

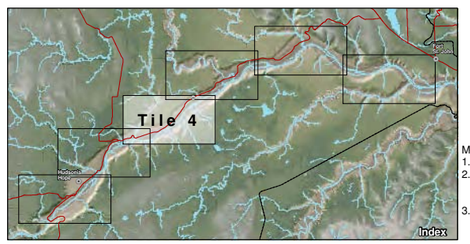
6,222,000

Peace River

Farrell Creek

N

Legend



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. Proposed Protected Areas - Integrated Land Management Bureau. Recreational Reserves/Sites - Land Resource Data Warehouse.

Legend

Recreation Reserves

Proposed Protected Areas

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

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BC hydro

Alternatives Environmental Mapping
Recreational Reserves/Sites &
Proposed Protected Areas
Tile 4 of 6

DATE	OCT, 2009	µ	DWG NO	F-10	R	0

567,000 570,000 573,000 576,000 579,000

6,222,000

6,219,000

6,216,000

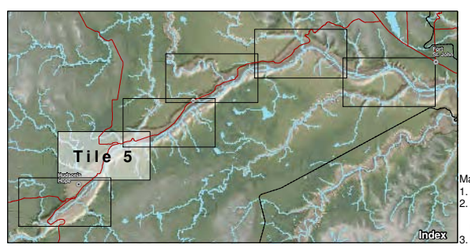
N

Farrell Creek

Peace River

Lynx Creek

DL



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. Petroleum Titles - Land Resource Data Warehouse.

Legend

Petroleum Titles

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

Klohn Crippen Berger

SNC·LAVALIN

BC hydro

Alternatives Environmental Mapping
Petroleum Titles
Tile 5 of 6

DATE	OCT, 2009	µ	DWG NO	F-11	R 0

558,000 561,000 564,000 567,000 570,000 573,000

6,213,000

6,210,000

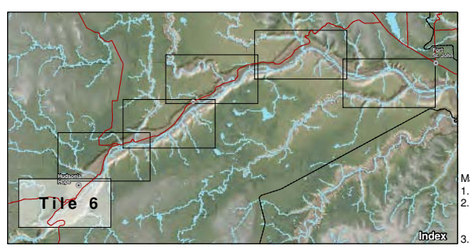
6,207,000

N

/PR

/R

Peace River



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Orthophotos created from 1:40,000, 1:20,000, and 1:5,000 scale photography taken June and Sept, 2007. Background imagery is from Landsat ETM+
3. Visual Landscape Inventory - Land Resource Data Warehouse.

Legend

Visual Landscape Inventory

Scale: 1:10,000 at 11x17
Scale: 1:20,000 at D-size

0 2.5 km

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BC hydro

Alternatives Environmental Mapping
Visual Landscape Inventory
Tile 6 of 6

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PEACE RIVER DEVELOPMENT
SITE C CLEAN ENERGY PROJECT

OPTIMIZATION OF PROJECT LAYOUT AND CONFIGURATION OF STRUCTURES

REVIEW OF ALTERNATE SITES ON THE PEACE RIVER

ADDENDUM 1

Updated Assessment Using New General Arrangement

Prepared by

Klohn Crippen Berger Ltd. and SNC-Lavalin Inc.

For

BC Hydro

Report No.:BKS-03-025
August 2011

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PEACE RIVER DEVELOPMENT
SITE C CLEAN ENERGY PROJECT

ADDENDUM 1

FOR THE
REVIEW OF ALTERNATE SITES
ON THE PEACE RIVER

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LIST OF ACRONYMS

GIS	Gas Insulated Switchgear
RCC	Roller Compacted Concrete

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PEACE RIVER DEVELOPMENT
SITE C CLEAN ENERGY PROJECT

ADDENDUM 1

for the
REVIEW OF ALTERNATES SITES
ON THE PEACE RIVER

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1. Introduction

The Review of Alternate Sites on the Peace River study evaluated a number of different alternates for developing the hydroelectric potential of the Peace River between Peace Canyon Dam and Site C, including:

- the Site C Base Case located at the axis historically designated as C3;
- a single dam located upstream of the Moberly River at the more favourable of axes historically designated as C1 and C2;
- a single dam located at Wilder Creek approximately 11.5 km upstream of Site C;
- two dams with a 15 m lower dam at axis C3 and a 15 m high dam located 66 km upstream (7b / Low C3);
- a cascade of three equal height dams;
- a cascade of four equal height dams; and
- a cascade of seven dams.

The Site C Base Case was evaluated assuming the historic general arrangement carried forward from the 2002 cost estimate update, and included design allowances identified during Stage 2 to mitigate rebound and seismic stability. Where a modified version of the Site C Base Case general arrangement was adopted at the other alternate sites, the same 2002 historical general arrangement with Stage 2 design allowances was adopted, with adjustments made to take into account topographical differences at these sites.

Layouts were developed so that key facility characteristics including the physical footprint and energy cost ratio could be defined for each alternate.

A multi-attribute decision making framework was used to assess the relative differences between:

- the impacts of each alternate and the Site C Base Case on the physical, biological and socio-economic environments based on the footprint information; and
- the functionality of each alternate and the Site C Base Case, including dam safety factors and life cycle factors.

Summary rankings and weightings for the physical, biological and socio-economic environments and functionality were plotted against energy cost ratio for each alternate.

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Four of the alternates, namely a dam at axis C1/C2 and the three, four and seven dam cascades were found to be dominated alternates (i.e., increasing the energy cost ratio does not provide a decrease in the relative footprint ratio) and therefore were screened out from further analysis. The ranking of the non-dominated alternates (i.e., where increasing the energy cost ratio does provide a decrease in the relative footprint ratio) relative to the Site C Base Case were:

1. Site C Base Case, with an energy cost ratio of 1.00;

2. Wilder Creek, with an energy cost ratio of 1.38; and

3. the two dam cascade with an energy cost ratio of 1.55.

BC Hydro's Stage 1 Completion Report (Reference 1) placed the early-stage estimate for Site C between $5.0 billion and $6.6 billion in nominal dollars. Therefore, each 0.1 increase in the energy cost ratio represents in the order of $500 million to $660 million loss of value. Construction of the project at Wilder Creek rather than Site C would result in a 38% increase in energy cost representing a loss in value of $1.9 billion to $2.5 billion.

A series of sensitivity analyses were performed on the three non-dominated alternates to determine whether changing the weightings would materially change the rankings.

