BC Hydro
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August 3, 2018

Canadian Environmental Assessment Agency
National Programs Division
160 Elgin Street
Ottawa, ON K1A 0H3

Attn: Nicolas Courville, Senior Enforcement Officer
Christie Nelson, Project Manager

Dear Nicolas Courville and Christie Nelson:

Re: Site C Project – Proposed Design Changes to the Halfway River Bridge Design

1. INTRODUCTION

On November 25, 2014, the Minister of the Environment issued a Decision Statement for the Site C Clean Energy Project setting out a description of the Project and the conditions under which the Project can be constructed and operated. The purposed of this letter is to inform you about proposed changes to the design of the Project with respect to the Halfway River realignment and specifically the bridge design described in Section 4.3 of the Environmental Impact Statement (EIS). Specifically, this letter describes:

- The difference between the EIS bridge design and the proposed modified design
- The impact of the modified design to relevant valued components as assessed in the EIS
- Studies on the design submitted during the environmental assessment
- Indigenous group consultation on the proposed amendments
- Government approvals related to the proposed amendments

Figure 1 attached in Appendix A shows the location of the Halfway River realignment and bridge crossing. The design of the Halfway River Bridge has evolved since issuance of the EIS in order to improve the safety and stability of the bridge in light of geotechnical conditions associated with the crossing. Overall, the proposed design changes are not expected to cause any adverse effects on valued components beyond the effects that were considered during the environmental assessment of the Project. The proposed changes are expected to provide several benefits, including increased safety and stability of the bridge, and a smaller overall riparian and terrestrial footprint of the Halfway River crossing.

2. PROPOSED MODIFICATIONS TO THE EIS

Table 1 summarizes the revisions to the design described in the EIS. Please refer to Appendix B, Proposed Modifications to EIS Section 4.3, for a redline version of the changes summarized in Table 1.

Table 1. EIS Halfway River Bridge Design Compared to Proposed Design Changes

Component	Statement Text from EIS	Revision to EIS Text
Highway 29 Realignment	Section 4.3.4.1, Table 4.5: Highway 29 Realignment Segments and Respective Watercourse Crossing Lengths For Halfway River: Total Length of Segment: 4.0 km Causeway Length: 640 m Bridge Length: 305 m Number of Piers: 3 Number of Bridge Spans: 4 Figure Number 4.32 Rev 0	Section 4.3.4.1, Table 4.5: Highway 29 Realignment Segments and Respective Watercourse Crossing Lengths For Halfway River:* Total Length of Segment: **3.7 km** Causeway Length: 0 m Bridge Length**: 1,042 m** Number of Piers: **12** Number of Bridge Spans: **13** Figure Number **4.32 Rev 2**

*__Note: the parameters for the Halfway River Bridge design are based on a conceptual design and are subject to change.__

3. COMPARISON OF EIS DESCRIPTION TO MODIFICATION

As described in Section 4.3.4.2 of the EIS, a number of highway alignment alternatives were assessed for each of the Highway 29 realignment segments. Each alternative was evaluated in terms of relative safety, environmental effects (including those on fish, wildlife, and habitat), social effects (including those on property, heritage, and agriculture), and costs. Each alignment also had two options for crossing of the respective watercourses: (a) a short bridge plus a causeway or (b) a long bridge. At the time of the environmental assessment, the Ministry of Transportation and Infrastructure preferred the short bridge option due to lower long-term maintenance costs. The design described in the EIS therefore reflects a Halfway River Bridge crossing with a causeway of 640 m and a bridge length of 305 m.

Since the EIS was issued, BC Hydro and its design engineering teams have continued to work on the design of the Highway 29 realignments. In the spring of 2017, BC Hydro undertook geotechnical investigations to obtain additional information on site conditions. These investigations indicated that there is a zone of highly weathered shale between gravel and shale bedrock at the Halfway River crossing. Through a slope stability analysis, geotechnical engineers determined that the presence of this weathered shale layer would significantly impact the stability of the causeway embankment that was previously designed. Alternate designs were explored, including flattening the slopes of the causeway to increase stability, but these were found to be not viable due to costs, potential lack of locally-available borrow and granular material, and schedule impacts associated with the increased causeway footprint fills and poor ground conditions. In the fall of 2018, BC Hydro determined that the most cost effective alternative was to eliminate the causeway altogether and to pursue a long bridge option, with conceptual parameters as described in Table 1: a bridge 1,042 m in length, no causeway, and a total of 12 piers. As indicated in their December 6, 2017 letter to BC Hydro, the Ministry of Transportation and Infrastructure endorses this revised conceptual design (see Appendix C).

All figures are provided in Appendix A. Figure 2 shows the general arrangement of the Halfway River Bridge, per EIS Section 4 (Figure 4.32, Rev. 0). Figure 3 shows the general arrangement of the proposed modified Halfway River Bridge (Figure 4.32, Rev 2). Figures 4 and 5 show the bridge profiles of the EIS design and the proposed modified design respectively.

4. EFFECT OF THE REVISED HALFWAY RIVER BRIDGE DESIGN ON THE PROJECT DESCRIPTION IN THE DECISION STATEMENT

The Project Description in the Decision Statement focuses on the components of the Project:

> "BC Hydro and Power Authority (the Proponent) proposes to construct and operate a dam and 1,100-megawatt hydroelectric generating station on the Peace River in northeastern British Columbia. The Site C Clean Energy Project (the Designated Project) would be the third in a series of dams on the Peace River in British Columbia. The project components would consist of an earthfill dam 1,050 metres long and 60 metres high, a 1,100-megawatt generating station and associated structures, a 83-kilometre long reservoir, realignment of four sections of Highway 29, and two 77-kilometre transmission lines along an existing transmission line right-of-way connecting Site C to Peace Canyon."

No changes to the Project Description in the Decision Statement will be required as a result of the Halfway River Bridge design changes.

5. EFFECT OF THE REVISED HALFWAY RIVER BRIDGE DESIGN ON DECISION STATEMENT CONDITIONS

The differences between the proposed modified design and the approved design in the EIS are not anticipated to cause any adverse effects on valued components beyond the effects that were considered during the environmental assessment of the Project. For this assessment, the following valued components were reviewed and are described below: fish and fish habitat, vegetation and ecological communities, wildlife resources, harvest of fish and wildlife resources, current use of lands and resources for traditional purposes and heritage resources. The assessment is supported by information in Figures 6 and 7, which compare the footprint and environmental features that are affected by the EIS bridge design versus the proposed modified design. These valued components are reflected in six Decision Statement Conditions:

- Condition 8 – fish and fish habitat
- Condition 9 – disturbance and destruction of migratory birds
- Condition 10 – non-wetland migratory bird habitat
- Condition 11 – Wetlands used by migratory birds and for current use of lands and resources for traditional purposes.
- Condition 14 – current use of land and resources for traditional purposes
- Condition 15 – archaeological and heritage resources
- Condition 16 – species at risk, at risk and sensitive ecological communities and rare plants

Fish and Fish Habitat (Condition 8)

The proposed modification to the Halfway River Bridge design is not expected to cause any additional effects on fish and fish habitat beyond those predicted in the EIS. As shown in Figures 6 and 7, the 640 m causeway per the EIS design will be replaced by piers in the proposed modified design, resulting in a smaller overall riparian and terrestrial footprint of the Halfway River crossing.

Final design details are pending for the proposed modified bridge. It is not anticipated that instream disturbances associated with the piers in the modified design will exceed those that have been assessed for the EIS design. A detailed assessment of the instream impacts of the piers per the final bridge design will be undertaken by a qualified environmental professional prior to construction of the bridge, in accordance with the federal *Fisheries Act*.

Vegetation and Ecological Communities and Wildlife Resources (Conditions 9, 10, 11, and 16)

The proposed modification to the Halfway River Bridge design is not expected to cause any additional effects on vegetation and ecological communities or wildlife resources beyond those predicted in the EIS. As shown in Figures 6 and 7, the 640 m causeway per the EIS design will be replaced by piers in the proposed modified design, resulting in a smaller overall riparian and terrestrial footprint of the Halfway River crossing. Therefore, no additional impact on sensitive ecological communities or wildlife habitat is anticipated beyond what has been assessed in the EIS.

Harvest of Fish and Wildlife Resources (Condition 14)

Project effects on the harvest of fish and wildlife resources were assessed in the EIS by considering Project changes to the use of and access to hunting, fishing, trapping, and guide outfitter areas, tenure areas, or the availability of harvested species based on the results of the assessment of the Project on fish and wildlife resources. Because the proposed modified design of the Halfway River Bridge will not result in any additional effects on fish and fish habitat, vegetation and ecological communities, and wildlife resources, it is not expected to cause any additional effects on the harvest of fish and wildlife resources beyond those predicted in the EIS.

Current Use of Lands and Resources for Traditional Purposes (Condition 14)

Project effects on Current Use of Lands and Resources for Traditional Purposes were assessed in the EIS by considering Project changes to current use of lands and resources for hunting, fishing and trapping activities, as well as current use of lands and resources for activities other than hunting, fishing and trapping by Aboriginal groups. Because the modified design of the Halfway River Bridge will result in reduced interactions with fish and fish habitat, and will not result in any additional effects on vegetation and ecological communities and wildlife resources, it is not expected to cause any additional effects on the current use of lands and resources beyond those predicted in the EIS.

Heritage Resources (Condition 15)

The proposed modification to the Halfway River Bridge design is not expected to cause any additional effects on heritage resources because the footprint for the new design is almost entirely contained within the footprint of the original design, and the majority of this area was already considered and assessed in the EIS.

The east side of the proposed bridge may encroach on a small portion of an archaeological site HbRi-33 that was previously outside of the footprint (Figure 7). This overlap may result in the need for approximately 10 additional shovel tests, the result of which could trigger a recommendation for further shovel testing or archaeological excavations at the location. This work would be undertaken with participation of Indigenous groups and any archeological finds managed as required under the applicable Acts and Site C Heritage Program.

6. RELATED STUDIES SUBMITTED DURING THE ENVIRONMENTAL ASSESSMENT

The following EIS sections refer to the Halfway River Bridge design.

- Section 12.4.3 Effects Assessment – Construction – Fish Health and Survival
    - Section 12.4.3.1 Changes in Fish Health and Survival Due to Sediment Inputs
        - Highway 29 Realignment and Hudson's Hope Shoreline Protection

No other valued component assessments contain specific references to the Halfway River Bridge design.

7. PROVINCIAL ENVIRONMENTAL ASSESSMENT CERTIFICATE

In addition to the federal Decision Statement authorizing the Site C Project, the Halfway River Bridge is authorized under provincial Environmental Assessment Certificate (EAC) #14-02. The EAC includes Project design elements. As such BC Hydro is currently seeking an amendment to EAC #14-02 to reflect the changes to the Halfway River bridge design.

7. INDIGENOUS GROUP CONSULTATION/ENGAGEMENT

<u>Environmental Assessment</u>

During the environmental assessment process for the project, Indigenous groups, through traditional land use studies, identified concerns regarding potential effects of the Highway 29 realignment and replacement bridge at Halfway River related to impacts on fishing sites, cultural sites, sacred sites and potential burials. Comments provided by Indigenous groups on the Environmental Impact Statement, and BC Hydro's responses, are available on the EAO's website for the project.[1]

BC Hydro has invited Indigenous groups to ground truth Highway 29 realignment areas, including Halfway River and we will continue to work with interested Indigenous groups in this area with the goal of mitigating any site-specific concerns.

[1] The table of Information Requests from Indigenous groups and BC Hydro's responses can be found at https://projects.eao.gov.bc.ca/api/document/5887e157d876de1347b51259/fetch

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EAC Amendment Request

BC Hydro's draft request to the Environmental Assessment Office to amend Section 4.3.4.1, Table 4.5 of the EAC Schedule A (which are the same as Section 4.3.4.1, Table 4.5 of the EIS) was provided to the following Indigenous groups on July 6, 2018: Blueberry River First Nation, Dene Tha' First Nation, Doig River First Nation, Duncan's First Nation, Fort Nelson First Nation, Halfway River First Nation, Horse Lake First Nation, McLeod Lake Indian Band, Saulteau First Nations, and Nun wa dee (representing Prophet River First Nation and West Moberly First Nations), Kelly Lake Métis Settlement Society and Métis Nation British Columbia. BC Hydro requested that Indigenous groups provide comments by July 18, 2018 and offered to meet to review the draft amendment request. Indigenous groups were advised that their input would inform the final amendment request to be submitted by end of July 2018. No comments were received from Indigenous groups on the draft requested amendment.

Regulatory and compliance matters for BC Hydro's northeast projects (including Site C) are discussed during regular/monthly meetings with some BC Treaty 8 First Nations. Upon request, the Halfway River Bridge EAC/EIS amendment will also be introduced and discussed at meetings scheduled for September 2018. The Halfway River Bridge EIS amendment application will also be presented to Treaty 8 First Nations at the Site C Permitting Forum #10 in September 2018.

8. GOVERNMENT APPROVALS/ENDORSEMENTS

BC Hydro will be submitting applications for the following permits and approvals related to the Highway 29 realignment at Halfway River:

- *Land Act* Licence of Occupation (planned application date July 2018)
- *Forest Act* Occupant Licence to Cut (planned application date July 2018)
- *Water Sustainability Act* Section 11 Approval for instream works (planned application date July 2018)
- *Navigation Protection Act* Approval or Notice of Work (planned application date July 2018)

In addition, an assessment by a Qualified Environmental Professional of potential impacts to fish and fish habitat will be undertaken in accordance with the federal *Fisheries Act.*

9. ATTACHMENTS

Appendix A: Figures

- Figure 1: Location of Halfway River Highway 29 realignment segment
- Figure 2: General arrangement of Highway 29 realignment segment at Halfway River, per Section 4.3 (Figure 4.32 Rev 0)
- Figure 3: General arrangement of Highway 29 realignment segment at Halfway River, per proposed modified design (proposed Figure 4.32 Rev 2).
- Figure 4: Profile of Halfway River Bridge, per EIS (not to scale)
- Figure 5: Profile of Halfway River Bridge, per proposed modified design (not to scale)
- Figure 6: Halfway River Bridge - EIS Design versus Modified Design
- Figure 7: Halfway River Bridge - EIS Design versus Modified Design and Environmental Features

Appendix B: Proposed Modifications to EIS

- EIS Section 4.3 showing the changes proposed by this amendment in redline.

