SCHEDULE A

Site C Clean Energy Project

Volume 1, Sub-sections 4.3 to 4.5, of the Amended Environmental Impact Statement for the Site C Clean Energy Project prepared by the Proponent and submitted to the Joint Review Panel on August 2, 2013.

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 and six low level outlets 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 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	3.7	0	up to 1,042	12	13	Figure 4.32, Rev 2
Cache Creek	up to 9.0	N/A	up to 700	up to 8	up to 9	Figure 4.33 Rev 1 and 4.33 Rev 1 – Detail

NOTE:
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.

The alignments considered were:

- Three in an inland corridor, located along the toe of the slope along the west side of the terrace
- 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 or West Pine 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	85^{th} 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 85^{th} 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 or West Pine 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, the discharge channel, Highway 29 construction, Hudson’s Hope shoreline protection, and for areas along the reservoir requiring protection during reservoir filling.” 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, Highway 29 realignment segments, Hudson’s Hope Shoreline Protection, and areas of the reservoir requiring protection during reservoir filling using highway-rated haul trucks on existing public roads (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 or from West Pine Quarry, 138 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 1,600 workers with contingency to accommodate up to 2,200 workers at peak periods and up to 200 additional camp support workers, for a total camp occupancy of up to 2,400, based on single occupancy accommodation units. 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 in the camp located on the north bank of the Peace River (camp) shown in Figure 4.37 of Schedule A. The camp would be removed at the end of the construction phase and the site reclaimed.

The camp has a capacity for up to 2,200 workers and up to 200 camp support workers, for a total camp occupancy of up to 2,400, based on single occupancy accommodation units.

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 the camp to the Fort St. John area and to the North Peace Regional Airport – for commuters, airport transfers, and leisure transport to town.

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.

Current protocols for ice management on the Peace River would be unaffected by construction of the Project.

4.4.1 Site Preparation

4.4.1.1 Clearing

Generally, areas where major earthworks would be carried out, such as in the dam site area, Highway 29 realignment, new all-season access roads, and construction material source areas would require the complete removal of vegetation, including stumps, i.e., clearing and grubbing. The transmission lines would have a combination of clearing with and without stump removal. The reservoir has a number of clearing treatments prescribed, including some retention of vegetation depending on location and other external factors.

The clearing and debris management plan for the Project is described in Volume 1 Appendix A Vegetation, Clearing and Debris Management Plan and describes the areas that would be cleared.

4.4.1.2 Grubbing

Grubbing would be carried out in areas where construction activities or quarrying would subsequently be carried out.

4.4.1.3 Stripping

Stripping of topsoil would generally be done with a tracked bulldozer, and the material would be either stockpiled on-site for use during reclamation or hauled to another location for storage.

4.4.1.4 Contaminated Sites

Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 3 Contaminated Sites Report describes the assessments of potentially contaminated sites undertaken prior to filing this Environmental Impact Statement. Potential contaminated sites would be further assessed prior to the commencement of site preparation activities. Confirmed contaminated sites would be remediated as Part of site preparation.

4.4.1.5 Infrastructure

All infrastructure components such as public utilities and oil and gas structures and buildings would be inventoried and the necessary plans prepared for protection or relocation.

4.4.1.6 Fencing

The perimeter of the dam site area would be fenced and gated as required to prevent unauthorized access.

4.4.1.7 Helipad

Helipad(s) would be constructed on the south bank for emergency evacuation.

4.4.2 Typical Road and Highway Construction Activities

4.4.2.1 General Activities

General activities would include site preparation as described in Section 4.4.1 and construction of temporary facilities (site offices, utilities, workshops, storage, testing laboratories, vehicle storage and maintenance facilities, hazardous materials storage, fuel storage, and refuelling sites).

4.4.2.2 Gravel Production

Gravel pit development and operation would be required to produce roadway aggregates. Gravel for embankments would be excavated and hauled to the embankment location by trucks. Materials for road sub-base, base, and asphalt would be produced by crushing and screening gravel in the gravel pit to provide the specified gradations.

4.4.2.3 Road and Highway Grading

Grading would include all excavation for roadbeds and drainage works, embankment and causeway construction, and granular aggregate placement to form the roadbed. Unsuitable or surplus excavated material would be disposed of within the proposed right-of-way or designated waste areas.