It was found that the following changes to the weightings would not change the outcome:

1 Weighting environment at 60% and functionality at 40%, which given the nature of the project, the size of the investment and the consequences of functionality problems, was considered the lowest weighting that could be reasonably given to functionality.

2 Weighting the aquatic resources of the Moberly River at 100% with no weight given to the aquatic resources of the other tributaries, which would be unreasonable given the size and importance of the Halfway River which provides habitat for blue-listed bull trout as well as other species.

3 Giving riparian habitat, islands, and shorelines a higher weighting in the biological account and weighting agricultural land at 50% of the overall land value in the socio-economic account.

The consultants that undertook the alternates study concluded that:

- there were no environmental factors that would eliminate an alternate;
- the relative differences in environmental impacts and functionality between alternates were small; and

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- in their opinion, the small relative differences in benefits between the alternates did not justify the significantly greater costs.

In the opinion of the three organizations, the multi-attribute assessment confirmed that Site C was the preferred site.

Stage 2 studies concluded that a refined and updated design of the proposed project was required. Since the completion of the alternates study, the project layout has been optimized and the structures reconfigured. The optimization studies were carried out in 2010 to evaluate different arrangements and dam types, and resulted in the selection of a general arrangement which, based on current information, balanced technical, environmental and social considerations, uncertainty and risk. This revised arrangement is described further under Section 3 of this addendum as well as in BC Hydro's Project Description Report (Reference 2) and forms the basis for the 2010 project cost estimate. The following addendum summarizes the results of an updated assessment undertaken to examine the impact that adopting the revised project general arrangement as the Site C Base Case would have, if any, on the results of the alternates study.

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2. Original Site C Base Case General Arrangement

The topography, site geology, layout, design allowances for rebound mitigation and seismic stability, and details of the sequence of construction and river diversion for the Site C Base Case adopted in the alternates study are described in detail under Section 10.4 of the report. Figure 10-1 shows the general arrangement of the original Site C Base Case.

The dam would be a zoned earthfill dam consisting of a central impervious core with outer shells of sands and gravels. The dam would be approximately 1120 m long at the crest and 60 m high above river level. The base of the impervious core would be set in a trench excavated through the river bed and into the bedrock to provide a watertight seal.

A major excavation would be required to stabilize the left bank slope above the dam, which would involve removing approximately 18 million m^3 of earth material.

The spillway, power intakes, penstocks and powerhouse would be located adjacent to the dam on the right bank terrace. An approach channel would convey water from the reservoir to the spillway and the power intakes.

The power intakes would convey water from the reservoir to the turbines. The intakes would be located adjacent to the spillway structure and would be 96 m wide and approximately 40 m high. There would be six separately gated openings each connected by a steel penstock to a turbine in the powerhouse. The 9.35 m diameter penstocks would be encased in concrete and partly buried in granular backfill behind the intake structure. The powerhouse would contain six Francis turbines and associated generators rated at approximately 150 MW each (total 900 MW) under a net head of 48.8 m.

The spillway would have gated headworks with a concrete lined chute leading to a submerged stilling basin energy dissipater. The energy dissipater would absorb sufficient energy from the spillway discharge to prevent downstream erosion from endangering the dam or power station. The spillway would have six radial gates with sills at El. 446.5 m.

Following transformation to 138 kV, power from the generators would be delivered by cable to the switchgear building located above and to the south of the power station.

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3. Revised Site C Base Case General Arrangement

The revised general arrangement that was developed for Site C during the optimization and configuration stage maintained the concept of an earthfill dam across the Peace River channel and located all of the structures on the right bank, oriented so as to minimize their susceptibility to foundation discontinuities. The revised arrangement would buttress the right side valley wall with roller compacted concrete (RCC) thick enough to resist all loading above the valley floor and would transfer load from the headworks structures deep into the valley floor. The earthfill dam would abut against the RCC buttress on the right bank. The powerhouse and stilling basin would be located on the buttress in the valley bottom, while the power intake and spillway headworks structures would be constructed at the top of the buttress. All of the structures would be oriented at right angles to the river channel and the existing valley wall. The spillway would be located on the downstream side of the powerhouse, where previously it had been located upstream of the powerhouse and adjacent to the toe of the earthfill dam. The objective of this arrangement is to:

- minimize the hydraulic load acting on the buttress and transfer the load to the rock;
- minimize potential rebound by:
  - minimizing excavation depths;
  - loading excavations;
  - minimizing differential excavation depths by orienting the structures perpendicular to the valley wall; and
  - locating the powerhouse and stilling basin in the river bed.
- minimize the effects of the low strength bedding planes on the structures' stability.

The large excavation on the north bank slope would still remain. Other notable changes made to the revised arrangement that differ from the original Base Case arrangement include:

- the base width of the approach channel was increased from 90 m to 200 m to decrease channel velocities;
- the capacity of the powerplant was increased from 900 MW to 1100 MW, resulting in larger penstocks and a larger powerhouse footprint. This increased capacity is achieved with no change to the maximum normal operating range for the Site C reservoir and negligible changes in footprint relative to the reservoir area. As with the original arrangement, 6 units would still be used to generate the power. The increased capacity resulted in an increase in the cost;

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- The spillway was divided into two separate compartments for maintenance reasons, and the overall spillway width was increased from 120 m to 180 m in order to reduce the unit discharge to a maximum of 100 $m^3/s/m$. As noted with the powerplant footprint, the increase in the spillway footprint is negligible in relation to the overall project footprint, however these changes increased the cost;
- Mid level outlets in the form of spillway under-sluices were incorporated into the gated spillway arrangement to enable the reservoir to be drawn down in case of an emergency and also to facilitate maintenance and repair to the approach channel (if required) during the life of the project. This addition increased the cost;
- An auxiliary free overflow side channel spillway was added to the arrangement to provide spill redundancy and capacity in case spillway gates were inoperable, and additional operational and maintenance flexibility. This addition increased the cost;
- An updated cofferdam scheme was developed, which included the addition of a left bank cofferdam, which would maximise the construction works that could take place at the site prior to diversion of the river through the diversion tunnels. This addition increased the cost;
- A permanent bridge across the Peace River located downstream of the dam site and the associated south bank access road running along the island are no longer required to access the powerplant (see Figure A3). This reduces the environmental impact on the island which reduces the overall project footprint. Access to the south bank in the revised arrangement would be over a temporary construction bridge located at the dam site which would be removed at the end of construction and, for the completed works, access would be provided across the dam; and
- Surplus excavated material previously designated for relocation to areas R1 and R5 on the island and in the back-channel downstream of the dam site (see Figure 10-1) would now be relocated upstream of the dam site and ultimately be inundated by the reservoir, thereby reducing the impact on these environmentally sensitive downstream areas.