Appendix C: Letter

- Letter of endorsement from Ministry of Transportation and Infrastructure, dated December 6, 2017, for modified Halfway River Bridge design

10. CLOSURE

I trust this submission provides useful information regarding BC Hydro's proposed changes to Section 4.3.4.1, Table 4.5 of the EIS. We look forward to discussing these changes with you further. In the meantime, please don't hesitate to contact me at 604-695-5204 if you have any questions or comments.

Regards,
<Original signed by>

Karen von Muehldorfer
Regulatory Manager
Site C Clean Energy Project
Karen.vonMuehldorfer@bchydro.com

Cc: Shanna Mason, Environment, Permitting and Community Benefits Director, BC Hydro

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APPENDIX A: FIGURES

- Figure 1: Location of Halfway River Highway 29 realignment segment
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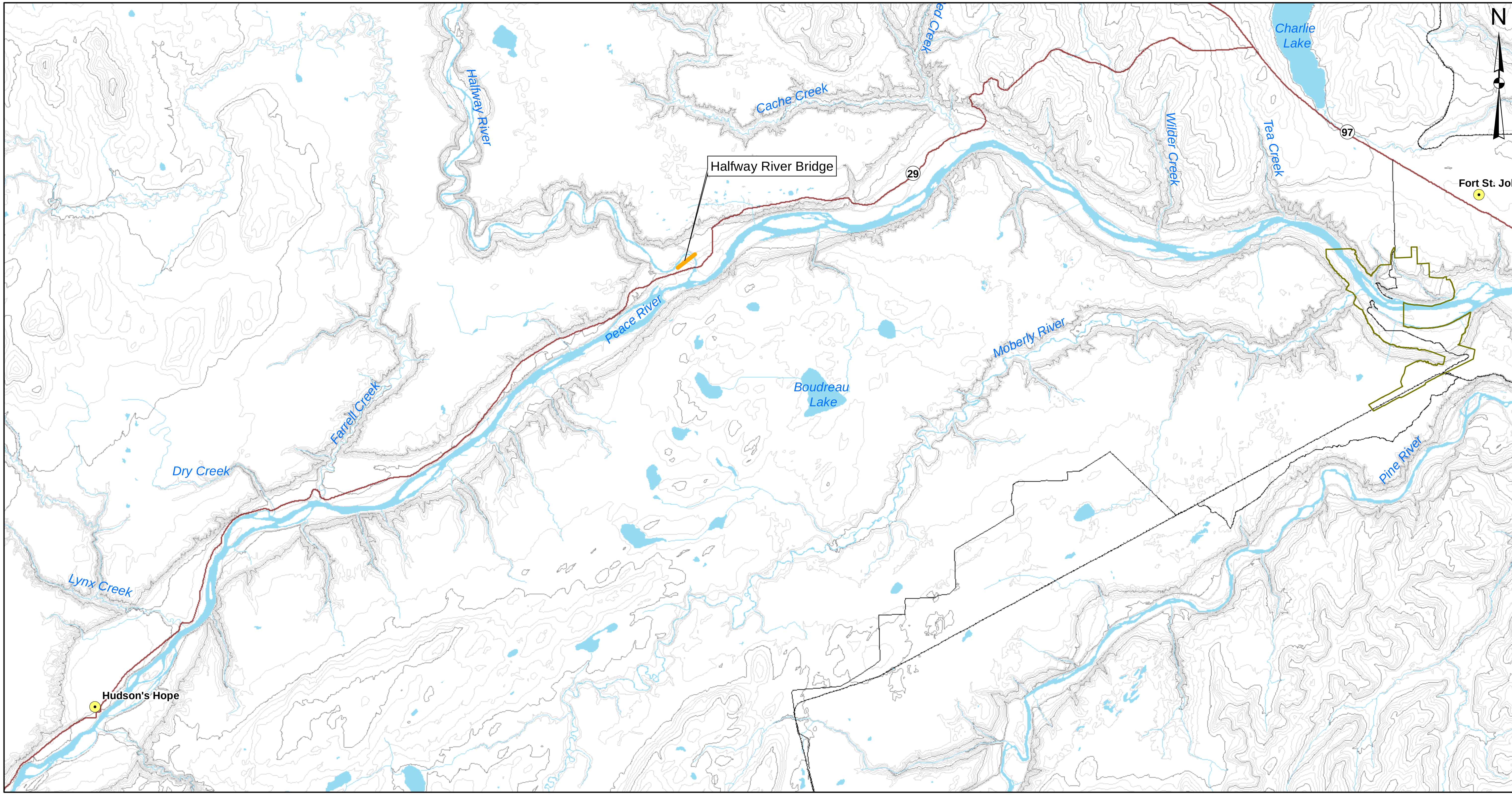
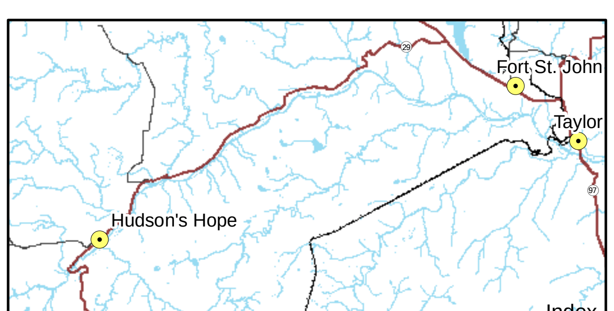
- Figure 7: Halfway River Bridge - EIS Design versus Modified Design and Environmental Features

Figure 1: Location of Halfway River Highway 29 realignment segment





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.

Legend

- Proposed Bridge
- Dam Site Area
- Existing Highway
- Existing Access Roads
- Railway
- Index Contour (100m)
- Intermediate (20m)

1:180,000 0 5 km

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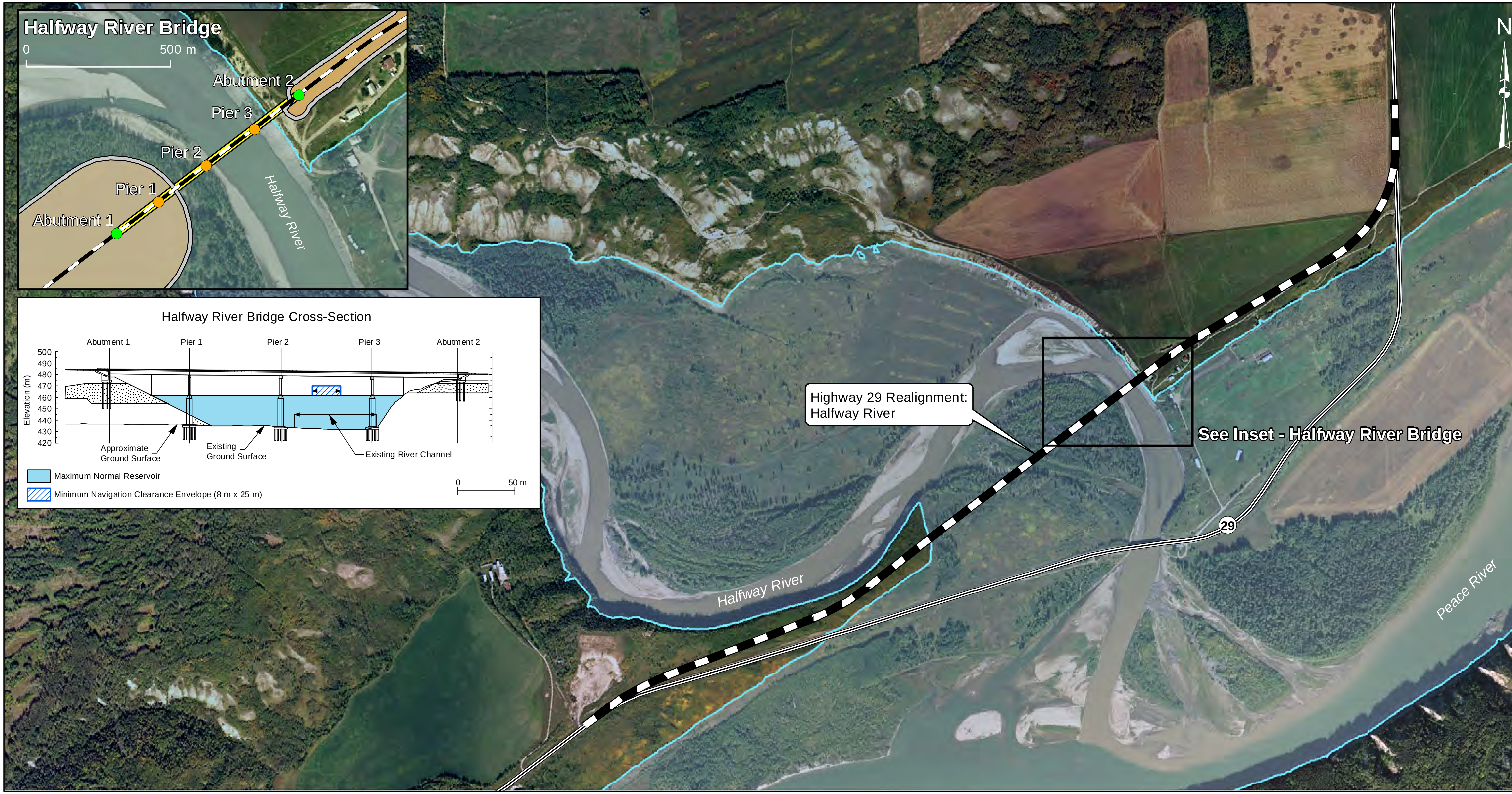
Figure 1 - Halfway River Bridge Location

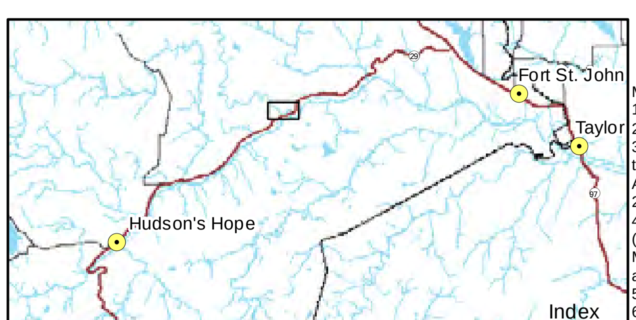
Date	Jun 26, 2018	DWG NO	1016-N11-00014	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

Path: X:\ArcGIS\Projects\Regulatory\HalfwayRiver_Bridge_Location_1016-N11-00014.mxd

Figure 2: General arrangement of Highway 29 realignment segment at Halfway River, per EIS Design (Figure 4.32 Rev 0)





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Orthophotos created from 1:40,000 photos taken Sept10th 2007; 1:15,000 photos taken Aug 26, 2011; 1:5,000 photos taken Aug 26, 2011; TRIM
4. Proposed maximum normal reservoir level (full supply level-461.8 m) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/Aug 2006.
5. Realignments subject to change.
6. Reservoir elevation = 461.8 m does not consider realignments.

Legend

- Highway 29 Realignment
- Proposed Bridge
- Road Embankment
- Pier
- Abutment
- Maximum Normal Reservoir Level (461.8 m)
- Existing Highway 29

1:13,000 0 0.5 km

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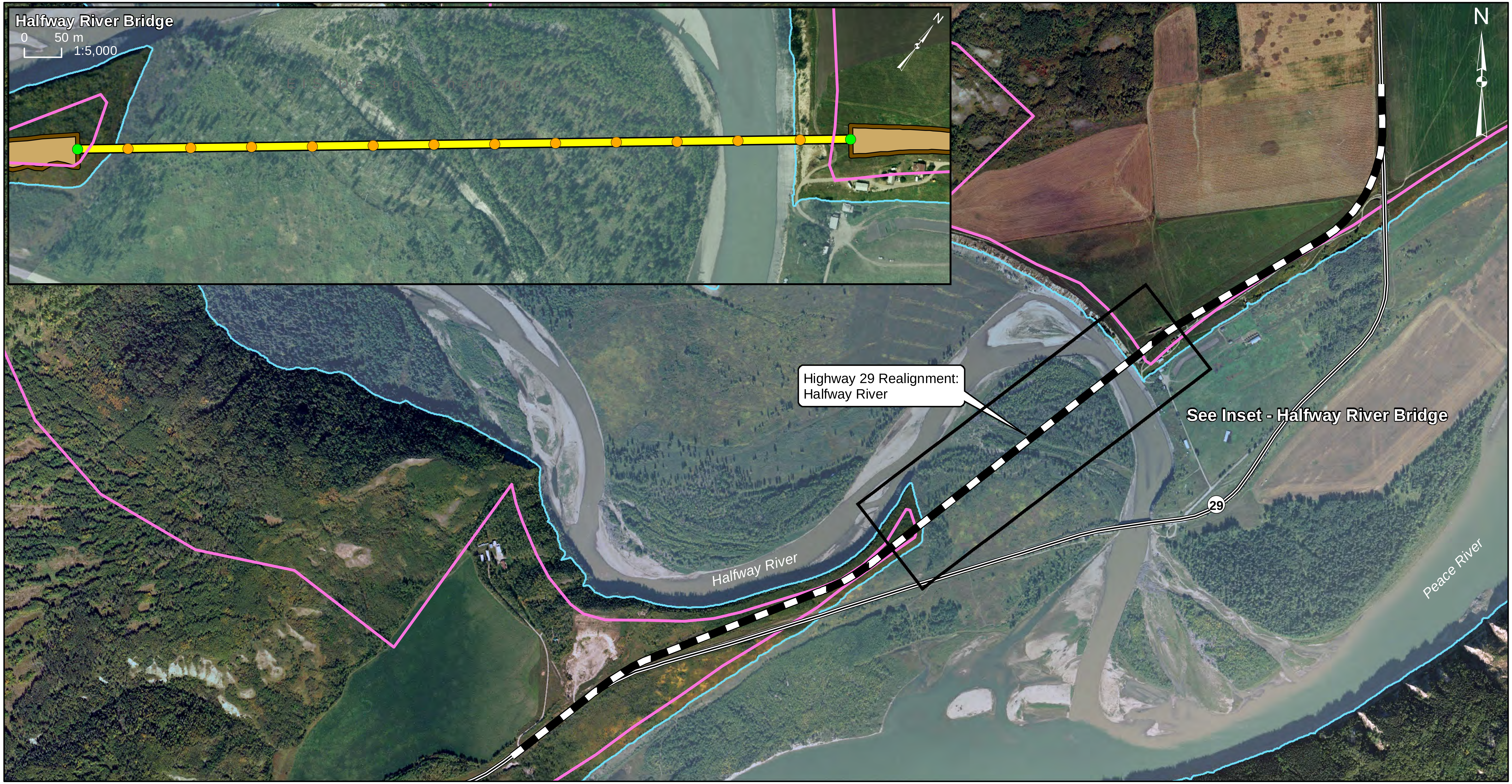
SITE C CLEAN ENERGY PROJECT