Winter access roadbeds would be constructed mainly from snow and ice, with a minimal amount of soil to assist the freezing of the road, or to provide a more durable surface.

4.4.2.4 Drainage

Drainage works would include ditching, culvert installation, and placement of riprap and bedding. Temporary works, such as diversion of existing watercourses through cofferdams, may be required to facilitate road and bridge construction.

4.4.2.5 Bridge Construction

Bridge works would include driving piles in dry and wet conditions, placing concrete fill and columns for foundation, placing approach works, erecting girders, and placing the bridge deck. Bridge works would also include placement of bridge end fills, and placement of riprap and bedding. Concrete could be provided from existing commercial sources. Concrete batch plants may also be established and would include water supply, cement, and fly-ash storage and facilities for mixing concrete.

Temporary bridges and water crossings may include winter crossings, abutment bridges, and pile bridges. Winter crossings may be snow or gravel-covered box culverts. Abutment bridges would include modified railway flatbed cars, or steel girders and timber deck placed on timber crib or concrete abutment footings. Pile bridges would include pipe pile piers installed into the riverbed, with a timber deck supported on structural steel girders.

4.4.2.6 Finishing

Finishing of highways and roads would include the construction of a running surface consisting of gravel, sealcoat, or asphalt pavement. Depending on the running surface and conditions, finishing may also include pavement markings, roadside barrier placement, new and relocated signage, electrical installations, fencing, and landscaping. Asphalt paving would require the establishment of an asphalt plant.

4.4.2.7 Traffic Management

In addition to the Project Traffic Management Plan outlined in Volume 5 Section 35 Summary of Environmental Management Plans, traffic management during construction would be in accordance with either the BC *Standard Specifications for*

Highway Construction, the *Forest Practice Code – Forest Road Engineering Guidebook,* or the latest version of the BCMOTI *Traffic Management Guidelines for Work On Roadways.* Standard traffic control measures would be used for guiding traffic during construction.

4.4.2.8 Reclamation and Decommissioning

All temporary construction areas, including laydown areas and temporary access roads, would be deactivated and reclaimed on completion of construction.

Abandoned sections of highways and roads would be reclaimed through pavement removal, scarifying of road base, drainage restoration, and landscaping. Reclaimed asphalt would be disposed of or recycled for use elsewhere in the Project.

Existing roads and bridges may require widening, brushing, signage, or other improvements to meet the Project needs.

4.4.3 Dam, Generating Station, and Spillways

Construction of the dam, generating station, and spillways and of construction-supporting infrastructure such as worker camps, construction offices, temporary facilities and site access roads would take place within the bounds of the dam site area (Figure 4.36). Within the dam site area, environmental protection zones and restricted activity zones would be established to minimize or avoid potential construction effects in those areas. Construction activities would not be conducted within the environmental protection zones, while restricted construction activities would be conducted within the restricted activity zones. These zones currently include:

- Restricted activity zones along the north shore of the Peace River, with the construction of the north bank access road and the access road to the end of the conveyor from the 85th Avenue Industrial Lands the only permitted activities
- Restricted activity zone at the southeast corner, with the construction of the access road from the Septimus Siding the only permitted activity

Figure 4.37 depicts key construction activities and their respective locations within the dam site area.

The construction of the dam, generating station, and spillways can be categorized into four key stages:

- Preliminary works
- Stage 1 – river channelization (Figure 4.38)
- Stage 2 – river diversion (Figure 4.39)
- Reservoir filling and commissioning

The total construction period would be eight years. The current schedule of key construction activities is summarized in Figure 4.40.

4.4.3.1 Preliminary Works

The first construction activities would be site preparation, construction of some temporary access roads, and construction and setup of the temporary facilities required for construction of the permanent works. The dam, generating station, and spillways would be constructed under several contracts. Each contractor would be responsible for setting up their own temporary facilities; therefore, this stage of the project would overlap the subsequent stages.

Excavation of the upper Part of the north bank would commence early in this stage and continue to the end of construction (see Section 4.4.3.3 for a description of activities for the excavation of the north bank).

4.4.3.1.1 Temporary Facilities

After site preparation, levelling ground and placing gravel for the development of temporary facilities, parking areas, staging, and laydown areas would be required. This section describes the temporary facilities that would be set up in the dam site area.