The revised general arrangement that was adopted for the Site C Base Case in this update is presented on Figure A1 appended to this addendum. This project layout formed the basis for the 2010 project cost estimate update. Figure A2 illustrates the construction facility areas for the revised project arrangement and represents the majority of the areas that contribute to the overall footprint at the dam site. Figure A3 shows the relative difference between the footprints of the revised general arrangement and the historical general arrangement at dam

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site C3. No significant change in footprint results from adopting the new general arrangement at site C3. This is discussed in more detail under Section 5. The direct construction cost of the revised general arrangement increased by approximately 25% in relation to the direct construction cost for the historical general arrangement (when escalated to 2010 dollars using Statistics Canada's non-Residential price index). The cost for the updated site C3 base case, against which all other alternates will be assessed in this updated evaluation, has therefore increased.

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4. Updated Energy Cost Ratio's

Costs for each of the alternates were re-evaluated on the same basis and using the same assumptions adopted in the alternates study. Since no flow or operating conditions have changed by adopting the updated general arrangement, there is no change to the amount of energy generated by each of the alternates. Energy ratios for all of the re-evaluated alternates have, therefore, not changed.

Single Dam Alternates

Applying the updated general arrangement at each of the single dam alternate sites, i.e., Site C2 and Wilder Creek would result in an increase in the direct construction costs for each of these alternates. Increased direct construction costs translate into increased contingency, management and engineering, overhead (construction insurance) and IDC costs which are all dependent on the direct construction cost. Consequently, the overall cost of these two alternates increased relative to the updated base case site C3, meaning that the cost ratio, and consequently the energy-cost ratio for alternate C2 and Wilder Creek increased. Table 4-1 below highlights the changes in cost ratio and energy cost ratio for alternates C2 and Wilder Creek.

Table 4-1: Updated Cost Ratio and Energy Cost Ratio for C2 and Wilder Creek

	C2	Wilder Creek
Previous Cost Ratio	2.08	1.20
Updated Cost Ratio	2.13	1.25
Energy Ratio (unchanged)	0.97	0.87
Previous Energy Cost Ratio	2.14	1.38
Updated Energy Cost Ratio	2.20	1.43

Cascade Alternates

Alternate 7b/low C3 would only be affected at the low C3 site when applying the updated general arrangement. The project that would be constructed at site 7b is not dependent on the base case arrangement and would, therefore, remain unchanged from that described in the alternates report. The low C3 site arrangement would be based on the updated general arrangement, which has an increased cost. The result is an increase in the overall cost of the 7b/low C3 alternate. However, the cost increase is not proportional relative to the increased base case site C3 cost since site 7b's costs have remained unchanged. Thus, when compared to the updated base case Site C3 cost, there is an overall decrease in the relative cost ratio for alternate 7b/low C3. The lower cost ratio for

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this alternate results in a beneficial decrease in its energy cost ratio. This means there would be a reduced loss in value at this site compared to the previous evaluation based on the historical general arrangement.

The three, four and seven dam cascade alternates do not change in cost as they are independent of the base case general arrangement. Since their overall costs do not change, compared to the updated base case site C3 cost which has increased, the cost ratio of these alternates relative to the updated base case site C3 alternate decreases. This results in a decrease in the energy cost ratio. Again, this means that the loss in value of these alternates has decreased compared with the loss in value when evaluated using the historical base case general arrangement at site C3.

Table 4-2 below highlights the changes in cost ratio and energy cost ratio for the cascade alternates.

Table 4-2: Updated Cost Ratio and Energy Cost Ratio for Cascade Alternates

	7b/Low C3	3 Dams	4 Dams	7 Dams
Previous Cost Ratio	1.49	1.80	2.16	1.49
Updated Cost Ratio	1.32	1.26	1.54	1.15
Energy Ratio (unchanged)	0.96	0.95	0.95	0.85
Previous Energy Cost Ratio	1.55	1.88	2.27	1.76
Updated Energy Cost Ratio	1.37	1.32	1.62	1.35

Dominated Alternates

The three, four and seven dam cascade alternates are independent of the updated base case general arrangement and have, therefore, not changed. Their footprints are also, therefore, unchanged. In addition, adopting the updated general arrangement at site C2 does not result in any material change in footprint compared to its footprint when adopting the historical base case general arrangement. While the energy cost ratios for the three, four and seven dam cascade alternates have decreased, they are still 32%, 62% and 35%, respectively, greater than the updated base case site C3 alternate's energy cost ratio. In addition, their relative overall footprint ratios are unchanged and still all greater than the updated base case site C3 alternate. The updated base case site C3 project cost is quoted at $7.9 billion (2010$) in BC Hydro's Project Description Report (Reference 2). The higher energy cost ratios for the three, four and seven dam cascade alternates therefore represent a loss in value of between $2.5 billion to $4.9 billion (32% to 62%). These alternates still remain dominated alternates (i.e. increasing the energy-cost ratio does not provide a decrease in relative footprint ratio). These alternates are therefore more

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expensive and provide no benefit compared with the updated base case site C3 alternate. They were, therefore, screened out from any further analysis (as was the case in the alternates study).

The energy cost ratio for the alternate of a single dam at site C2 increased, meaning the loss in value at this site is even greater than previously evaluated. With no change in the relative footprint ratio for this alternate, it too was once again screened out from further analysis.

Non-Dominated Alternates

The two dam cascade (7b/low C3) alternate and the alternate for a single dam at Wilder Creek were previously identified in the alternates study as being non-dominated alternates (i.e. alternates where increasing the energy cost ratio does provide a decrease in the relative footprint ratio). These two alternates are discussed further under Sections 5 and 6 of this addendum, respectively.

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5. Two Dam Cascade (7b / Low C3)

The two dam cascade alternate is described under Section 10.7 of the main report. This alternate consists of an arrangement of gravity structures located at site 7b on the more competent rocks of the Gates Formation, and a lower dam at site C3 with the same arrangement as the Site C Base Case, but with all structures lowered by 15 m.

The arrangement of gravity structures at site 7b do not change. Therefore, under this evaluation, there is no impact or change in evaluation of results at site 7b.