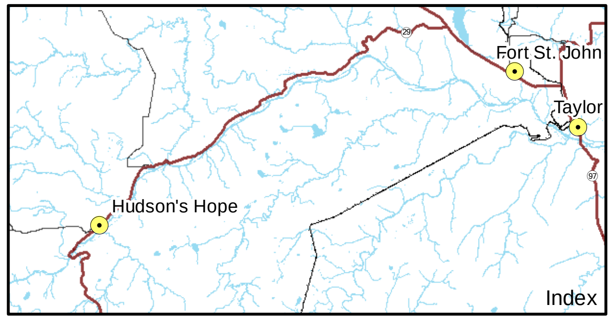
Figure 4.32
General arrangement of Highway 29 realignment segment at Halfway River

Date	Nov. 23, 2012	DWG NO	1016-C14-B6158-18	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification

Figure 3: General arrangement of Highway 29 realignment segment at Halfway River, per proposed modified design (Proposed Figure 4.32 Rev 2)





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Orthophotos created from 1:40,000 photos taken Sept. 10th 2007.
5. Proposed reservoir area (461.8m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August, 2006.
6. Realignments subject to change.
7. Reservoir elevation = 461.8 m does not consider realignments.
8. Preliminary Stability Impact Line placement is subject to final highway design.

Legend

- Highway 29 Realignment
- Proposed Bridge
- Road Embankment
- Pier
- Abutment
- Maximum Normal Reservoir Level (461.8 m)
- Preliminary Stability Impact Line
- Existing Highway 29

1:13,000

0 650 m

BC Hydro

Figure 4.32
General arrangement of Highway 29 realignment segment at Halfway River

Date	Jul 19, 2018	DWG NO	1016-C14-B6158-18	R 2

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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Figure 4: Profile of Halfway River Bridge, per EIS Design (not to scale)

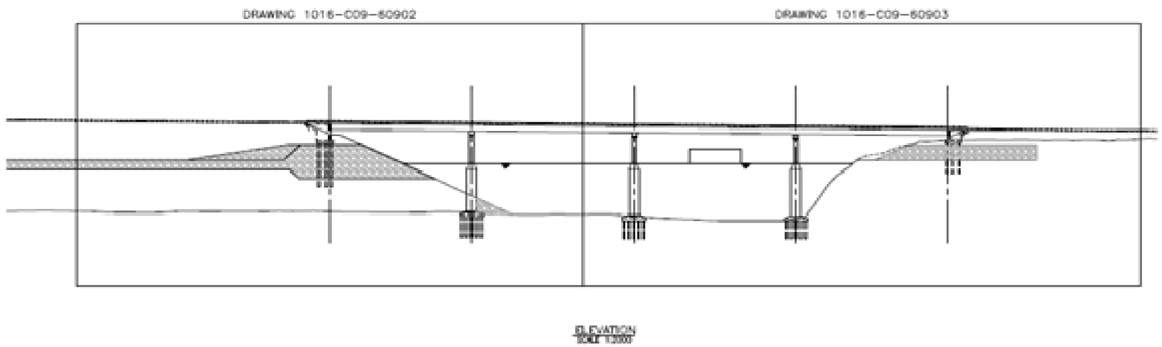


Figure 5: Profile of Halfway River Bridge, per proposed modified design (not to scale)

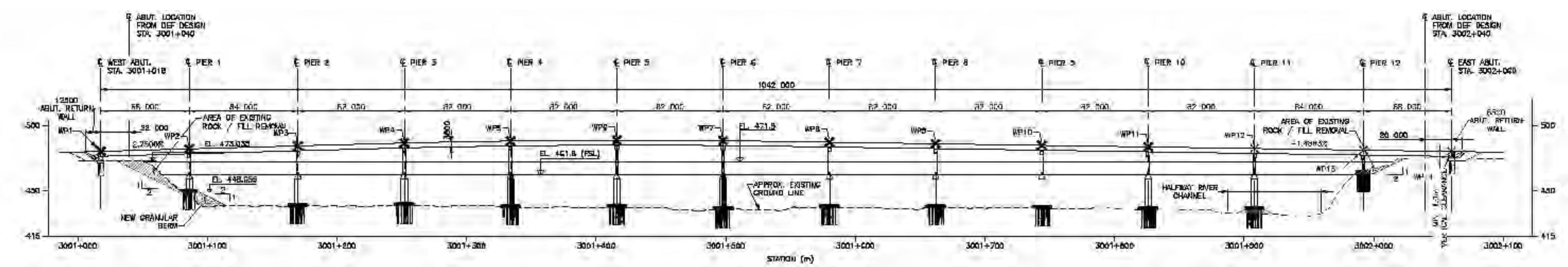
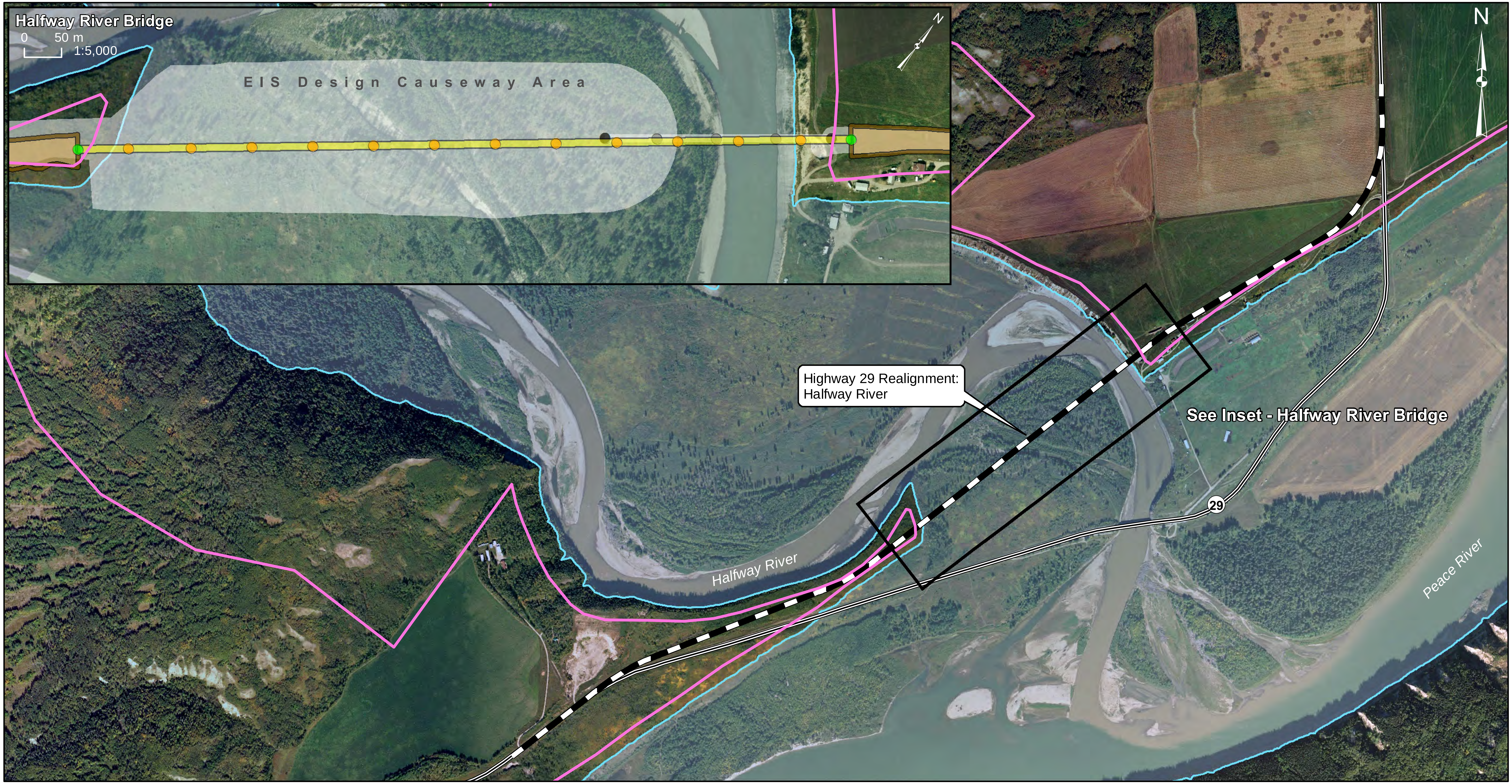
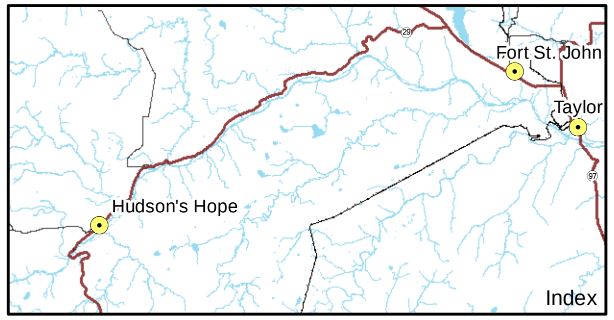


Figure 6: Halfway River Bridge - EIS Design versus Modified Design



1:13,000

0 650 m



Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Orthophotos created from 1:40,000 photos taken Sept. 10th 2007.
5. Proposed reservoir area (461.8m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August, 2006.
6. Realignments subject to change.
7. Reservoir elevation = 461.8 m does not consider realignments.
8. Preliminary Stability Impact Line placement is subject to final highway design.

Legend

- Highway 29 Realignment
- Proposed Bridge
- Road Embankment
- Pier
- Abutment
- Pier (EAC Design)
- Abutment (EAC Design)
- Footprint/Toes (EAC Design)
- Preliminary Stability Impact Line

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Highway 29 Realignment – Halfway River Bridge
EAC Schedule A Design versus Modified Design

Date	Jul 19, 2018	DWG NO	1016-N11-00005	R 1

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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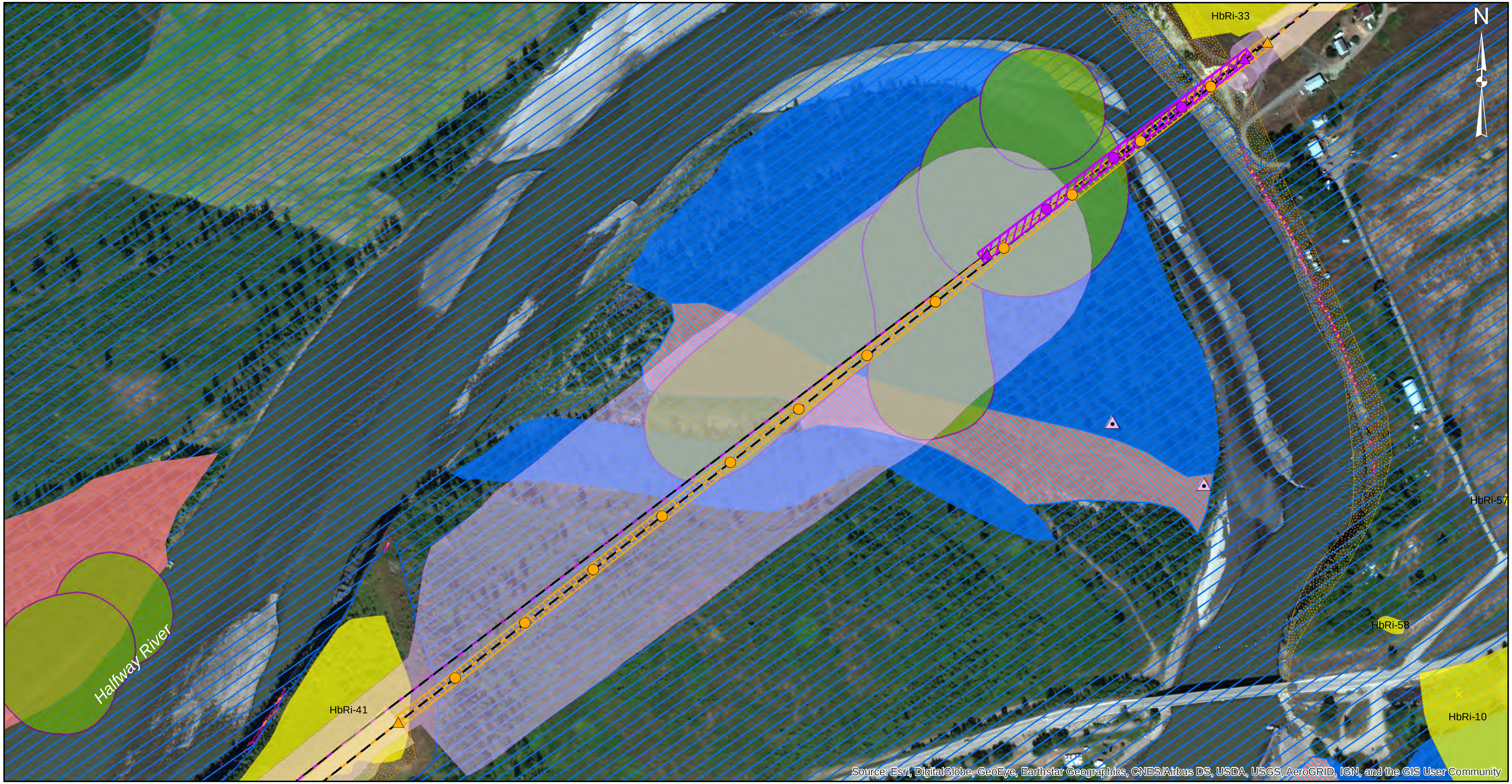
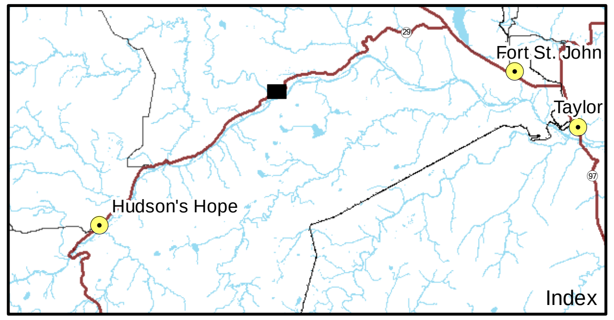
Figure 7: Halfway River Bridge -- EIS Design versus Modified Design and Environmental Features