4.4.3.1.2 Utilities

Utilities such as water supply (potable and non-potable), sewer, natural gas, electricity and telecommunications would be installed on-site.

On the north bank of the dam site area, electricity would be provided by one or more connections to the existing BC Hydro 25 kV distribution system, which includes duct banks along the Alaska Highway and overhead lines on wood poles. Where it is not possible to use existing duct banks, new duct banks would be constructed. The overhead lines would be upgraded from single phase to three phase by the addition of a three phase cross arm and lines. Some wood poles would be replaced.

The preferred route would follow a duct bank from the Fort St. John substation and then via existing poles along 81 Avenue, 100 Street, 85 Avenue, Old Fort Road, and 240 Road to the point-of-interconnection.

The alternative route would follow duct banks from the Fort St. John substation to the terminus pole at 81 Avenue and 87 Street, then northwest along the Alaska Highway to a terminus pole at the Alaska Highway and 242 Road and then via existing poles along Old Fort Road and 240 Road to the point-of-interconnection. No duct banks exist from 81 Avenue and 87 Street to the Alaska Highway and 242 Road; therefore, new duct banks would be constructed.

A temporary 138 kV substation would provide temporary construction power on the south bank of the dam site area. The temporary substation would be connected to the existing 138 kV transmission line that crosses the dam site area and would supply 25 kV power to the construction facilities. Construction of the substation would require site preparation and grading, installation of grounding, fencing, concrete footings and electrical equipment, and testing and commissioning. Alternatively, one or more 138 kV/25 kV mobile substations could be used. After energization of the new Site C substation, the temporary facilities on the south bank would be decommissioned and removed. The equipment would be redeployed to other BC Hydro site(s).

Backup diesel generators would be provided in case of power failures and to provide power prior to the interconnection of the substations to the BC Hydro system.

4.4.3.1.3 Dam Site Temporary Worker Accommodation

Construction of the north bank camp would commence within the first few months after construction commencement. Construction of the south bank camp would commence approximately six to eight months later.

4.4.3.1.4 Waste Treatment and Management Facilities

Waste water treatment facilities would be constructed within the dam site area to treat the waste water from the camps and other temporary buildings. Hazardous waste (including lubricants, antifreeze, etc.) and solid waste would be collected and disposed of.

4.4.3.1.5 Installation and Operation of Temporary Facilities

After site preparation, temporary construction facilities would be erected and installed on-site, including: site offices, workshops, laboratories and testing facilities, storage facilities, fabrication shops, safety, first aid and security facilities, and vehicle maintenance facilities. These facilities would likely comprise prefabricated structures, containers and trailers, but could also include structures requiring erection of structural steel members, cladding and roofing, construction of concrete base slabs, and wood frame construction.

4.4.3.1.6 Explosive Storage

It is anticipated that about one-third of the rock that would be excavated can be broken (ripped) with heavy equipment. However, drilling and blasting would be required for rock that is too hard to rip. Drilling and blasting may be required for excavation of the diversion tunnels (although mechanical excavation by road headers may be an economic option, depending on contractor experience and preference).

Packaged explosives such as dynamite and detonators would be stored on-site in explosives magazines constructed at designated areas, a safe distance from other facilities. The explosives would be transported to the site, unloaded, and stored in the magazines. When required, explosives would be loaded and transported to the excavations requiring drilling and blasting.

Blasting agents such as ammonium nitrate fuel oil would likely be used for bulk excavations such as the approach channel and foundation of the roller compacted concrete buttress. The components (ammonium nitrate and fuel oil) would be stored separately and only mixed together when placed in the blast holes. Licensed facilities would be used for the maintenance and repair of the trucks that deliver and mix the blasting agents.

4.4.3.1.7 Fuel Storage and Refuelling Sites

Fuel required for all construction equipment would be stored in fuel tanks at a designated location called a tank farm. The tank farm would likely comprise steel fuel storage tanks, erected above ground. The tanks may be constructed on footings or may be placed directly on the levelled natural ground. Bulk fuel would be delivered to the site by road or rail, and transferred from the delivery trucks or tankers into the storage tanks at the tank farm. Spill containment would be provided at the tank farm. Refuelling would not take place adjacent to a body of water unless the area was contained by a dike or other structure. All fuel delivery vehicles would be equipped with spill kits.