Applying the revised Site C Base Case general arrangement at site C3 results in the following physical impacts:

- Total excavation quantities are marginally reduced. The left bank stabilization, earthfill dam and diversion excavations are essentially unchanged. However, the approach channel excavation increases by approximately 4 Mm^3 in the revised arrangement due to the wider, longer approach channel. The excavation for the right bank structures reduces by approximately 6 Mm^3 in the revised arrangement as the structures are oriented perpendicular to the valley wall and the excavation profile generally follows the natural topography. The net result is a decrease in total excavation volume in the revised arrangement.
- The local footprint at the dam site increases by approximately 30 ha. The increase is not related to the footprint of the power generating structures, but is rather due to refinement of the construction facilities areas. The overall footprint of the left bank, dam and generating facilities has actually reduced slightly in the revised arrangement. However, the areas allocated for site offices, concrete production, and material storage have increased. This is largely due to area “E” shown on Figure A2, which was not previously included. As described for the revised Base Case arrangement under Section 3 above, the permanent downstream bridge across the Peace River and associated access road along the island are also not required for the two dam cascade, which reduces the environmental impact on the island and provides a slight reduction in project footprint. The overall increase of 30 ha is negligible when compared to the overall project footprint and translates to an increase of only 0.3% relative to the total reservoir area of 9310 ha. Figure A3 shows the assumed footprint of the original general arrangement overlaid with the revised general arrangement and construction facilities areas for comparison. It is evident that the area for the right bank camp and BC Hydro offices, located south of

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the dam and generating structures, falls outside the original assumed footprint.

- The fill volume for the earthfill dam marginally increases due mainly to refinements made to the excavated depth of the core trench and adjustments made at the interface of the dam and the RCC buttress on the right bank.
- The concrete volumes increased. This is largely due to the addition of the RCC buttress, which requires 2.4 Mm^3 of roller compacted concrete. The reinforced concrete volume also increases mainly due to the increased spillway width and the addition of an auxiliary spillway and corresponding free overflow side channel.
- The switchgear building was previously located adjacent to the powerhouse. In the revised arrangement, there is no space to locate the switchgear building adjacent to the powerhouse Therefore, an open-air switchyard is anticipated to be located on top of the south bank terrace as shown on Figure A2. This adds marginally to the damsite footprint when compared with the original arrangement. The revised arrangement's open air switchyard has minimal Gas Insulated Switchgear (GIS) components. This is better, environmentally, when compared with the original Base Case arrangement that included an enclosed switchgear building requiring more GIS components and therefore, additional SF_6. [1]

From the evaluation conducted, it does not appear that there will be any significant impact or change to the overall footprint at site C3 by applying the low revised Site C Base Case arrangement. The marginal increase in footprint area at the dam site is considered to be negligible in relation to the overall project footprint. The overall footprint ratio for 7b/low C3 is therefore determined to be essentially unchanged.

As detailed in Section 4 above, the energy cost ratio for this alternate reduced from 1.55 to 1.37. The 37% greater energy cost relative to the updated base case site C3 alternate represents a loss in value of approximately $2.9 billion. With only a marginal increase in the local dam site footprint for the revised Site C Base Case arrangement at site C3, it is concluded that the overall impact to the results of the alternates study assessment for the two dam cascade would not change. The 2 dam cascade (7b/low C3) would still not be considered preferable to the project being constructed as a single dam at site C3.

[1] According to the Intergovernmental Panel on Climate Change, SF_6 is the most potent greenhouse gas that it has evaluated.

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6. Wilder Creek

The Wilder Creek alternate is described under Section 10.6 of the main report. This location, 11.5 km upstream of Site C3 and immediately downstream of the confluence of Wilder Creek and the Peace River, was chosen as a potentially suitable site due to the terraces located on each bank of the river near to the proposed Site C reservoir level. For the purpose of the update documented in this addendum, it was assumed that the revised general arrangement could be applied at the Wilder Creek location with minimal changes made to adjust the arrangement for the change in topographic elevations. The revised general arrangement is presented at the Wilder Creek location on Figure A4.

The following physical impacts result from applying the revised Site C Base Case general arrangement at the Wilder Creek location:

- The approach channel at the Wilder Creek location would have to be approximately 10% longer than at site C3 due to the natural topography of the right bank terrace at this location. This results in an increase to the excavation and riprap quantities as well as a slight increase in the local footprint area.
- Total overall excavation quantities reduce marginally however for similar reasons to the physical impacts at site C3 described above. The approach channel is significantly wider and longer than the original arrangement which causes approach channel excavation volumes to increase. The revised orientation of the right bank structures, however, causes a reduction in excavation volumes that more than offsets the increased approach channel excavation volumes, resulting in a net decrease in excavation.
- The original Base Case footprint area was selected at Wilder Creek to maximize the available area of the terraces for use during construction. The revised Site C Base Case arrangement fits within the local footprint area assumed for the original arrangement (see Figure A4). It can, therefore, be assumed that the overall damsite footprint area does not change. However, the tailrace footprint is slightly larger for the revised arrangement and a spoil area was added within the river channel on the left bank downstream of the diversion outlet. The net addition of the tailrace and spoil area is approximately 11.5 ha, which is a negligible 0.12% increase compared with the total reservoir area of 9310 ha.
- The fill volume for the earthfill dam marginally increases for the same reasons described at site C3 above, i.e. refinement of the core trench elevation and adjustments made at the interface of the dam and the RCC buttress on the right bank.

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- The concrete volumes increase significantly for the same reasons described at site C3 above, i.e., the addition of the RCC buttress, wider spillway and the auxiliary spillway and corresponding free overflow side channel.
- Similar to site C3, there is no space to locate the switchyard adjacent to the powerhouse. Therefore, the switchyard must be located on the terrace above the approach channel. The majority of this area on the terrace is required during construction for access, work areas, material storage, and site offices and camps. Possible solutions include reducing the already tight construction facilities areas sufficiently to allow room for the switchyard, constructing the switchyard late enough in the construction schedule that area on the terrace would be available, or creating additional area by excavating into the steep right bank slope above the terrace. All of these options are undesirable and would have negative cost and schedule impacts when compared to the original base case arrangement. Footprint area at the dam site and overall cost will, therefore, at best remain the same, but likely increase for the revised base case arrangement at Wilder Creek.