Legend

Maximum Normal Reservoir Level (461.8 m)

Modified Design
- Pier
- Abutment
- Bridge
- Centerline
- Pier Cap
- Road Embankment

EAC Schedule A Design
- Pier
- Abutment
- Bridge
- Centerline
- Pier Cap
- Road Embankment

- Beaver Lodge/Bank Den
- Potential Bank Swallow Habitat
- Noxious Weed
- Rare Plants
- Grasslands
- Wetlands
- Blue Listed Ecosystem
- Red Listed Ecosystem
- Archaeological Site

Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Imagery: ESRI Online Base Mapping
5. Proposed reservoir area (461.8m maximum normal elevation) from Digital Elevation Models (DEM) generated from LiDAR data acquired July/August, 2006.
6. Functional Design is subject to change though Detailed Design.

1:3,500 — 0 25 50 100 150 200 m

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Highway 29 Realignment - Halfway River Bridge EAC Schedule A Design versus Modified Design and Environmental Features

Date	Jun 27, 2018	DWG NO	1016-C14-10311-2	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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APPENDIX B: PROPOSED MODIFICATIONS TO EIS SECTION 4.3

Complete EIS Section 4.3 showing the changes proposed by this amendment in redline.

The transmission line right-of-way requirements were reduced by changing the design and the sequencing of construction of the two 500 kV transmission lines so that the two existing 138 kV transmission lines could be removed. This sequencing is described in Section 4.3.3; however, the effects assessment is based on the greater width of right-of-way.

The capacity of the Stage 2 diversion works described in Section 4.4.3 was increased by increasing the diameter of the diversion tunnels. Volume 2 Section 11.4 Surface Water Regime describes the changes to upstream and downstream water levels during Stage 2 diversion based on the smaller diameter tunnels. The effects assessment is based on the changes described in Volume 2 Section 11.4 Surface Water Regime, except that the description of the effects of the environment on the Project contained in Volume 5 Section 37 Requirements for the Federal Environmental Assessment is based on the larger diameter tunnels.

4.3 Project Components

The components of the Project are:

- Dam, generating station, and spillways
- Reservoir
- Substation and transmission lines to Peace Canyon Dam
- Highway 29 realignment
- Quarried and excavated construction materials
- Worker accommodation
- Road and rail access

These components are described in the following subsections. Design and planning of the Project have continued since submission of the Project Description Report (BC Hydro 2011). The descriptions provided below supersede the descriptions contained in the Project Description Report (BC Hydro 2011). The locations of the Project components and activities are shown in Figure 4.11.

Alternative means of carrying out the Project are described in Volume 1 Section 6.0 Alternative means of Carrying out the Project. Alternatives that were considered for some of the Project components are described in the following subsections.

4.3.1 Dam, Generating Station, and Spillways

The general arrangement of the dam, generating station, and spillways is shown in Figure 4.12 and an artist's rendition is shown in Figure 4.13.

From north to south, the main components of the dam, generating station, and spillways are:

- The left (north) bank stabilization, a large excavation to remove unstable materials from the bank above the earthfill dam and flatten the slope for long-term stability
- Two diversion tunnels used for river diversion during construction

- The earthfill dam across the river valley abutting onto bedrock on the north bank and a buttress of roller compacted concrete (RCC) on the south bank
- The RCC buttress that would support the south wall of the valley and provide an abutment for the earthfill dam and the foundation for the generating station and spillways
- The generating station, consisting of power intakes, penstocks (large pipes that convey the water from the intakes to the powerhouse) and powerhouse
- A spillway with three radial gates, six low level outlets, and a free overflow auxiliary spillway to discharge inflows that exceed the capacity of the generating station
- A lined approach channel to convey water from the reservoir to the power intakes and the spillways
- Three 500 kV transmission lines to conduct electricity from the generating station to the substation and transmission lines, which would connect the Project to the bulk transmission system at Peace Canyon Dam

The earthfill dam, RCC buttress, power intakes, spillway headworks and associated training walls would impound the reservoir. These structures would be designed and constructed to international and Canadian standards to withstand the normal loads (including self-weight, reservoir and tailwater loads; internal water pressures due to seepage, ice, temperatures; and the interaction between the bedrock and the structures, as well as loads resulting from extreme floods and earthquakes).

An understanding of the consequences of dam failure underlies several principles in the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2007) and is used to establish two principle design criteria, the inflow design flood, and the earthquake design ground motion. BC Hydro has adopted the highest dam classification for Site C. This results in the highest standard for the inflow design flood and earthquake design ground motion.

The inflow design flood adopted for Site C is the probable maximum flood, which is defined as the most severe flood that may reasonably be expected to occur at a particular location. Derivation of the probable maximum flood is described in Volume 5 Section 37 Requirements for the Federal Environmental Assessment.

The earthquake design ground motion adopted for Site C has an annual exceedance frequency of 1 in 10,000. Volume 2 Section 11.2 Geology, Terrain, and Soils provides information on the regional and site-specific seismic hazard assessment.

4.3.1.1 Earthfill Dam

4.3.1.1.1 General Description

An earthfill dam has been selected as the best dam type for the geological conditions at Site C. A cross-section of the earthfill dam is shown in Figure 4.14. The design of the earthfill dam is conventional and there are many precedents around the world. In fact, the International Commission on Large Dams' World Register of Dams (ICOLD 2011) lists 443 earthfill dams with heights equal to or greater than the height of the proposed earthfill dam at Site C. The design and performance of earthfill dams is well understood. The dam would have a central impervious core with filters on each side of the core, gravel drains on the downstream side of the core and outer shells of sands and gravels. The characteristics of the materials used to construct the dam are described in Section 4.3.1.1.2.

Weathered rock and colluvium would be removed from the abutments of the dam. In the riverbed, the shells of the dam would be founded on alluvium that overlies bedrock on the floor of the valley. The impervious core would be founded in a core trench excavated into the shale bedrock. Cement grout would be pumped into a curtain of closely spaced holes drilled along the floor of the core trench to a depth of about 20 m in the riverbed and about 30 m in the north abutment to seal joints and other discontinuities.

Table 4.2 lists some earthfill dams that have been constructed on bedrock with similar characteristics as the bedrock at Site C. Two of these dams, Mangla and Karkeh, are located in highly seismic areas and have a maximum design earthquake (MDE) of 0.4 g compared to 0.25 g at Site C.

Table 4.2 Earthfill Dams Built on Bedrock Similar to Site C

Name (Country)	Year Constructed	Height (m)	Foundation
Bath County Upper Dam (USA)	1985	146	Shale interbedded with sandstone and siltstone
Mangla Dam (Pakistan)	1967	136	Claystone and siltstone of Siwalik (fresh water deposited) formations with bedding planes up to 1 m thick and bentonite seams. Strength of claystone very similar to shale at Site C.
Karkheh Dam (Iran)	2000	128	Shale
Ramganga Dam (India)	1970	126	Siwalik formation with alternate bands of shale and sandstone with occasional thin bands of siltstone
Jennings Randolph (USA)	1985	90	Shale
Zahara (Spain)	1994	80	Shale
Oahe (USA)	1948	75	Shale
Gardiner (Canada)	1967	64	Bearspaw formation comprising sandstone and clay shale with bentonite lenses
Garrison USA	1953	64	Shale
Goi (Japan)	1995	57	Shale
Balderhead (UK)	1964	48	Shale
Beltzville (USA)	1969	52	Shale
Cowanesque (USA)	1980	46	Calcareous and shaley sandstone with thick beds of shale
Aabach (Germany)	1981	45	Shale
Chatfield (USA)	1975	45	Shale
Waco (USA)	1965	43	Shale with bentonite seams
Tioga Hammond (USA)	1979	43	Shale
Kamenik (Bulgaria)	1994	40	Shale

Any seepage through the impervious core would be intercepted by the free-draining filter and drain layers downstream of the core, and conducted to the toe of the dam by a drainage blanket. The gradation of the filters and drains would be designed so that fine material could not be eroded from the core or filters by seepage. The filters would be processed as described in Section 4.4.3 to meet the required gradation.

Drainage tunnels in both the left and right abutments would intercept seepage through the abutment rock.

The upper Part of the upstream face of the dam would be protected from wave erosion by riprap on a bedding of finer rock.

The earthfill dam would be approximately 1,050 m in length. The design elevation of the dam crest (i.e., the top of the dam) would be 469.4 m, approximately 60 m above the present river level, providing a freeboard of 7.6 m above the maximum normal reservoir level (elevation 461.8 m). The selected freeboard is large enough to provide protection from the following environmental factors:

- With the maximum normal reservoir level:
  - Set-up and waves generated by the wind with an annual exceedance frequency of 1 in 1,000 years coming from the direction that results in the highest waves
  - Landslide-generated waves
  - Seismic seiche and settlements due to the earthquake design ground motion
  - Freezing of the impervious core
  - Malfunction of spillway gates
- With the reservoir at the maximum flood level (elevation 466.3 m) during passage of the inflow design flood:
  - Seiche and waves generated by the wind with an annual exceedance frequency of 1 in 100 years coming from the direction that results in the highest waves

Please refer to Volume 5 Section 37 Requirements for the Federal Environmental Assessment for a discussion of the effects of the environment on the Project.

The dam would have a crest width of approximately 10 m and would be constructed higher than the design elevation to allow for settlement of the earthfill.

As described in Section 4.4.3, the foundation of the earthfill dam would be isolated from the river by cofferdams so that the construction would take place in the dry. As shown in Figure 4.14, the upstream and downstream cofferdams would be incorporated into the earthfill dam. The space between the upstream cofferdam and the upstream shell of the dam would be filled with surplus materials from the excavations required to construct the Project structures.

4.3.1.1.2 Materials Used to Construct the Earthfill Dam

Preliminary gradations of various fill materials for the dam are shown on Figure 4.15. These gradations may be refined during detailed design.

Extensive investigations have been undertaken to identify suitable sources of materials for construction of the earthfill dam (see Section 4.3.5.4). These investigations included laboratory testing to confirm the properties of the proposed source of earthfill material described below.

Impervious core (Zone 1 Figure 4.14) would be:

- Glacial till sourced from the 85th Avenue Industrial Lands (see Section 4.3.5.2) with maximum particle size up to 150 mm and containing a minimum of 20% silt and clay, i.e., 20% finer than 0.075 mm
- Free of any organics
- Placed within 2% of its optimum moisture content as determined by standard Proctor compaction tests
- Placed in a manner to prevent segregation in layers a maximum of 300 mm thick and compacted by a vibratory or pneumatic roller to a minimum dry density equal to 98% of standard Proctor maximum dry density
- Placed only when temperatures are above freezing
- Protected from freezing during winter, and any frozen material would be removed prior to placing new material the following season
- Would have permeability equal to or less than 1×10^{-6} cm/s after compaction
- Internally stable

As conventional for large earthfill dams, the final placement and compaction requirements – including layer thickness, compactor type, and number of roller passes required to achieve the specified density – would be confirmed by a test fill completed prior to placement in the dam.

In the vicinity of the left abutment and at the contact with the RCC buttress, impervious core material with a higher plasticity would be selected. It would be placed at or above optimum moisture content, and the layer thickness reduced to 150 mm to provide the best contact.