4.4.3.1.8 Truck Washing Stations

Truck washing stations would be established at designated locations on both banks. Trucks used to deliver and batch concrete would be washed independently from all other trucks and would have their own designated washing sites. Water used at all of the truck washing sites would be collected and treated.

4.4.3.1.9 Aggregate and Filter Processing Plants

Aggregate (sand, gravel, and crushed stone) would be required for production of concrete and roller compacted concrete, and for the filters in the earthfill dam. Aggregate and filter materials would be processed from sand and gravel excavated from various sources within the dam site area to meet the required specification. Aggregate and filter material processing plants would be located close to the sand and gravel sources. Material would be excavated from the sources and trucked to the processing plant(s), where they would be stockpiled. The gravels would then be put through a crusher to break up the larger stones. Once crushed, the sand and gravel would be screened, washed, and sorted into stockpiles of specified material size. Trucks would be loaded and would then transport the processed materials to their required location for use. Waste water from washing would be collected and treated. Dust generated in the processing operations or as a result of stockpiling would be controlled.

4.4.3.1.10 Concrete Batch Plants

Concrete batch plants would be established on both banks. The plants would include storage facilities for cement, fly-ash, and other additives. The batch plants would have bins for all of the materials required to produce concrete (sand, various sizes of aggregates, cement, fly-ash, and water) and would mix the materials to produce the concrete. Waste water from the batch plants would be collected and treated.

Conventional concrete would be deposited into mixer trucks or into buckets loaded onto flatbed trucks, which would transport the concrete to the required locations on-site, where the concrete would be placed, vibrated, and ultimately cured.

Roller compacted concrete (RCC) would likely be transported from the batching plant to the buttress and approach channel via a conveyor system. Trucks may also be used if required. The RCC would be dumped from the conveyor onto trucks, which in turn would transport the RCC directly to where it would be placed. After the trucks had dumped the RCC, it would be spread with bulldozers to the approximate lift (layer) height and subsequently compacted using vibratory and drum rollers. Waste water from the batch plants would be collected and treated.

4.4.3.1.11 Relocation of Surplus Excavated Materials

Much of the material excavated for construction of the dam, generating station, and spillways would be unsuitable for construction or would be surplus to construction requirements, and would need to be relocated. The areas shown on Figure 4.37, Figure 4.38 and Figure 4.39 have been designated for relocation of unsuitable and surplus excavated material. Table 4.10 summarizes the source of material, relocation area, and approximate embankment volume.

Table 4.10 Relocation of Surplus Excavated Materials

Area	Material Source	Embankment Volume (million m^3)
L3	North bank excavations	10.9
L5	North bank excavations	7.7
L6	North bank excavations	1.4
R5a	South bank excavations	6.3
R5b	South bank excavations	1.3
R6	South bank excavations	1.5

Work on developing the areas outside of the riparian zones would commence as Part of the preliminary works. Areas within the riparian zones would be developed as Part of Stage 1. The areas would be used until completion of the Project.

Area L3 would be cleared and grubbed as Part of the site preparation activities. The remaining areas would require clearing and grubbing in riparian zones. Areas L5, L6, and R5 would all require construction of retention berms to retain the relocated material and isolate it from the river.

The retention dikes would be gravel berms constructed from excavated river gravels. The inside face of the gravel berms (i.e., the slope not exposed to the river) and bottom of the retention areas would be lined with impervious material such as glacial till or lacustrine material coming from on-site locations. In addition, a capping layer of impervious material would be overlaid on the relocated materials. This lining and capping material would minimize infiltration through the relocated materials, and mitigate possible acidic drainage and metal leaching from the shale bedrock or other surplus excavated materials (see Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 4 Acid Rock Drainage and Metal Leaching Management Plan). Riprap would be placed on the outer faces of the retention dikes to prevent erosion by the river.

Surplus excavated material would be transported via truck to these locations, dumped, and spread to the ultimate design elevations and slopes. Areas L5 and R5 and the area between the upstream face of the completed earthfill dam and the upstream cofferdam would ultimately be completely inundated with water when the reservoir is impounded near the end of construction.