It should be noted that the criteria adopted for sizing the original footprint at Wilder Creek was to allow a minimum of 100 ha on each of the left and right banks for construction facility areas such as laydown areas, material storage, concrete production, penstock fabrication and camp facilities. The lower left bank terrace did not provide sufficient area for these estimates. Therefore, additional footprint area was included on an upper left bank terrace that could be suitable for a camp area. The latest construction facilities areas drawing at site C3 (see Figure A2) allows for a 150 ha BC Hydro office and camp area (area “E”), a 260 ha RCC concrete plant and lab (area “D”), and a 60 ha material storage area (area “F”) on the right bank. The total of these areas is 470 ha. At Wilder Creek the maximum suitable area available on the right bank is approximately 140 ha, and 110 ha on the left bank for a total of 250 ha. For the purposes of this update, it has been assumed that 250 ha is sufficient. If additional area was required at Wilder, it could only be achieved by significant excavations into the existing slopes or by extending the footprint further away from the project site on the left bank upper terrace. Both of these options would create a bigger footprint, resulting in an increase in the cost of this alternate and, therefore, an increase the energy cost ratio.

As discussed under Section 3, adopting the revised base case site C3 arrangement at Wilder Creek results in an increased cost ratio of the Wilder Creek alternate, which in turn results in an overall increase in the energy cost ratio from 1.38 to 1. 43 for this alternate relative to the updated base case site C3 alternate. This represents a loss in value of approximately $3.4 billion. With an increased energy cost ratio for Wilder Creek and no significant

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change in footprint ratio, the Wilder Creek alternate still remains unattractive and does not offer any increased benefit. Applying the updated general arrangement to the Wilder Creek site does not, therefore, change the opinion of the previous evaluation made during the alternates study.

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7. Summary and Conclusions

BC Hydro's Project Description Report (Reference 2) quotes an updated project cost estimate for the Site C Clean Energy Project of $7.9 billion (2010$) and is based on the updated project general arrangement. The cost estimate was done as a detailed bottom-up estimate, carried out on the new general arrangement, which is at a far more advanced level of design than any of the other alternates.

As described in the alternates study, the evaluation of costs for the various alternates has been done to different levels of detail due to the difference in the level of design detail available for each alternate. It was anticipated that if screening level evaluations indicated that any alternate was competitive with the Base Case, a more detailed cost estimate would be undertaken on that particular alternate. This has proved not to be the case.

The current evaluation reviewed the impact of adopting the updated general arrangement on the evaluation of alternates, and showed that the energy cost ratios for the single dam alternates (i.e., C2 and Wilder Creek) would increase as a result, while the energy cost ratios for the cascade alternates (i.e. two, three, four and seven dam cascades) would decrease. In all instances, the footprint ratios remained either unchanged, or had a minor change that was considered to be negligible for the purposes of the evaluation.

The single dam at site C2 alternate, as well as the three dam, four dam and seven dam cascade alternates all still remain dominated alternates (i.e. increasing the energy cost ratio does not provide a decrease in the relative footprint ratio) and have sub-optimum footprint ratios at a higher energy cost. These alternates were, therefore, again screened out from further analysis, as was done in the original alternates study.

Applying the revised Site C Base Case general arrangement for the two dam cascade and Wilder Creek alternates results in changes to the physical impacts at each site, including:

- slightly increased local footprint areas;
- marginal reduction in total excavation volumes;
- marginal increase in earthfill volumes for the dam; and
- and increases in total concrete volumes.

Overall, no significant change to the project footprint area results at either of these alternate sites by adopting the revised Base Case general arrangement. These same physical impacts are experienced when applying the revised Site C

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Base Case general arrangement at site C3. This implies that although the physical impacts differ slightly for each alternate, the relative difference in project footprint at each site is not expected to change materially. The Wilder Creek energy cost ratio increased from 1.38 to 1. 43 as a result of the increased cost of the new general arrangement. With no effective change to Wilder Creek's footprint ratio, this alternate now becomes even less favourable due to the increased cost of energy, which now represents a loss of approximately $3.4 billion.

The energy cost ratio for the 7b/low C3 alternate reduced from 1.55 to 1.37 when considering the new general arrangement. While this indicates an improvement over the previous evaluated historical general arrangement, the 37% greater energy cost compared with the base case still represents a significant loss in value in the order of $2.9 billion. With no improved footprint ratio, this alternate does not provide any benefit over the single dam base case site C3 alternate.

The only impact that affects the physical, biological, or socio-economic environment is a negligible increase in the local dam footprint for some of the alternates examined under this evaluation. The benefits of the revised arrangement in terms of facility characteristics and functionality are consistent across all alternates and, therefore, do not yield an advantage to any one alternate.

The conclusion of this evaluation is that application of the updated general arrangement results in no change to the final opinion drawn from the alternates study, which is that the multi-attribute assessment confirms Site C (i.e., a single dam at site C3) to be the preferred site for the project.

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8. References

1) BC Hydro, “Peace River Site C Hydro Project, Site C Feasibility Review: Stage 1 Completion Report”, December 2007.

2) BC Hydro, “Project Description, Site C Clean Energy Project”, May 2011.