Based on the following testing, the 85th Avenue Industrial Lands was confirmed to be the best source of impervious material for use in the core of the earthfill dam:

- Soil classification tests (sieve, hydrometer, specific gravity, moisture content, and Atterberg limits)
- Double hydrometer
- Standard Proctor compaction
- Consolidation
- Triaxial shear strength
- Permeability
- Assessment of internal instability in a large permeameter
- Sand castle
- Hole erosion test

- Mineralogical testing X-ray diffraction, X-ray fluorescence, and scanning electron microscope

Fine filter (Zone 2A Figure 4.14) would be:

- Granular free-draining material sourced from the dam site area with a maximum size of 10 mm and containing a maximum of 5% silt and clay
- Well graded and within its specified gradation limits (D_{15} of fine filter less than 0.7 mm)
- Free of any organics
- Placed in a manner to prevent segregation in layers a maximum of 500 mm thick and compacted by a vibratory roller to a minimum of 70% relative density

The fine filter material particles would have to be sound and durable, and conventional concrete aggregate testing for fine aggregates have been completed on the material. The following tests were performed on samples of granular material from the dam site area to confirm that suitable fine filter could be produced from the materials available at site:

- Specific gravity and water absorption
- Magnesium sulphate soundness test
- Mineralogical testing
- Organic impurities
- Petrographic number

Coarse filter (Zone 2B Figure 4.14) would be:

- Free-draining material sourced from the dam site area with maximum size of 50 mm and containing a maximum of 2% fines
- Well graded within its specified gradation limits (D_{15} of coarse filter to be equal to or less than 5 times D_{85} of fine filter)
- Free of any organics
- Placed in a manner to prevent segregation in layers a maximum of 500 mm thick and compacted by a vibratory roller to a minimum of 70% relative density

The coarse filter material particles would have to be sound and durable, and conventional concrete aggregate testing for aggregates have been completed on the material. The following tests were performed on samples of granular material from the dam site to confirm that suitable coarse filter could be produced from the materials available at site:

- Specific gravity and water absorption
- Magnesium sulphate soundness test
- Los Angeles abrasion test
- Micro-deval test
- Mineralogical testing

- Organic impurities
- Petrolgraphic number

Shell material (Zone 3 Figure 4.14) would be:

- Granular free-draining material sourced from the dam site area with maximum size 200 mm and containing less than 5% silt and clay fines
- Well graded within its specified gradation limits (D_{15} of shell material to be equal to or less than 5 times D_{85} of coarse filter)
- Free of any organics
- Placed in a manner to prevent segregation in layers a maximum of 600 mm thick and compacted by a vibratory roller to a minimum of 80% relative density

Shell material would be the granular material sourced from the required excavations or from the right bank terrace in the dam site area. The following tests were performed on samples of granular material from the dam site to confirm that it would be suitable for shell material:

- Gradations
- The same tests as listed for coarse filters

Riprap bedding (Zone 5D Figure 4.14) would be:

- Hard, sound and durable fine rock sourced from the West Pine Quarry (see Section 4.3.5.2) with a maximum size of 250 mm and minimum size of 40 mm
- Well graded between its maximum and minimum size (D_{15} of riprap bedding material equal to or less than five times D_{85} of shell material)
- Placed in a manner to prevent segregation in layers a maximum of 600 mm thick and compacted by a vibratory roller to a minimum of 80% relative density

The material quality would be the same as the riprap; the tests undertaken to demonstrate the suitability of the material in the West Pine Quarry for riprap listed below also apply to riprap bedding.

The riprap (Zone 6D Figure 4.14) would be:

- Hard, sound, and durable fine rock sourced from the West Pine Quarry (see Section 4.3.5.2) with a maximum size of 1,100 mm and minimum size of 300 mm
- Well graded between its maximum and minimum size (D_{15} of riprap to be equal to or less than five times D_{85} of riprap bedding material)
- Carefully dumped and dressed in place with a backhoe

The following tests were performed on samples of rock from the West Pine Quarry to confirm that suitable riprap and riprap bedding could be obtained from the quarry:

- Petrographic analysis (thin section and aggregate type)
- Specific gravity and water absorption
- Los Angeles abrasion

- Micro-deval
- Magnesium sulphate soundness test
- Freeze and thaw
- Unconfined compressive strength
- Unit weight
- Wetting and drying

4.3.1.2 Approach Channel

The approach channel would convey water from the reservoir to the generating station and spillways. The depth of water in the approach channel would vary from 24 m to 26 m below the maximum normal reservoir level. The approach channel would be approximately 200 m wide and 900 m (measured along the centreline) from the inlet to the end of the spillways. The approach channel would have an impervious lining to reduce seepage into the underlying bedrock. The majority of the lining would be impervious fill covered by bedding and riprap. In high velocity areas, such as adjacent to the power intakes and spillway headworks, the lining would be RCC or reinforced concrete. Discontinuities exposed in excavated rock surfaces would be sealed before placing the impervious fill lining. The approach channel would be divided into two sections by an 8 m high berm running down the middle of the channel. This berm would enable either section of the approach channel to be dewatered for inspection, maintenance, and repair of the approach channel lining with the reservoir drawn down to an elevation of 440 m.

During final design, the use of manufactured geomembranes, such as low density polyethylene for the approach channel lining instead of impervious fill, would be investigated. If manufactured geomembranes are found to be suitable, the amount of glacial till required from the 85th Avenue Industrial Lands would be reduced from that shown in Section 4.3.5.

4.3.1.3 RCC Buttress

As shown in Figure 4.16, the RCC buttress would extend from upstream of the core of the earthfill dam to the downstream end of the spillways. The buttress is divided into the following four major sections:

- Core buttress, which forms the south abutment of the earthfill dam at the core
- Dam buttress, which forms the south abutment of the downstream shell of the earthfill dam
- Powerhouse buttress, which supports the generating station
- Spillway buttress, which supports the spillways

Permanently exposed surfaces of the buttress would be faced with conventional concrete designed for exposure to the climatic conditions at site. As shown in Figure 4.16, a drainage gallery would run through the dam, power, and spillway buttresses, and would be connected to a deep drainage tunnel by a curtain of drilled drain holes. A grout curtain would extend along the south face of the buttress to seal discontinuities in the rock and reduce the seepage into the drainage system.

The buttress would transfer the water load in the approach channel and the loads from swelling of the bedrock in the valley wall down to the bedrock in the riverbed level by compression in the inclined buttress.

A cross-section of the core buttress is shown in Figure 4.17. The core buttress would be about 133 m long, 4 m greater than the maximum width of the impervious core of the earthfill dam plus the width of the fine and coarse filters. The height of the buttress would be about 65 m. The contact with the earthfill dam would be angled in the downstream direction so that any downstream movement of the earthfill dam would compress the contact. The contact would be faced with conventional concrete and finished to provide a flat surface for sealing the impervious core of the earthfill dam. A grout curtain beneath the core buttress would connect the earthfill dam grout curtain to the grout curtain along the south face of the buttress.

A cross-section of the 230 m long dam buttress is shown in Figure 4.18. The dam buttress would have a maximum height of 69 m. The height of the dam fill on the downstream side would vary with the slope of the downstream face of the earthfill dam. There would be no special treatment of the RCC face in contact with the gravel fill of the downstream shell of the earthfill dam.

A cross-section of the 170 m long powerhouse buttress is shown in Figure 4.19. The powerhouse buttress provides the foundation for the generating station. The powerhouse buttress would have a maximum height of 56 m to the underside of the power intakes.

A cross-section of the 200 m long spillway buttress is shown in Figure 4.20. The spillway buttress would provide the foundation for the spillways. The spillway buttress would have a maximum height of 60 m to the underside of the spillway headworks.

The vertical face of the core and dam buttress, the power intakes, and the spillway headworks, and associated training walls would form the north side of the approach channel.

4.3.1.4 Generating Station

The generating station would consist of six power intakes, six penstocks, and a six-unit powerhouse (Figure 4.19 and Figure 4.21). The intakes and penstocks would convey water from the approach channel to the turbines located in the powerhouse.

The power intakes would be constructed from reinforced concrete. As shown in Figure 4.19, the intakes would have a bell mouth intake to gradually accelerate the flow from the approach channel to the penstock. There would be a transition from the rectangular shape of the intake water passage to the circular shape of the penstock. Each intake would have a trashrack on the upstream face to prevent large debris from passing through the turbines. Each intake would be equipped with a vertical service gate and hoist capable of closing against full turbine flow in the event of an emergency. The intake gates would be used to seal the intake so that the penstock and turbine could be emptied for routine inspection and maintenance. Slots would be provided in the intakes so that a bulkhead gate could be installed to enable the intake to be emptied, so that gate guides could be inspected and maintained in the dry. The bulkhead gate would be installed using the gantry crane with the intake gate closed so that there would be no flow through the intake.

The penstocks would convey water from the intakes to the turbines. The penstocks would be fabricated from steel plate and would have an internal diameter of about 10.2 m. The lower bend shown in Figure 4.19 would reduce to the inlet diameter of the turbine, which would be about 8.6 m. A flexible coupling would connect each penstock to the turbine inlets.

The powerhouse would contain six generating units with a combined installed capacity of up to 1,100 MW. As shown in Figure 4.12, the powerhouse would be located immediately upstream of the spillways. As shown in Figure 4.19, the generating station would consist of a reinforced concrete substructure and a structural steel superstructure clad with painted insulated metal siding.

Vertical axis Francis turbines would be used. The output of the turbines would be controlled by high pressure hydraulic governors. Slots would be provided at the ends of the draft tubes so that stoplogs could be installed to enable the draft tube to be emptied so that the turbine could be inspected and maintained in the dry. The stoplogs would be installed using the gantry crane on the draft tube deck when the turbine shuts down so that there would be no flow through the turbine.

Two sumps would be located at the bottom of the superstructure. These sumps would contain the pumps required for emptying the turbines for inspection and for discharging building drainage, which would be pumped through an oil/water separator before discharging into the river.

The generators would be air cooled. Each generator would be connected to a transformer located upstream of the units, on the transformer deck. The transformers would step up the generator voltage to the 500 kV transmission voltage. Containment systems would be provided under each transformer with a capacity greater than the volume of oil contained in each transformer. Drainage water from the containment systems would pass through an oil/water separator before discharge to the river.

Each pair of transformers would be connected to a 500 kV transmission line via switchgear located between the transformers. The switchgear would enable either or both of the transformers to be connected to the transmission line. The switchgear would be insulated with sulphur hexafluoride (SF_6) gas.

Three 500 kV transmission lines would connect the three pairs of units to the substation south of the approach channel.

The powerhouse would contain all of the ancillary mechanical and electrical equipment and systems required to support operation and maintenance of the generating equipment.

All discharges from the generating station would be conveyed to the river downstream of the dam by the tailrace (see Figure 4.12), which would be protected from erosion by riprap.

4.3.1.5 Spillways

As shown on Figure 4.12 and Figure 4.21, there would be a gated service spillway and a free overflow auxiliary spillway.

The gated spillway would be separated into two separate compartments by a central concrete dividing wall, which would allow one compartment to be isolated and dewatered for inspection, maintenance, and, if necessary, repairs while the other compartment remained in service.

The reinforced concrete headworks structure would be equipped with seven radial gates to control the discharges (water releases) from the reservoir. Spillway discharges would be conveyed by a concrete chute into a two-stage stilling basin to dissipate the energy and minimize the erosion of the riverbed during large discharges. The spillway controls would be designed so that spillway gates would open in the event of an outage of the powerplant to provide downstream flows.

As shown in Figure 4.20, undersluices would be provided in several of the spillway bays. These sluices would be used during reservoir filling and to draw the reservoir down in the unlikely event that repairs are required in the approach channel.

The free overflow auxiliary spillway would provide additional spill capacity in the unlikely event that some of the spillway gates become inoperable during an emergency. The auxiliary spillway would consist of an ungated concrete overflow section and a concrete chute and stilling basin.

The spillways would have the following discharge capacities:

- 11,000 m^3/s at the maximum normal reservoir level
- 16,700 m^3/s at the maximum flood level

The spillway would be designed to maximize energy dissipation while minimizing the potential for dissolved gas supersaturation.

All discharges from the generating station and spillways would be conveyed to the river downstream of the dam by the discharge channel (see Figure 4.12), which would be protected from erosion by riprap.

4.3.2 Reservoir

The Project would create an 83 km long reservoir that would be on average two to three times the width of the current river, which is up to approximately 1 km wide. The reservoir would be a maximum of 55 m deep at the deepest section of the river at the earthfill dam.

Table 4.3 lists key reservoir levels. The normal operating range between the maximum normal reservoir level and the minimum normal reservoir level would be 1.8 m.

Table 4.3 Key Reservoir Levels

Reservoir Level	Elevation (m)	Comments
Maximum flood level	466.3	Peak reservoir level during passage of the inflow design flood
Maximum normal reservoir level	461.8	Not exceeded during normal operation Only exceeded for short periods during large floods (annual probability less than 1 in 1,000)
Minimum normal reservoir level	460.0	Never below this level during normal operation
Minimum operating level	455.0	Lowest level at which the generating station could be operated if the reservoir had to be drawn down for any reason
Drawdown level	444.0	The lowest level that the reservoir can be drawn down to and pass upstream flow of 1,600 m^3/s through the spillway low level outlets.

Figure 4.22 shows water surface profiles from Peace Canyon Dam to Site C Dam for the existing river and the reservoir for the maximum discharge from Peace Canyon Dam, with the mean annual flow from the tributaries between Peace Canyon and Site C. It can be seen that the reservoir would back up to the tailrace of the Peace Canyon Dam. Figure 4.22 shows how the depth of water increases relative to the existing river levels downstream from Peace Canyon Dam to Site C. The reservoir bathymetry showing the water depths in the reservoir based on LiDAR mapping of the existing topography is contained in Figure 4.23.

Figure 4.24 shows surface area and volume plotted against elevation. The reservoir would have a maximum surface area of approximately 9,330 ha and a volume of approximately 2,310 million m^3 at the maximum normal reservoir level. The reservoir would have a minimum surface area of approximately 9,030 ha and a volume of approximately 2,145 million m^3 at the minimum normal reservoir level. The normal operating range would provide an active storage volume of 165 million m^3. The average residence time of the water in the Site C reservoir would be 22 days.

In addition to the flooding of the Peace River, the lower reaches of several tributaries would be flooded. Table 4.4 presents the increase in surface area and extent of flooding as a result of the Project at the maximum normal reservoir level and the minimum normal reservoir level.