In order to haul excavated materials to Area R5a, a temporary construction access bridge would be required across the lowest reach of the Moberly River. The temporary access bridge would have a clear span over the main channel of the Moberly River. This crossing is temporary as it would only be used for transportation of surplus materials to Area R5a and would be removed before filling of the reservoir.

4.4.3.2 Stage 1 – River Channelization

Work on Stage 1 would commence after receipt of the applicable federal authorizations.

The north and south bank Stage 1 cofferdams shown on Figure 4.38 would confine the river to its main channel.

The nominal crest elevations of the cofferdams would provide a freeboard of over 1 m above the maximum consolidated ice envelope at the site, determined using Comprehensive River Ice System Simulation Program model described in Volume 2 Appendix G Downstream Ice Regime Technical Data Report. The crest of the cofferdam would be about 6 m above the maximum normal river level.

4.4.3.2.1 North Bank Stage 1 Cofferdams

The Stage 1 cofferdams on the north bank would include the cofferdams around the diversion tunnel inlet and outlet locations, as well as along the shore of the central island between these two locations, in order to isolate the north side of the river and enable construction activities on the north bank of the river to commence. These cofferdams would be constructed in riparian zones that would require clearing and grubbing.

Gravel from local sources in or near the river would be excavated for cofferdam construction. Gravel extraction would be done, keeping a berm of gravel between the extraction area and the river to provide isolation. The gravel fill would be placed to construct the cofferdams and riprap from off-site locations would be transported via truck to the site and placed on the slopes of the cofferdams for erosion control. In order to prevent seepage under the gravel cofferdams, a vertical cut-off would be installed through the cofferdams to provide an impermeable barrier. The cut-offs would be either a slurry trench wall or a steel secant pile wall.

Slurry trench walls would be a trench about 1 m wide, excavated through the cofferdam and the alluvium in the riverbed down to bedrock. During excavation, the sides of the trench would be supported by thick, dense slurry of bentonite clay and water. The trench would then be in-filled with a mixture of cement, bentonite, aggregate, and water to create an impermeable wall. The slurry trench would be excavated by a backhoe or crane equipped with a clamshell or dragline.

Secant piles are circular steel pipes installed side by side through the earthfill cofferdam and riverbed alluvium down to bedrock, and connected by a series of interlocks welded onto the sides of the piles to form a continuous interlinked wall of piles. The secant piles would be installed by a crane equipped with a pile driving hammer. If necessary, a down-the-hole hammer could be used to break any large rocks encountered.

Once the cut-off walls have been installed, the water on the inside of the cofferdams would be pumped out to dewater or dry out the area where excavation and construction activities would take place.

Alternate methods of cut-off construction could be used, depending on contractor preferences.

Work would commence on the portion of the earthfill dam located within the north bank Stage 1 cofferdams as soon as the area is dewatered (see Section 4.4.3.3 for a description of the activities for construction of the earthfill dam and Figure 4.38, which shows the excavation for the earthfill dam within the cofferdams).

4.4.3.2.2 South Bank Stage 1 Cofferdams

The Stage 1 cofferdam on the south bank would be constructed along the river edge to isolate the south bank construction activities. All clearing, grubbing, gravel extraction, excavation, gravel fill placement, riprap placement, cut-off installation, and dewatering activities are identical to those described for the north bank Stage 1 cofferdams.

Work would commence on the portion of the earthfill dam located within the south bank Stage 1 cofferdams and the south bank structures as soon as the area has been dewatered (see Section 4.4.3.3 for a description of the activities for construction of the earthfill dam and south bank structures and Figure 4.38, which shows the excavation for the earthfill dam and south bank structures within the cofferdams).

4.4.3.2.3 Temporary Construction Access Bridge

A temporary construction bridge across the Peace River would be installed concurrently with the Stage 1 cofferdams and remain operational until the downstream Stage 2 cofferdam has been completed (see Section 4.4.3.3), and could be used for access across the river. The bridge would have two lanes and provide easy access between both banks for safety and efficiency reasons. The bridge would not be used for hauling of excavated materials, but would have sufficient capacity to allow unloaded large equipment to cross.