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FIGURES

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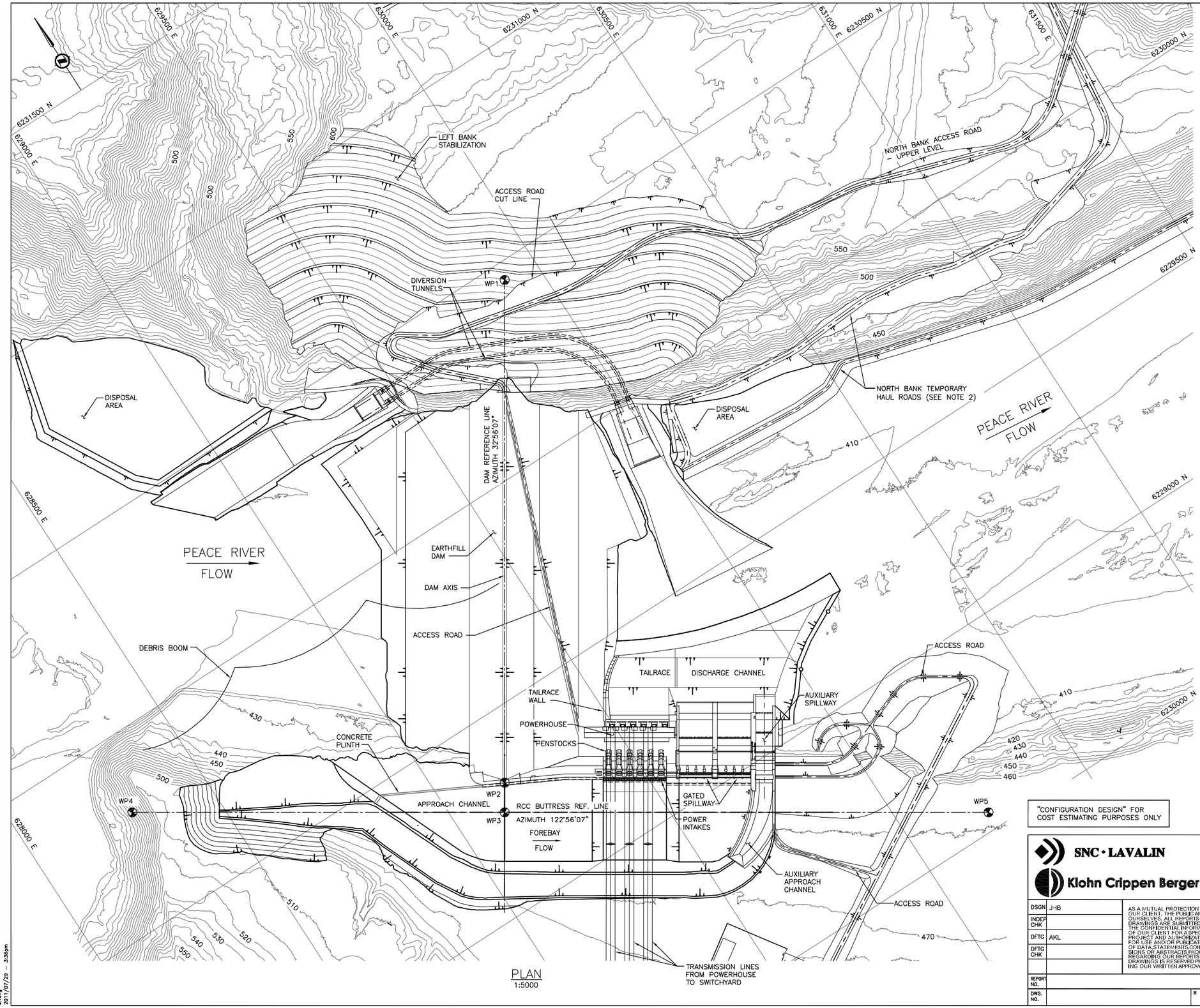

PLAN
1:5000

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METERS.
2. TEMPORARY HAUL ROADS TO BE USED DURING CONSTRUCTION. FOLLOWING CONSTRUCTION SITE ACCESS WILL BE VIA PERMANENT ACCESS ROADS ONLY.

REFERENCE POINTS		
WP#	NORTHING	EASTING
WP1	6230454.380	629904.840
WP2	6229320.457	629170.283
WP3	6229253.621	629126.987
WP4	6229797.312	628287.701
WP5	6228546.824	630218.058

"CONFIGURATION DESIGN" FOR COST ESTIMATING PURPOSES ONLY

0 250m
1:5000

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SITE C CLEAN ENERGY PROJECT

GENERAL ARRANGEMENT PLAN

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INDEP CHK		
DFTG	AKL	
DFTG CHK		
REPORT NO.		
DWG. NO.		R 0

DATE MARCH 2011	FIG NO FIGURE A1	
DWN	DWG NO	R 0

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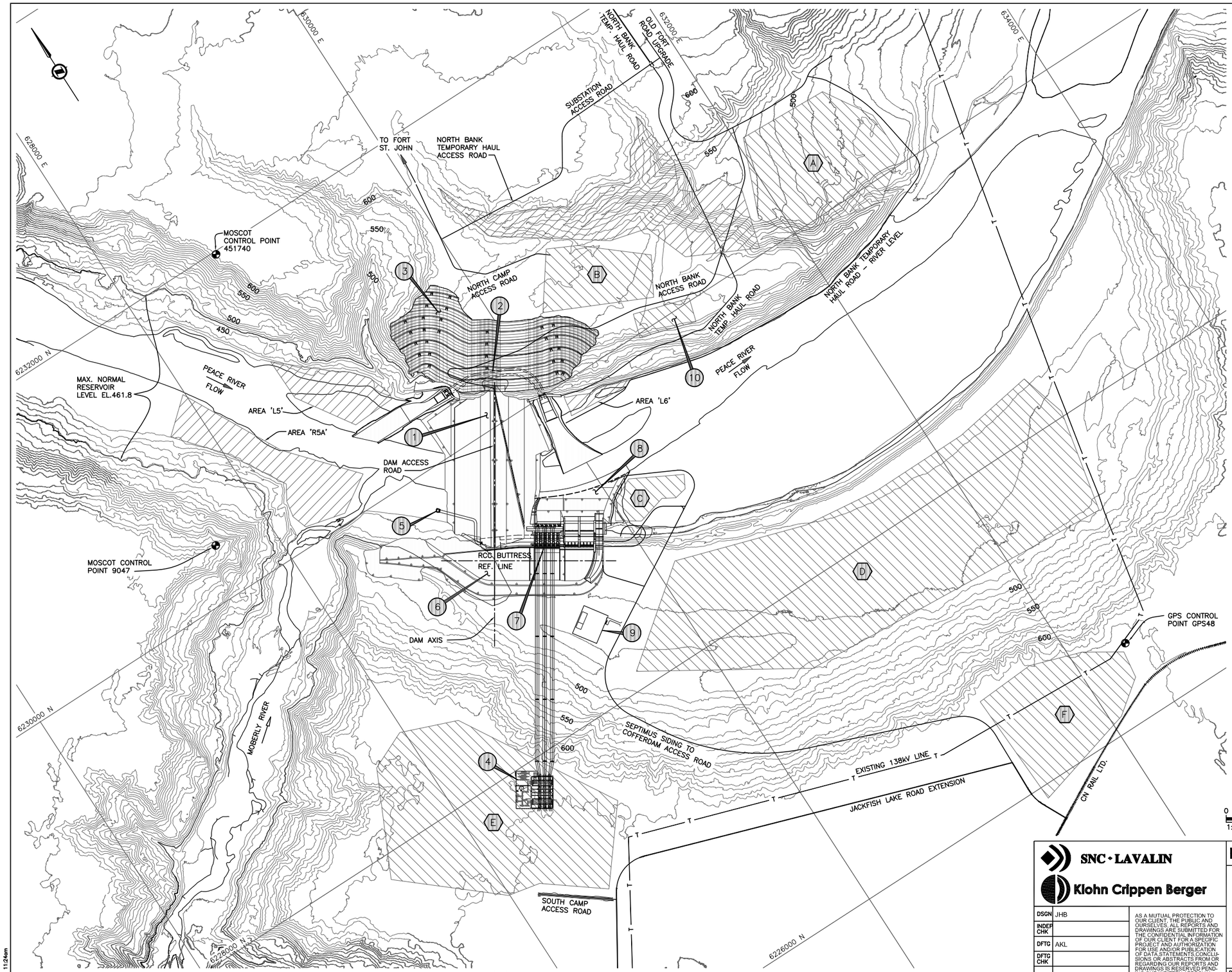