Table 4.4 Extent and Area of Flooding in the Peace River and its Tributaries

River or Tributary	Extent of Flooding (km)		Surface Area (ha)	
	461.8	460.0	461.8 m	460.0 m
Halfway River	15.3	14.5	850	805
Lynx Creek	1.3	1.1	25	21
Farrell Creek	3.6	3.3	58	53
Cache Creek	9.0	8.7	320	305
Wilder Creek	3.2	3.0	30	28
Tea Creek	1.2	1.1	14	13
Moberly River	11.6	11.2	418	399

As described in Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines, shoreline protection beneath Part of the community of Hudson's Hope would be constructed prior to filling the reservoir.

4.3.3 Substation and Transmission Line to Peace Canyon

4.3.3.1 General Description

As shown in Figure 4.12, the Site C generating station would be connected by three 500 kV transmission lines to a new substation located to the southeast of the generating station. Two new 500 kV alternating current transmission lines would connect the new Site C substation to the existing Peace Canyon substation, which is the point of interconnection for the Project to the bulk transmission system, a distance of approximately 77 km. These lines would be located within and immediately adjacent to an existing right-of-way as shown on Figure 4.25 and Figure 4.26. This right-of-way is currently occupied by two 138 kV transmission lines, which run from the G.M. Shrum generating station at W.A.C. Bennett Dam to supply power to Fort St. John and Taylor. As shown on Figure 4.26:

- West of Jackfish Lake Road, the new 500 kV transmission lines would be constructed within the existing 118 m wide right-of-way. To accommodate these transmission lines, the total existing right-of-way would be cleared, extending the clearing by 72 m. A one-time clearing extent up to 14 m beyond the right-of-way would be required to remove any danger trees.
- East of Jackfish Lake Road, to accommodate the Project access road (see Section 4.3.7) and the new 500 kV transmission lines, the right-of-way would be increased by 34 m. In some areas, it may be possible to reduce the additional widening to 17 m. To accommodate these transmission lines and the Project access road, the clearing extent would be increased between 89 m and 106 m, depending on the road alignment. As a result of the widened right-of-way, no one-time danger tree clearing is required east of Jackfish Lake Road.

The Site C substation would include 500 kV to 138 kV step-down transformers to provide service to Fort St. John and Taylor, and allow for the removal of the 138 kV lines. The advantages of connecting Fort St. John and Taylor to the new Site C substation would be:

- Improvements in system reliability, as they would be connected to the transmission system at a much closer point
- Reduction in transmission system energy losses for the supply to Fort St. John and Taylor

The first of the new 500 kV lines would be constructed along the north side of the existing 138 kV lines from Peace Canyon to the Site C substation (see Figure 4.26). After commissioning of the first new 500 kV line and the substation, the 138 kV lines to Fort St. John and Taylor would be connected to the transformers in the Site C substation. The existing 138 kV lines between G.M. Shrum and the Site C substation would then be decommissioned and removed. The second of the new 500 kV lines would then be constructed in the portion of the right-of-way previously occupied by the 138 kV lines. Some portions of the 138 kV lines in the vicinity of G.M. Shrum may remain in-service for local needs.

The substation would have space to allow for additional connections to Fort St. John and Taylor in the future at either 138 kV or 230 kV.

One or two microwave and communications towers approximately 20 m high would be constructed near the Septimus Siding for system communications. A second tower may be required on the north bank to provide the required coverage. The communications equipment installed would be compatible with the new generation system communication equipment that BC Hydro will be installing in the Project area in the future. These communications upgrades would proceed whether or not the Project proceeds.

Access roads would be required for the construction of the transmission lines and maintenance during operation (see Section 4.3.7).

4.3.3.2 Transmission Line Alternatives Considered

In addition to the proposed route, BC Hydro considered the following two alternative routes for connecting the Site C substation to the Peace Canyon substation:

- Locating the transmission corridor on the north side of the Peace River
- Connecting via submarine transmission cables in the reservoir

4.3.3.2.1 Alternative 1 – North Transmission Corridor

BC Hydro considered locating two 500 kV transmission lines adjacent to the existing 138 kV transmission line. However, because of the geotechnical risk posed by unstable slopes near river crossings, a transmission corridor for the 500 kV lines would be located further north (Figure 4.27). While a corridor on the north side of the Peace River might be technically feasible, it would involve the acquisition of new rights-of-way on approximately 135 parcels of Crown and private land. A potentially feasible route would be 5 km to 10 km longer than the existing corridor on the south side. Total area of this right-of-way would be 1,263 ha.

BC Hydro did not believe there was adequate justification to pursue this alternative further because:

- Of the increased cost of the transmission line
- It would require the acquisition of rights on 135 parcels of land totaling 1,263 ha while BC Hydro already has a right-of-way on the south bank
- Widening of the existing right-of-way would have lesser environmental effects

4.3.3.2.2 Alternative 2 – Submarine Transmission Cable Connection between Site C and Peace Canyon

BC Hydro examined the concept of connecting Site C to the Peace Canyon station through two 500 kV alternating current submarine cables along the reservoir bottom. Each transmission circuit would be made up of three submarine cables, six in total would be required.

The cables would have to be laid on a stable surface and for maintenance requirements, BC Hydro requires a separation between cables of at least 100 m. The separation would be required so that each cable could be raised to the surface for inspection and repair if necessary and then lowered back to the bottom of the reservoir without any risk of contacting other cables. Therefore, a total width of over 600 m would be required to lay the cables.

Voltage compensation would be required because the cables would be 70 km in length. Series compensation stations would be required at both Site C and Peace Canyon.

Issues with this alternative included:

- The cost of submarine cables would be in the order of eight to 10 times greater than overhead lines
- Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines discusses the stability of the reservoir shoreline. To avoid the risk of burying or damaging the submarine cables, they would have to be routed to avoid areas where slides into the reservoir or materials from the eroding shoreline could reach them. The risk is that it may not be possible to raise a buried cable to the surface for inspection and repair. To avoid the risk associated with the reservoir slopes it would be necessary to lay the cables on flat surfaces such as riverbank

terraces or along the existing river channel, which would increase the length of the cables. There are a number of locations where the width of the valley floor is either insufficient to lay the cables or to avoid high banks, where slope stability and erosion would pose a risk to the reliability of the lines. These locations include: river kilometer 45 to 46, Attachie, and river kilometer 84 to 85.

- The transmission line would have to be completed prior to reservoir filling so that it would be ready to accept power when the generating station is commissioned and enters into service. Delays to the in-service date so that the cables could be laid from the reservoir surface would cost in the order of hundreds of millions of dollars, due to accumulated interest, and would not be an economically feasible option. The cables would be laid on dry land (e.g., on terraces) prior to reservoir filling, except where it would be necessary to lay the cables in the river to avoid the slope issues described above. Submarine cables are typically laid at sea or on large lakes by specialized cable laying vessels. Since the Peace River in British Columbia is not navigable for large vessels, it would not be possible to use such a vessel for Site C. Therefore, the in-river portion of the cables would have to be laid by a barge fabricated from modular units that could be shipped by road or rail.
- Road and rail capacity would limit the spool diameter and the length of cable that could be transported to the site for laying by barge or on land. This would require multiple cable splices, which would decrease the reliability of the cables.

In summary, the alternative of connecting Site C to Peace Canyon substations through submarine cables is uneconomic, with higher risks and lower reliability.

4.3.4 Highway 29 Realignments

4.3.4.1 General Description

Highway 29 connects Hudson’s Hope to Fort St. John and runs along the north side of the Peace River. It is a two-lane rural arterial undivided highway under the jurisdiction of the BC Ministry of Transportation and Infrastructure (BCMOTI).

Segments of the highway would be flooded by the Site C reservoir, resulting in the need to realign approximately 30 km of existing highway at Lynx Creek, Dry Creek, Farrell Creek, Halfway River, and Cache Creek. A section east of Farrell Creek that would not be flooded by the reservoir would need to be relocated further away from the reservoir shoreline due to the effects of long-term erosion and potential instability (see Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines). The alignments, including bridge cross-sections, are shown on Figure 4.28 through Figure 4.33. The lengths of each segment of the highway relocation, including causeway and bridge lengths, are given in Table 4.5.

Table 4.5 Highway 29 Realignment Segments and Respective Watercourse Crossing Lengths

Segment	Total Length of Segment (km)	Causeway Length (m)	Bridge Length (m)	Number of Piers	Bridge Span	Figure Number
Lynx Creek	8.0	290	160	1	2	Figure 4.28
Dry Creek	1.5	N/A	11 m pipe-arch culvert	1	N/A	Figure 4.29
Farrell Creek	2.0	150	170	N/A	2	Figure 4.30
Farrell Creek East	6.0	N/A	N/A	N/A	N/A	Figure 4.31
Halfway River	~~4.0~~3.7	~~640~~0	~~305~~1,042	~~3~~12	~~4~~13	Figure 4.32 Rev 1
Cache Creek	8.5	240	200	1	2	Figure 4.33

NOTES:
The parameters for the Halfway River Bridge design are based on a conceptual design and are subject to change.
N/A – not applicable

Where required, navigable clearance envelopes would be 8 m high by 25 m wide.

Existing local roads within the realigned segments would be connected to the new highway alignment. Private and commercial driveways would be re-established. Driveway locations would be determined in consultation with private property owners and to the approval of BCMOTI.

4.3.4.2 Alternative Highway Alignments Considered

A number of highway alignment alternatives were developed for each of the segments. A multiple account evaluation process was undertaken to evaluate the alternatives for each segment. Characteristics evaluated included the relative safety, environmental effects (including those on fish, wildlife, and habitat), social effects (including those on property, heritage, and agriculture), and costs of each alternative. The process included workshops in which the characteristics of each alternative were ranked. Workshop participants included representatives of BC Hydro, the Site C Integrated Engineering Team, BCMOTI, and highway design consultants.

Each alignment had two options for crossing the watercourse:

- A short bridge plus a causeway
- A long bridge

BCMOTI preferred the short bridge options due to lower long-term maintenance costs, so the long bridge options were dropped.

4.3.4.2.1 Lynx Creek Alternatives

Four alignments for the Lynx Creek section were initially considered (BC Hydro, 2009). During public consultation in 2008, property owners expressed a preference for using the existing Millar Road, so two additional alignments using Millar Road were added.

- One along the reservoir
- Two in a central corridor using a portion of Millar Road

The alignment shown in Figure 4.28 was selected as the preferred alternative. Even though it would have higher cost than the next highest ranked alternative, which was in the inland corridor, this alignment would:

- Utilize a portion of the existing Millar Road alignment and therefore reduce requirements for private property
- Affect fewer fields and a relatively small forested area, resulting in reduced potential adverse effects on the natural habitat
- Require minimal to no in-stream works on the Lynx Creek segment and therefore would have minimal adverse effects on aquatic or riparian habitat
- Have lower potential for collisions between vehicles and wildlife
- Have lower potential agricultural effects

4.3.4.2.2 Halfway River

Three alignments for the Halfway River section were considered (BC Hydro 2009). The overriding design consideration at Halfway River is the potential effect of a landslide-generated wave (see Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines), which affects the vertical road alignment and the design of the bridge.

The alignments considered were:

- One inland. located along the toe of the slope on the west side of the terrace
- One along the reservoir shoreline
- One using the inland alignment north of the river, crossing the river at an angle, and using the reservoir shoreline alignment south of the river

The alignment shown in Figure 4.32 was selected because it was the lowest overall cost and was considered to have a reasonable balance between the environmental and social factors.

4.3.4.2.3 Cache Creek

Two alignments for the Cache Creek section were considered (BC Hydro 2009). The alignments considered were:

- One along the reservoir shoreline
- One inland located along the toe of the slope on the west side of the terrace

The alignment shown in Figure 4.33 was selected because it has:

- Lower cost
- Less private land requirements
- Less severed actively farmed land
- Less agricultural land required for the right-of-way

- Fewer geotechnical issues

4.3.5 Quarried and Excavated Construction Materials

4.3.5.1 General Description

A variety of quarried and excavated materials would be required for construction of the dam, generating station and spillways, Highway 29 realignments, access roads and the Hudson's Hope shoreline protection. These materials would be sourced from various locations in the Project vicinity, as shown in Figure 4.11.

In the following descriptions, off-site materials refers to materials that are excavated at and transported from a location away from the construction site (off-site) to the site where the materials would be used to construct a Project component. Except where noted otherwise, off-site materials would be transported from the sources to the construction sites by highway-rated trucks on public roads.

In the following descriptions, on-site materials refers to materials that would be sourced at the construction site, and come from excavations required for construction of the Project component or from a location within the boundaries of the site.

The approximate quantities of material to be used in the Project from each source are shown in Table 4.6 and Table 4.7. The quantities of unsuitable and surplus materials are shown in Table 4.8 and Table 4.9. The volume of unsuitable material and the total volume excavated may vary depending on the yield of the quarries, thickness of topsoil, occurrence of zones of material with gradations or moisture contents outside of the required specifications, and the like. For the purpose of the environmental assessment, reasonable but conservative assumptions (i.e., to give higher quantities) have been made.

4.3.5.2 Off-Site Sources

Development plans for the following off-site quarry and excavated materials sources describing the locations, boundaries and haul routes are provided in the following parts of Volume 1 Appendix C Draft Construction Materials Development Plans:

- Part 1 – Impervious Till Core Material Source Development Plan (85th Avenue Industrial Lands)
- Part 2 – Wuthrich Quarry Development Plan
- Part 3 – West Pine Quarry Development Plan
- Part 4 – Portage Mountain Quarry Development Plan
- Part 5 – Del Rio Pit Development Plan

The dimensions of the quarries and the excavated materials sources will depend on the method of development adopted by the contractors. Refer to the quarry and excavated materials development plans for potential development methods and dimensions.