The temporary construction bridge would comprise pipe pile piers installed into the riverbed, with a timber deck supported on structural steel girders. The bridge would be multi-span, with a length of about 330 m, and constructed across the Peace River near the toe of the earthfill dam between the north and south bank Stage 1 cofferdams. The north bridge abutment would be constructed as Part of the diversion tunnels outlet cofferdam. A crane located on the cofferdam would install the piles for the first pier, and then the support girders and deck for the first span. In this manner, the bridge would be constructed span by span across the main river channel to the abutment in the south bank Stage 1 cofferdam. Construction of this temporary bridge would take approximately 14 weeks. After the Stage 2 downstream cofferdam has been completed, the temporary construction bridge would be redundant as access between the banks would be over the downstream cofferdam, which would provide a wider access with greater load capacity. Therefore, the bridge would be dismantled and removed,

4.4.3.2.4 Diversion Works

Construction of the diversion works would be on the critical path; therefore, work would start as soon as access is available.

The diversion tunnels would be constructed through and under the north bank. Construction of the diversion tunnel portals, structures, and tunnels would include the following activities:

- Excavating overburden and rock at each end of the diversion tunnels (behind the diversion tunnels inlet and outlet cofferdams) to form the portals for the two diversion tunnels, which would include drilling and blasting, and rock support, including rock bolts and shotcrete
- Excavating rock underground to form the two diversion tunnels, either by drilling and blasting or by a road-header, which is a piece of heavy equipment with a mechanical arm equipped with a rotating cutter bit at the end that excavates the rock
- Installing rock support, which would include steel ribs at each end of the tunnels, rock bolts and shotcrete
- Relocating excavated material, loaded onto and transported via trucks, to Area L5 (upstream) and Area L6 (downstream)
- Erecting formwork, fixing reinforcing steel, and placing and curing concrete for the construction of the diversion inlet and outlet structures
- Erecting formwork and placing and curing concrete to construct the concrete tunnel linings, including cement grouting to fill voids between the concrete and the tunnel roof

- Installing diversion tunnel gates and hydraulic hoists
- Excavating diversion tunnel inlet and outlet channels outside the extents of the diversion cofferdams (i.e., excavation of river alluvium and gravel from the existing riverbed using long-arm excavators; machinery working in water would use biodegradable hydraulic fluid)
- Dewatering (partial drying) wet material from the wet excavations
- Excavating diversion tunnel inlet and outlet channels inside the cofferdams
- Installing erosion protection in the diversion tunnel inlet and outlet channels; options include riprap both inside and outside the confines of the cofferdams, or placement of a concrete slab within the confines of the diversion tunnel outlet cofferdam. Riprap installed outside of the cofferdams would be placed underwater in the riparian zone.

4.4.3.3 Stage 2 – River Diversion

After completion of the diversion works, the Peace River would be diverted through the diversion tunnels and the main river channel would be blocked off with upstream and downstream cofferdams (the Stage 2 cofferdams) in order to isolate the area where the earthfill dam would be constructed across the Peace River (see Figure 4.39).

River diversion would consist of the following activities:

- Flooding the tunnels by pumping water from the river to provide balanced water levels across the inlet and outlet cofferdams
- Removing sections of the diversion inlet and outlet cofferdams at the upstream and downstream ends of the tunnels with heavy machinery working in water and in the riparian zone
- Placing riprap in water along the bottom of the river channel and along the exposed sides of the cofferdam where inlet and outlet cofferdam sections were removed
- Placing the upstream closure section across the Peace River downstream of the diversion tunnel inlet location by trucking rock from off-site locations, dumping it above water level, and then pushing it into the river with a bulldozer
- Placing the downstream closure section using identical procedures to the upstream closure section
- Dumping sand and gravel from trucks running on the rockfill onto the upstream face of the rockfill closure sections to reduce flow through the rockfill
- Transporting gravel from on-site locations, dumping it above water level, and then pushing it into the river with a bulldozer to form a platform just above water level between the closure sections (Figure 4.39) to form the base of the upstream and downstream Stage 2 cofferdams
- For the upstream cofferdam only, transporting impervious material from the 85th Avenue Industrial Lands, dumping it above water level, and then pushing it into the river with a bulldozer between the rockfill closure section and the gravel platform to form the base of the upstream cofferdam