PLAN
1:12500

NOTES:

1. FOR GENERAL ARRANGEMENT SEE FIGURE A1.
2. TRANSMISSION LINE FROM SWITCHYARD TO PEACE CANYON NOT SHOWN FOR CLARITY.

REFERENCE CONTROL POINTS		
CONTROL POINTS	NORTHING	EASTING
MOSCOT – 451740	6231980.068	628678.624
MOSCOT – 9047	6230351.461	627620.811
GPS – GPS48	6226504.716	632360.661

LEGEND:

1. EARTHFILL DAM
2. DIVERSION TUNNELS
3. LEFT BANK STABILIZATION
4. SWITCHYARD
5. LOW LEVEL OUTLET INTAKE STRUCTURE
6. APPROACH CHANNEL
7. RIGHT BANK STRUCTURES
8. TAILRACE AND DISCHARGE CHANNELS
9. BC HYDRO WAREHOUSE
10. RECEPTION CENTER

FACILITIES AREAS:

- A – HOWE PIT – ZONE 2 – PROCESS PLANT – STAGING AREA, STORAGE
- B – LEFT BANK 500 MAN CAMP AND OFFICES
- C – PENSTOCK FABRICATION AREA
- D – RCC CONCRETE PLANT AND LAB – CEMENT FLY ASH STORAGE AREA – CRUSHER AGGREGATE STOCK PILE – CRUSHER SOURCE MATERIAL
- E – BC HYDRO OFFICES – FIRE STATION – MEDICAL SERVICE – RIGHT (SOUTH) CAMP 1500 MAN
- F – MATERIAL STORAGE

DISPOSAL / FILL AREAS

—T—T—T— EXISTING TRANSMISSION LINE

RAIL LINE

0 500m
1:12500

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CONSTRUCTION FACILITIES AREAS
GENERAL ARRANGEMENT
PLAN

DATE	MARCH 2011
FIG NO	FIGURE A2
DWN	
DWG NO	R 0

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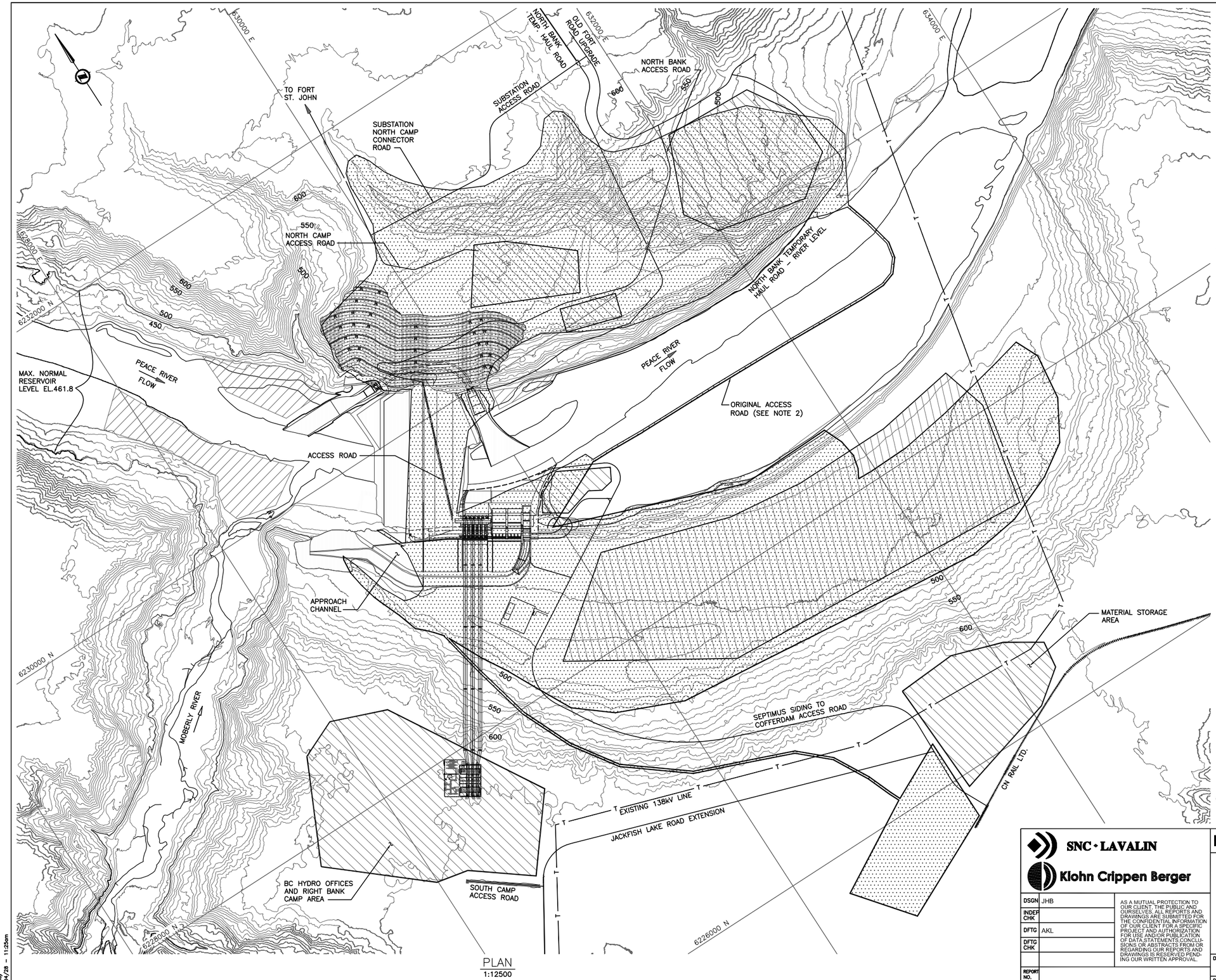

PLAN
1:12500

NOTES:

1. TRANSMISSION LINE FROM SWITCHYARD TO PEACE CANYON NOT SHOWN FOR CLARITY.
2. A PERMANENT ACCESS BRIDGE AND SOUTH BANK ACCESS ROAD ACROSS THE ISLAND WAS INCLUDED IN THE FOOTPRINT FOR THE ORIGINAL GENERAL ARRANGEMENT. THE BRIDGE AND ROAD ARE NOT REQUIRED FOR THE REVISED GENERAL ARRANGEMENT.