Table 4.6 Approximate Quantities of Materials for Dam, Generating Station, and Spillways

Material Description	Volume Placed (1,000 Compacted m^3)				
	West Pine Quarry	Wuthrich Quarry	85th Avenue Industrial Lands	Dam Site Area	Total
Impervious	N/A	N/A	2,921	414	3,335
Filters and drains	N/A	N/A	N/A	1,599	1,599
Shell and granular	N/A	N/A	N/A	12,616	12,616
Dam random fill	N/A	N/A	N/A	1,832	1,832
On-site access road	N/A	N/A	N/A	3,733	3,733
Permanent riprap and bedding	869	N/A	N/A	N/A	869
Temporary riprap and bedding	N/A	350	N/A	N/A	350
RCC and concrete aggregates	N/A	N/A	N/A	4,244	4,244
Total	869	350	2,921	24,438	28,578

NOTE:

N/A – not applicable

Table 4.7 Approximate Quantities of Materials for Highway 29, Access Roads, and Hudson's Hope Shoreline Protection

Material Description		Volume Placed (1,000 Compacted m^3)						
		Portage Mountain Quarry	Inundated Areas Along Reservoir	Road Alignment Excavation	Dam Site Area	Del Rio Pit	Commercial Pits	Total
North bank – Highway 29 realignment, access roads and reservoir shoreline protection during filling	Riprap and bedding	447	N/A	N/A	N/A		N/A	447
	Granular aggregates (processed)	N/A	484	N/A	N/A	N/A		484
	Fill and borrow	N/A	9,381	830	N/A	N/A	7	10,218
	Concrete aggregates	N/A	N/A	N/A	N/A	N/A	12	12
South bank – access roads	Riprap and bedding	2	N/A	N/A	N/A	N/A	N/A	2
	Granular aggregates (processed)	N/A	N/A	N/A	N/A	50	464	514
	Fill and borrow	N/A	N/A	301	118	200	77	697
	Concrete aggregates	N/A	N/A	N/A	N/A	N/A	16	16
Hudson's Hope shoreline protection	Riprap and bedding	172	N/A	N/A	N/A	N/A	N/A	172
	Granular aggregates (processed)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fill and borrow	N/A	N/A	306	N/A	N/A	N/A	306
Total		621	9,381	1,437	118	250	1,060	12,868

NOTE:

N/A – not applicable

Table 4.8 Approximate Quantities of Unsuitable and Surplus Material for Dam, Generating Station, and Spillways

Material Description	Volume Placed (1,000 Placed m^3)				
	West Pine Quarry	Wuthrich Quarry	85th Avenue Industrial Lands	Dam Site Area	Total
Surplus[a]	1,150	915	N/A	N/A	2,065
Unsuitable[b]	N/A	N/A	325	12,085	12,085
Stripping and overburden	242	330	177	20,304	21,053
Total	1,392	1,245	502	32,389	35,528

NOTES:

[a] Surplus materials at West Pine and Wuthrich would be stockpiled for usage by BCMOTI or by others; unsuitable material at the 85th Avenue Industrial Lands would be used for final landscaping

[b] Unsuitable materials for construction would be relocated as described in Section 4.3.2.3 N/A – not applicable

Table 4.9 Approximate Quantities of Unsuitable and Surplus Materials for Highway 29, Access Roads, and Hudson's Hope Shoreline Protection

Material Description	Volume Placed (1,000 Placed m^3)					
	Portage Mountain Quarry	Inundated Areas Along Reservoir	Road Alignment Excavation	Dam Site Area	Other Sources	Total
Surplus[a]	463	N/A	N/A	N/A	100	565
Unsuitable	N/A	N/A	9	N/A	N/A	9
Stripping and overburden	33	761	718	N/A	48	1,560
Total	498	761	727	N/A	148	2,134

NOTES:

[a] Surplus material at Portage Mountain and other gravel pits would be stockpiled for usage by BCMOTI or by others N/A – not applicable

4.3.5.2.1 85th Avenue Industrial Lands

The 85th Avenue Industrial Lands is a 96 ha parcel of land located in the Peace River Regional District, adjacent to the City of Fort St. John. BC Hydro owns all parcels of land within the site. All impervious material (i.e., glacial till) required for the construction of the earthfill dam core and the approach channel lining would be excavated from the 85th Avenue Industrial Lands. The impervious core in the closure section of the Stage 2 upstream cofferdam (see Section 4.4.3.3) may also be sourced from the 85th Avenue Industrial Lands depending on the suitability of material available on-site.

A conveyor would transport material from 85th Avenue Industrial Lands to the dam site area. The conveyor would off-load materials into a large hopper or to a stockpile close to the hopper. Trucks would then be loaded directly from the hopper or by front-end loader from the stockpile and transport the material to the placing location within the dam site.

4.3.5.2.2 Wuthrich Quarry

Temporary riprap and bedding material would be required for construction of parts of cofferdams, for lining parts of the inlet and outlet channels of the diversion tunnels, and for the erosion protection of the access road along the north bank of the river (see Section 4.3.7). The source of this temporary riprap would be the Wuthrich Quarry, which is an existing BCMOTI quarry located approximately 7 km northwest of Fort St. John. Further development by BC Hydro would expand the area that has been excavated by BCMOTI, but would be within the current boundaries of the quarry.

Riprap and bedding material would be transported from Wuthrich Quarry to the dam site by highway trucks on existing public roads.

4.3.5.2.3 West Pine Quarry

Permanent riprap and bedding material would be required for the upstream face of the dam, approach channel lining, containment dikes, cofferdams, some parts of the diversion tunnel inlet and outlet channels, the tailrace, and the discharge channel. The source of this permanent riprap and bedding material is the West Pine Quarry, located on provincial Crown land approximately 75 km southwest of Chetwynd along Highway 97 (approximately 160 km from the Project site).

There are currently two transportation options under consideration for the permanent riprap and bedding material:

1. Use the existing railway siding at the quarry and haul the material to the site by rail; one train per day would be required. Riprap and bedding would be unloaded at the Septimus Siding in the dam site area and moved to a stockpile. An extension of the siding may be required within the quarry. Due to breakage during extra handling. More rock would have to be quarried with this option.
2. Haul the material directly to the dam site area using highway-rated haul trucks, using both existing public roads and the Project access road (see Section 4.3.7)

The transportation option would be selected by the contractor(s) using the riprap and bedding. For the purposes of environmental assessment, the trucking option has been assumed, as while it has less quarrying it has the greater footprint.

4.3.5.2.4 Portage Mountain

Permanent riprap and bedding material for the Hudson's Hope shoreline protection, for the areas along the reservoir requiring protection during reservoir filling, and for Highway 29 construction would be sourced from Portage Mountain, 16 km southwest of Hudson's Hope. Portage Mountain is currently undeveloped.

Excavated material would be transported from the quarry to the construction site using highway haul trucks via the access roads described in the development plan and existing public roads.

4.3.5.2.5 Del Rio Pit

Some of the gravel required for the construction of the Project access road and upgrades to the Jackfish Lake Road and other roads on the south bank would come from the Del Rio Pit, an existing gravel source operated by the BCMOTI. The pit is located 50 km north of Chetwynd, B.C., along Jackfish Lake Road, west onto Douglas Road and then onto Del Rio Pit Road.

The License of Occupation on Crown lands for the gravel reserve spans approximately 142 ha and is traversed by the 138 kV transmission line right-of-way.

4.3.5.2.6 Inundated Areas

Potential aggregate sources along the Peace River and tributary river valleys were identified. At each of the Highway 29 segments requiring realignment or upgrading, and for the Hudson's Hope shoreline protection, the closest sources within the area that would be flooded by the proposed reservoir have been identified as off-site sources for the required construction materials.

Where the sources would be at shallow depth after reservoir impoundment, opportunities for enhancement of fish habitat by contouring and habitat complexing would be explored.

4.3.5.2.7 Commercial Pits

Materials sourced from local commercial pits for construction of Highway 29 would include aggregates for the asphalt pavement and concrete.

Some fill for the Hudson's Hope shoreline protection could be sourced from local commercial pits.

Materials from commercial pits for the Project would be extracted under the terms of the development and other permits for those pits held by the pit owners.

4.3.5.2.8 Area E

Area E has been identified as a contingency pit for gravel to be used for road construction on the south bank or for construction of the earthfill dam. The identified area could provide up to one million m^3 of gravel. Area E is adjacent to the Teko Pit, located just west of the confluence of the Peace and Pine rivers. This pit is operated by BCMOTI (east of the rail line) and by CN (west of the rail line).

The access road from this area is very steep and, if required, gravel could be hauled by rail from the siding in the Teko Pit to the Septimus Siding.

4.3.5.3 On-Site Sources

4.3.5.3.1 Highway 29 and Hudson's Hope Shoreline Protection

Materials from excavations required for highway realignment that are suitable as fill would be used for the highway embankments.

As described in Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines, the Hudson's Hope shoreline protection would be a combination of a berm and slope flattening. Suitable material from the slope flattening excavation would be used for construction of the berm.

4.3.5.3.2 Dam, Generating Station, and Spillways

Impervious material for construction of cofferdams and lining of disposal areas would be sourced from required excavations and from a source on the north bank outside the limits of the north bank stabilization excavation.

About 40% of the fine filter for the earthfill dam would come from a source on the north bank of the river, and the remainder from the south bank terrace downstream of the dam.

All of the gravel excavated for the construction of the dam, generating station, and spillways would be used for construction.

Aggregates for concrete and RCC and gravel for the shell of the dam would be sourced from the south bank terrace downstream of the dam.

4.3.5.4 Alternative Off-Site Material Sources Considered

The following subsections describe alternative off-site sources of materials that were considered and provide the rationale as to why these sources are not proposed for use in construction of the Project.

4.3.5.4.1 Dam, Generating Station, and Spillways

Impervious Material

Reconnaissance studies concluded that suitable impervious material was likely to be found on the north side of the Peace River close to the dam site area, and was unlikely to be found on the south side.

Geotechnical investigations were carried out on the north side of the river in 2009 and 2010 to identify potential sources of impervious core material. The 2009 investigation focused on understanding the surficial geology and stratification of the area, and identified the most promising source areas for further investigations. The 2009 investigations consisted of:

- 104 auger holes (up to 35 m depth, 125 mm diameter)
- 7 test pits (up to 5.2 m depth)
- Laboratory testing on representative samples

Additional investigations were carried out in 2010 to further define the potential sources. The 2010 investigations consisted of:

- 15 sonic drill holes (up to 29 m depth and 120 mm diameter)
- 8 test pits (up to 8.3 m depth)
- 6 piezometers installed for groundwater level monitoring
- Laboratory testing on representative samples

Of the potential sources investigated on the north bank, the 85th Avenue Industrial Lands were selected as the source of the impervious fill because it:

- Is close to the dam site area
- Has best gradation and plasticity
- Would require minimal moisture conditioning, as it has an average natural moisture content that is 1.3% dry of average optimum moisture content
- Can be compacted to a high density with an average dry density of 2,094 kg/m^3 standard Proctor maximum dry density
- Has the highest shear strength, varying from 32 to 35 degrees
- Is a more consistent product and in greater thickness, meaning that little material would be wasted
- Has less topsoil cover

4.3.5.4.2 Temporary Riprap

Tea Creek, located 6 km upstream of the dam on the north bank, was originally considered as the source for temporary riprap for the dam site. The haul distance to the dam is approximately 12 km by existing roads. The deposit is made up of sandstone outcrops of the Dunvegan formation on a bedrock ledge above Tea Creek. The rock, which includes thinly bedded planes of fine-grained sandstone overlain with overburden materials, is approximately 20 m thick.

The area was preliminarily assessed for environmental effects and a resident bat population was discovered residing along the outcrop. Other potential effects included the existence of rare species of plants, haul routes on agricultural lands, and the effect on farm operations and residences within 0.9 km to the east and 2.5 km upstream on Tea Creek. Because of these considerations, Wuthrich Quarry was selected as the source of temporary riprap.

4.3.5.4.3 Permanent Riprap

The Portage Mountain Quarry was considered as an alternate source of permanent riprap. Haul routes from Portage Mountain to the dam site area would be through Hudson's Hope:

- East along Highway 29 to the Alaska Highway, through Fort St. John and via the Old Fort Road

- South on Highway 29 through Moberly to Jackfish Lake Road and via the Project access road; due to the restricted capacity of Hudson's Hope Bridge, the load size would be limited, potentially increasing the number of trucks

Due to the potential effect on traffic, this option was dropped, even though it would be $10 million cheaper than using material from the West Pine Quarry. Of particular concern were the long hills on Highway 29 where trucks hauling riprap would cause considerable delays.

4.3.5.4.4 Highway 29 and Hudson's Hope Shoreline Protection

Other potential riprap sources near to Highway 29 and Hudson's Hope are the Castle formation and the Pringle formation, both on Bullhead Mountain, approximately 6 km north of Portage Mountain. The thinly bedded rock outcrops would result in a lower potential yield than at Portage Mountain, which would increase the cost of production and generate a larger footprint than on Portage Mountain in order to produce the same volume of material. The absorption, specific gravity, and soundness results are below those acceptable for use as riprap. An access road capable of supporting haul units would be required to be constructed for approximately 4 km to the better of the two locations at the Pringle prospect. Therefore, the Bullhead Mountain sources are no longer being considered as potential sources of riprap.

4.3.6 Worker Accommodation

BC Hydro is planning for provision of worker accommodation during the construction phase. The operation phase annual average workforce is predominantly of a regular, long-term nature that would be easily accommodated in local communities.

BC Hydro estimates it will generate approximately 10,000 person-years of direct employment during the construction period. The estimated average annual construction phase workforce on-site would be between 800 and 1,700 workers (with contingency, up to 2,100 workers). Approximately 90% of the workforce would be required for construction activities at the dam site. About 10% of the workforce would be required for off-site construction activities, including Highway 29 realignment, Hudson's Hope shoreline protection construction, road works, clearing, material transport, and transmission line construction. The workforce for the Project is expected to be composed of existing local residents, new local residents, and workers from outside the region who will maintain their permanent residence outside the region.