- Transporting, placing, and compacting gravel from on-site locations and impervious materials from 85th Avenue Industrial Lands to construct the closure sections of the upstream and downstream Stage 2 cofferdams
- Installing cut-off walls in both the upstream and downstream cofferdams using a slurry trench wall or a steel secant pile wall as described for the Stage 1 cofferdams
- Dewatering the area between the upstream and downstream Stage 2 cofferdams using pumps and pipes to pump water back to the river
- Transporting and placing riprap from off-site locations on the exterior faces of the Stage 2 cofferdams

4.4.3.3.1 Earthfill Dam and North Bank Excavation

Significant features of the Project include construction of the earthfill dam that would impound the reservoir, and excavation of overburden material from the north bank to improve the long-term stability of the slope. The construction activities associated with the earthfill dam and the north bank slope would be carried out in parallel over a number of years and would include:

- Excavating overburden material from the north bank slope with large excavators
- Excavating overburden, ripping, or drilling and blasting to excavate rock for the dam core trench (foundation)
- Relocating surplus excavated material via truck to Areas L3 (on the north bank terrace), L5 (upstream), and L6 (downstream)
- Cleaning the core trench with compressed air
- Applying shotcrete to the rock surfaces within the core trench to protect the surfaces from weathering
- Drilling holes into the core trench rock foundation and injecting grout, which is a cement water mixture, into the grout holes
- Drilling foundation drain holes
- Constructing an underground drainage system consisting of tunnels and drain holes into the north abutment
- Loading, transporting, placing, and compacting impervious glacial till from the 85th Avenue Industrial Lands for the core of the dam
- Loading, transporting, placing, and compacting sand and gravel (from the aggregate processing plants located downstream of the dam on the south bank terrace and on the north bank) for the filters of the dam
- Loading, transporting, placing, and compacting gravel from the south bank terrace gravel pits for the shells of the dam
- Loading, transporting, and placing riprap (from off-site locations) on the upper portion of the upstream face of the earthfill dam
- Removing the cut-off wall installed in the downstream cofferdam so as not to impede the flow of water from the drainage zones within the earthfill dam by excavating out

the slurry trench cut-off wall or removing the secant piles and replacing them with granular material

- Placing asphalt paving on the powerhouse access road constructed on the downstream face of the dam to access the powerhouse (on the south bank) from the north bank

4.4.3.3.2 South Bank Structures

The construction activities for the south bank structures (RCC buttress, generating station, spillways, and approach channel) would include:

- Excavating overburden material, ripping, or drilling and blasting, and excavating rock
- Loading, transporting, and dumping the surplus excavated material, largely to relocation Area R5, using trucks, bulldozers, and graders
- Placing shotcrete on the rock foundation
- Drilling grout holes and injecting cement grout into the foundation to seal subsurface cracks and fissures within the foundations
- Excavating shear zones and filling with plastic concrete
- Loading, transporting, and placing impervious material from the 85th Avenue Industrial Lands in the approach channel as a liner
- Loading, transporting, and placing riprap and bedding material from the West Pine Quarry in the approach channel on top of the till lining
- Loading, transporting, and placing sand and gravel drainage layers
- Loading, hauling, placing, and curing the RCC buttress
- Erecting formwork, fixing reinforcing steel, loading, hauling, placing, and curing conventional concrete for the structures
- Erecting structural steel for the powerhouse superstructure using heavy equipment such as cranes
- Excavating river gravel in the wet in a riparian zone (i.e., beyond the limits of the south bank cofferdam) to excavate the tailrace channel
- Placing riprap in the wet
- Removing the cofferdam cut-off wall in the location of the tailrace
- Removing cofferdam gravel at the tailrace outlet
- Fabricating short sections of circular steel penstocks from plate, moving the penstock sections from the fabrication yard by truck, lifting the penstock sections into place with large cranes, and welding the sections together to erect the penstocks
- Transporting and placing gravel around the penstocks
- Placing asphalt paving at the permanent powerhouse parking areas
- Installing spillway gates and hoists
- Erecting structural steel and deck for the spillway access bridge

- Installing intake gates and hoists
- Installing generating equipment in the powerhouse
- Installing transformers and oil separators
- Installing ancillary mechanical and electrical equipment within the powerhouse
- Installing and energizing the transmission lines that connect the powerhouse transformers to the substation on the south bank

4.4.3.4 Reservoir Filling and Commissioning

Reservoir filling would take place near the end of construction and would be required for wet testing and commissioning of the units (see Volume 1 Appendix B Reservoir Filling Plan). The preference would be to fill the reservoir in the fall of the year when flows are normally low (after the flood season and before high flows from upstream generation); however, filling may occur at other times of year, depending on the final construction schedule.