LEGEND:

- FACILITIES AREAS
- ORIGINAL ARRANGEMENT FOOTPRINT
- DISPOSAL / FILL AREAS
- —T—T—T— EXISTING TRANSMISSION LINE
- RAIL LINE

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RCC BUTTRESS FOOTPRINT COMPARISON
GENERAL ARRANGEMENT
PLAN

DATE	MARCH 2011
FIG NO	FIGURE A3
DWN	
DWG NO	R 0

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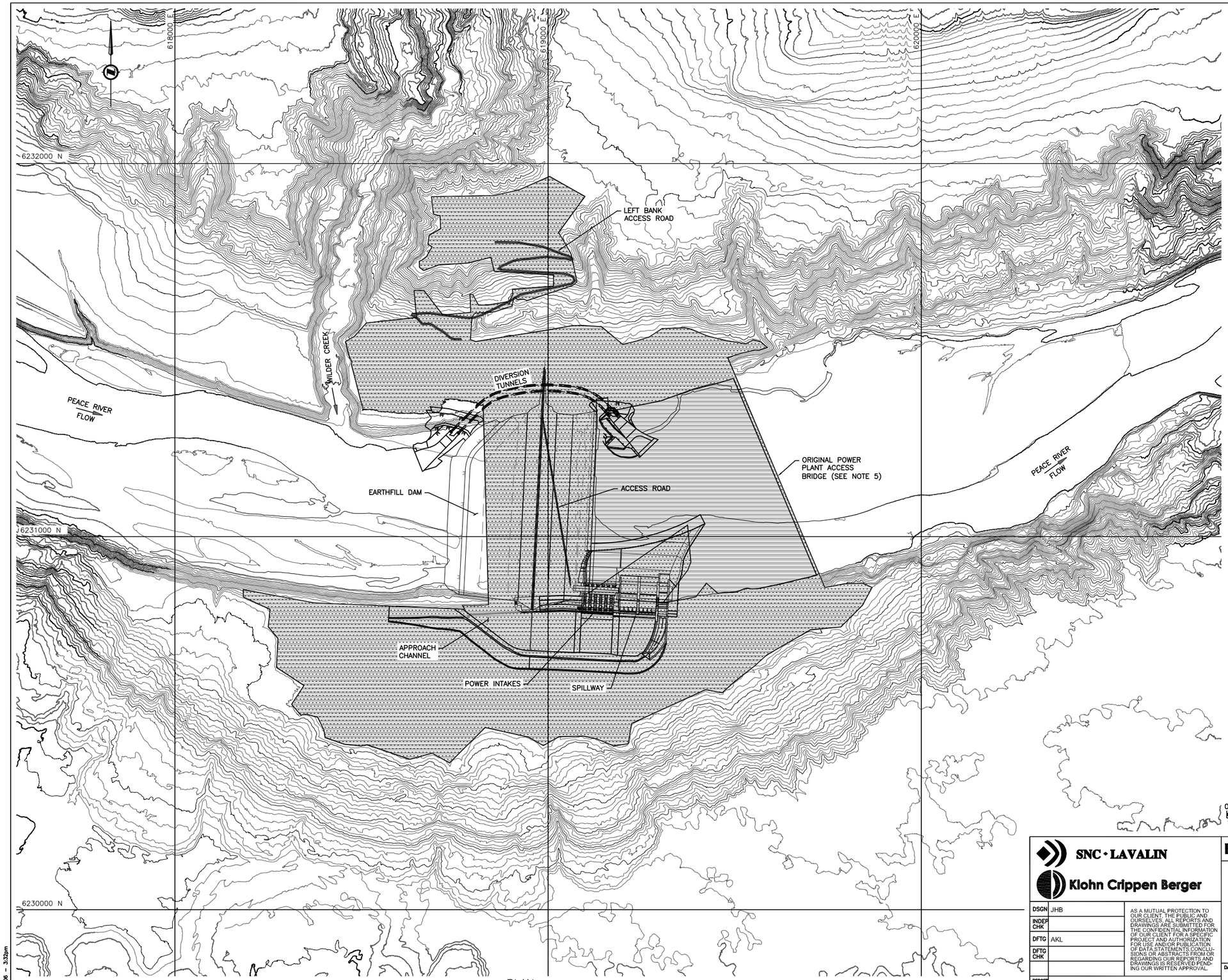

PLAN
1:10000

NOTES:

1. LAYOUT OF DAM, DIVERSION TUNNEL AND RIGHT BANK STRUCTURES ADOPTED AND MODIFIED FROM REFERENCE COST ESTIMATE REPORT FIGURE 3.
2. TOPOGRAPHY IS FROM 2008 LIDAR SURVEY PROVIDED BY BC HYDRO PHOTOGRAMETRY SERVICES.
3. GRID COORDINATES HAVE BEEN UPDATED TO NAD 83.
4. FOOTPRINT WAS ORIGINALLY DEFINED TO ALLOW FOR A MINIMUM OF 100ha ON THE LEFT BANK FOR LAYDOWN AND CAMP FACILITIES DURING CONSTRUCTION.
5. A PERMANENT ACCESS BRIDGE WAS INCLUDED IN THE FOOTPRINT FOR THE ORIGINAL GENERAL ARRANGEMENT. THIS BRIDGE IS NO LONGER REQUIRED FOR THE REVISED GENERAL ARRANGEMENT.

LEGEND:

ORIGINAL ARRANGEMENT FOOTPRINT (SEE NOTE 4)

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WILDER CREEK ALTERNATE GENERAL ARRANGEMENT

DATE	MARCH 2011	FIG NO	FIGURE A4
DWN		DWG NO	R 0

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