Worker accommodation planning is informed by the following objectives and considerations:

- Safety for public and workers
- Workforce attraction, retention, and well-being of workers and their families
- Project construction productivity, cost, and schedule
- Managing social and housing market effects in nearby communities, including opportunities to leave a beneficial housing legacy
- Support for new workers and their families who choose to move to the region

4.3.6.1 In-community Accommodation

BC Hydro is planning to build approximately 40 new permanent housing units for use by the construction workforce in the Fort St. John area. Following the construction period, these houses would become Part of the long-term housing stock in the area. The development approach of the new housing would be focused on two key objectives:

- Provide housing suitable for Site C workers and their families during construction
- Provide housing suitable for community affordable housing post-construction

4.3.6.2 Temporary Accommodation – Dam Site

Temporary accommodations during the construction phase are planned for the dam site, in the form of camp facilities, on both the north and south banks of the Peace River in close proximity to the work sites. Temporary accommodations would be removed at the end of the construction phase and sites would be reclaimed.

The camp housing would largely consist of prefabricated units. Where possible, workers would be housed in the north or south camp, based on the location of their work site. This would minimize the transport of workers through active construction areas, which would benefit worker safety, site productivity, and cost.

Camp facilities and utilities would be designed, constructed, operated, decommissioned, and permitted to be compliant with all applicable regulations.

The north bank camp is planned to be built in Year 1 and to operate through to the end of the construction phase, with capacity for approximately 500 persons. The south bank camp is planned to be built later in Year 1 and to operate through to the end of the construction phase as required. The south bank camp would be built with a base capacity for 500 workers, with capacity to be expanded to a potential peak capacity for up to approximately 1,200 persons. Both camps utilities and infrastructure would be planned to accommodate the potential peak occupancy including contingency.

Camp facilities would be generally self-sufficient and typically include:

- Dormitories
- Washing and laundry
- Kitchen and dining
- Recreation and leisure
- General services (e.g., medical, first aid, commissary)
- Fire protection system
- Water supply, treatment, and distribution
- Waste water management
- Solid waste management system (including use of the regional landfill)
- Security system
- Telecommunications
- Grid electricity and other fuel supply

- General parking
- Office buildings
- Transportation stops

A shuttle service would be provided as deemed necessary – from both the north bank and south bank camps to the Fort St. John area and to the North Peace Regional Airport – for commuters, airport transfers, and leisure transport to town and also between Chetwynd and the south bank dam site camp for daily commuters and for transfers to the camp.

4.3.6.3 Temporary Accommodation – Regional Locations

BC Hydro is considering two general locations away from the dam site area for accommodation to support construction activities. The need for these camps, and the size and operating period for each camp, would be determined during the construction phase based on project scheduling and local alternative accommodation options. The sites could include temporary camp units and RV spaces. Local site selection would be done to find a suitable and permissible site, which could be on BC Hydro-owned land, Crown land, or leased private land. Camp facilities and utilities would be designed, constructed, operated, decommissioned, and permitted to be compliant with all applicable regulations. The general areas where these facilities may be placed are based on the location of the construction work sites outside of the dam site area:

- General vicinity of Hudson's Hope
- General vicinity of the upper Jackfish Lake Road area (north of Chetwynd)

4.3.6.4 RV Parks

BC Hydro may secure use of dedicated long-stay RV spaces. These would likely be within the Fort St. John–Taylor and Hudson's Hope areas, to provide workers with another housing option. BC Hydro would seek an operator, such as the private sector or the local governments, to supply RV spaces, and would require the sites to be built and operated in compliance with all applicable regulations.

4.3.7 Road And Rail Access

Temporary and permanent access roads would be required for the construction and operation phases of the Project, respectively. Where feasible, existing access roads would be used and upgraded as required.

The design for new construction and upgrades to public roads would be in accordance with applicable British Columbia and Canadian guidelines, codes, supplements, and technical circulars. Upgrades to the provincial and municipal public roads would meet or exceed existing conditions. Design criteria would be established and approved by the relevant jurisdictional authority. Temporary construction service roads would be designed in accordance with applicable standards for operational equipment and other applicable guidelines.

Refer to Volume 4 Appendix B Project Traffic Analyses Report for information on Project-related traffic along each route.

Sections 4.3.7.1 and 4.3.7.2 describe the access to the dam site area from the north and south banks, respectively, and Section 4.3.7.3 describes the main access roads within the dam site area.

4.3.7.1 North Bank Access to Dam Site Area

Figure 4.34 shows the permanent and temporary access roads to the north side of the dam site area.

Access to the north side of the dam site area from Fort St. John and the Alaska Highway (Highway 97) would be via existing municipal and provincial public roads. Upgrades to the existing roads would include:

1. Hard-surfacing of 240 Road and the portion of 269 Road south of the intersection with 240 Road
2. Realigning a portion of Old Fort Road south of 240 Road, as shown on Figure 4.34
3. Improving public safety on 271 Road between the Wuthrich Quarry and Highway 97 by widening the shoulders or adding a paved path
4. Improving public safety on Old Fort Road north of 240 Road by widening the shoulders or adding a paved path
5. Potentially improving the Old Fort Road cross-section between 240 Road and the realigned segment, and from the end of the realigned segment to the Howe Pit entrance

The total length of required upgrades 1 and 2 above would be about 3.8 km, and the total length of upgrades 3, 4, and 5 above would be up to 7.6 km, depending on the results of an in-service road safety audit, consultation with the public and BCMOTI, and final design considerations. All upgrades to the existing roads listed above would be within the existing rights-of-way.

Access to the dam site from Old Fort Road and 269 Road would be controlled 24 hours a day, seven days a week throughout the construction period, so that only authorized traffic would be able to access the dam site area.

A conveyor would be installed to transport impervious material from the 85th Avenue Industrial Lands to the dam site area.

4.3.7.2 South Bank Access to Dam Site Area

4.3.7.2.1 General Description

Existing road networks on the south bank of the Peace River include the partially paved Jackfish Lake Road and an unpaved network of rail, transmission, oil and gas, and forest service roads.

Access to the south side of the dam site area from Chetwynd and the Alaska Highway would be via Highway 29, Jackfish Lake Road, and a new 33 km Project access road alongside the existing transmission line corridor (see Figure 4.35). Access to the dam site area via the Project access road would be controlled 24 hours a day, seven days a week throughout the construction period, so that only authorized traffic would use the road. After construction, the Project access road would remain in service to provide access to the eastern half of the transmission line and an alternate access to the dam, generating station, and spillways. While this would be a private road, others would be able to use the Project access road. Discussions would be held with applicable agencies, stakeholders, and First Nations to determine whether enforceable restrictions could be put on the road, or whether this would provide an opportunity to decommission other roads in the vicinity.

As shown on Figure 4.35, the CN Rail line to Fort St. John passes through the dam site area on the south bank. A new 2 km siding would be constructed on the north side of the CN Rail line at the existing Septimus Siding.

The current network of unpaved resource roads would be upgraded to provide access to the dam site area during the first year of construction, including isolated widening and localized grading, and road base repairs along the 53 km of unpaved resource roads.

Upgrades to about 31 km of the unpaved portion of Jackfish Lake Road would be undertaken in Year 3, prior to hauling of riprap from the West Pine Quarry to the dam site area. These upgrades would include road base strengthening and hard surfacing, which may require the widening of some sections.

In consultation with BCMOTI, BC Hydro would examine the feasibility, issues, and risks, and costs and schedule for widening the shoulders along the first 30 km of Jackfish Lake Road to meet current BCMOTI rural collector standards, potentially including two 1.5 m wide paved shoulders.

4.3.7.2.2 Alternate Access Routes Considered

BC Hydro conducted a multiple account evaluation to determine the preferred south bank access road. This process considered the relative safety, environmental effects, social effects, and costs of various options, and was similar to that used for the Highway 29 alternatives (see Section 4.3.4.2).

The following alternative alignments for the Project access from Jackfish Lake Road to the dam site area were considered:

- Alignments 1 and 2, predominantly following the existing 138 kV transmission line right-of-way, with a slight variation at the western end. Alignment 1 follows the transmission line for its whole length, while alignment 2 follows Jackfish Lake Road west from the point where the road meets the transmission line.
- Alignments 3 and 5, following existing resource development roads and then the transmission line corridor
- Alignment 4, following existing resource development roads and then a new undeveloped route to the dam site area

Alignments 1 and 2 are the shortest, most direct routes.

Alignments 2 and 3 had the highest safety rating of the five alignments.

Alignments 4 and 5 are more costly than the other three options, and have a greater effect on aquatic and riparian habitat.

Alignments 1, 2 and 3 all had very similar ratings for the social and environmental indicators, with the exception of safety as noted above.

Based on the above considerations, alignment 2 as shown in Figure 4.35 was selected.

4.3.7.3 Access Roads Within Dam Site Area

As shown on Figure 4.34, the main access roads within the dam site area connecting to Fort St. John would be:

- Along the north bank of the river (the river road) to Old Fort Road
- The north bank access road to 269 Road

As shown on Figure 4.35, the main access road within the dam site area connecting to Chetwynd via the Project access road would be the Septimus Siding road.

Within the dam site area, the contractors would construct many access roads for excavation, relocation of surplus excavated materials, construction of the dam, generating station, and spillways, and for interconnecting the temporary facilities described in Section 4.4.3. The location and routing of these roads would depend on the contractors' methods, sequences, and detailed planning for undertaking the work, and would vary from year to year. Therefore, only the main roads that would be used for construction and remain in place for operations are described herein.

The river road would run along the edge of the river on the north bank, connecting Old Fort Road to the downstream end of the diversion tunnels. This road would provide the primary construction access to the dam site area from the east. Excavation of the north bank slope would cut the existing single access road that currently traverses the slope via a series of switchbacks. Until access roads can be established across the north bank excavation, the river road would be the only low-level access to the diversion works and area within the north bank Stage 1 cofferdams (see Section 4.4.3.2). The road would be constructed from gravel and protected from erosion by riprap from the Wuthrich Quarry. After construction, the road would remain as a secondary access to the dam from the north bank.

The north bank access road would connect 269 Road to the upper level of the north bank in the dam site area. This would provide access to the north bank camp, warehouse, and contractors' work areas. After completion of the first stage of the north bank excavation, it would connect to temporary roads constructed over the north bank excavation and provide access to the river level. On completion of the Project, this road would become the permanent access across the north bank slope and earthfill dam to the generating station (see Figure 4.12).

4.3.7.4 Transmission Line Corridor Access

There is existing road access along most of the proposed route for the transmission lines as a result of construction and maintenance of the existing 138 kV transmission lines and other developments in the area. Some additional access roads may be required to individual structures and work sites.

4.3.7.5 Reservoir Preparation Access

Access required for reservoir clearing is described in Volume 1 Appendix A Vegetation, Clearing, and Debris Management Plan.

For construction access to the Hudson's Hope shoreline protection:

1. The intersection of Highway 29 and Canyon Drive would be reviewed to confirm estimated traffic delays resulting from construction, and options for mitigating any traffic delays to westbound traffic would be considered, such as:
    a. Construction of a dedicated left-hand turn slot, or
    b. Changing intersection priority by revising pavement markings and signing
2. A paved brake check area would be installed on Canyon Drive before the start of the 10% grade. Use of the brake check would be mandatory for all trucks hauling riprap from Portage Mountain.
3. Opportunities for constructing either arrestor beds or runaway lanes or both on Canyon Drive above Hudson's Hope would be explored and installed if feasible.

4.4 Construction

The construction activities described in the following subsections are based on the construction planning and assumptions made for the 2010 project cost estimate. Activities may be somewhat different depending on final design and procurement, including contractors' preferences for equipment, sequencing of activities and construction means and methods. However, the types of activities that might be used have been identified and all construction activities would be carried out in accordance with the Project Construction Environmental Management Program described in Volume 5 Section 35 Summary of Environmental Management Plans, with legal requirements applicable to those activities, and with the terms of permits issued with respect to those activities. The work would be contracted on the basis that contractors must commit to compliance with the Project Construction Environmental Management Program described in Volume 5 Section 35 Summary of Environmental Management Plans, legal requirements and the terms of all permits. All construction contracts would contain terms mandating compliance with the commitments made in the contractor's proposal or tender, as applicable.

Each of the following subsections describing construction activities should be read with the understanding that the work described therein would:

- Be conducted in compliance with a decision statement issued by the Minister of Environment of Canada
- Not commence until after an Environmental Assessment Certificate has been issued
- Not commence until the permits, licences, authorizations, and approvals necessary to conduct that activity have been obtained
- Be performed in accordance with the terms of those permits, licences, authorizations, and approvals, and the Construction Environmental Management Program described in Volume 5 Section 35 Summary of Environmental Management Plans

Sections 4.4.1 and 4.4.2 describe typical construction activities that are common to multiple project components. They are described separately to avoid the duplication of information.

APPENDIX B: LETTER

Letter of endorsement from the Ministry of Transportation and Infrastructure, dated December 6, 2017, for modified Halfway River Bridge Design

BRITISH
COLUMBIA

December 6, 2017

BC Hydro- Site C Clean Energy Project
333 Dunsmuir St, 6th Floor
Vancouver, BC
V6B 5R3

Attn: Farzad Kossari
Project Manager, Project Management and Operations

Re: Highway 29 Halfway River Bridge

Dear Farzad,

Please accept this letter as written confirmation that the Ministry of Transportation and Infrastructure endorses BC Hydro's design consideration of a lengthened bridge crossing on Highway 29 at Halfway River.

The Ministry acknowledges potential for an increase in lifecycle maintenance costs associated with a longer bridge structure than that described within the Environmental Impact Statement (EIS).

Any change in the Highway 29 Halfway River bridge scope, from that outlined within the EIS, will require Ministry engineering specifications to be satisfied.

We will continue to work with BC Hydro through any future design and engineering processes to provide technical and operational reviews for this project as required.

Sincerely,
<Original signed by>

Scott Maxwell
Regional Director, Northern Region
Ministry of Transportation and Infrastructure

cc: Melissa Holland, Director of Projects (BC Hydro)
Brent Davies, Sr. Project Manager (Ministry)

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