The sequence of activities for reservoir filling and commissioning would include:

- Closing the gate in one of the diversion tunnel inlet structures to close off the tunnel; this would reduce the amount of flow diverted through the tunnels and the reservoir level would begin to rise
- Closing the gate(s) in the second tunnel once the reservoir was high enough to use the spillway undersluices to control the discharge
- Using the undersluices to control the rate of reservoir filling, including holding the reservoir at specified levels
- Testing and commissioning the spillway gates
- Testing and commissioning the intake gates and generating units
- Constructing an earthfill cofferdam across the diversion tunnel outlet channel (placing gravel in the riparian zone)
- Dewatering the diversion tunnels by pumping water to the river
- Placing and curing concrete plugs in the tunnel at the centreline of the earthfill dam to permanently seal the tunnels

During testing and commissioning of the generating units, a portion of the river flow would be diverted through the spillway.

4.4.3.5 Demobilization and Reclamation Activities

After completion of the permanent parts of the Project, all temporary structures and construction facilities, including temporary access roads and bridges, would be decommissioned and removed from the site. Grading, landscaping, contouring, and revegetating of the site would be the final activity.

4.4.4 Reservoir

4.4.4.1 Clearing and Debris Management

Clearing and debris management in the reservoir, including the access requirements, are described in Volume 1 Appendix A Vegetation, Clearing, and Debris Management Plan.

4.4.4.2 Boat Traffic Management

Volume 3 Section 26 Navigation describes the restrictions that would be in place on water access during dam construction and reservoir filling to ensure the safety of boaters, including the proposed public notifications of the restriction by signage and other means.

4.4.4.3 Hudson's Hope Shoreline Protection

As described in Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines, the shoreline protection would be a combination of a granular berm and excavation to flatten the slope. The construction schedule for the Hudson's Hope shoreline protection is shown in Figure 4.42.

D.A. Thomas Road in Hudson's Hope, which provides access to the shoreline, would be upgraded to facilitate construction and future access to the proposed shoreline protection.

Approximately 9 ha along the berm would require clearing and grubbing of vegetation.

Materials required for the construction of the berm include:

- Clean gravel fill, cobbles or blast rock bedding material, to be placed in the river below the water level
- Cobbles or blast rock in areas where water emerges on the natural slope to allow free drainage behind the berm
- Granular materials that form the general fill for the bulk of the berm
- Riprap and bedding on the exposed surfaces for erosion protection

Approximately 270,000 m^3 would be excavated to flatten the existing slope in the mid-portion of the shoreline protection (see Figure 13-2 in Volume 2 Appendix B Geology, Terrain Stability, and Soil, Part 2 Preliminary Reservoir Impact Lines). A horizontal bench would be left above reservoir level at the toe of the flattened slope. Riprap and bedding would be placed at the reservoir level below this bench to protect the shoreline from erosion by waves. The material in the slope at this location is granular and meets the specifications for granular fill, so it would be used for construction of the adjacent sections of the berm.

The berm would follow the existing shoreline to produce a more natural look and would be constructed by importing borrow materials from a local granular source, either from the inundated area near Lynx Creek or from an adjacent shoreline island downstream from the berm. Both locations would be submerged after reservoir filling.

Access to the berm would be required for hauling the construction materials. The proposed access points are the existing D.A. Thomas Road and from within the limits of the slope flattening. Should the island downstream be the source for the imported granular material, then a foreshore tote road would be required between the end of the berm and the island. Adjustment to the existing materials along the shore and capping with some granular materials as a running surface would provide an adequate surface for trucks hauling materials.

4.4.5 Substation and Transmission Line to Peace Canyon

The construction schedule for the substation and transmission line is shown in Figure 4.41.

4.4.5.1 Transmission Line

Construction activities would include gaining access throughout the right-of-way, clearing the right-of-way, constructing access roads for construction, erecting the transmission towers, and stringing the conductors, as well as decommissioning of the existing 138 kV transmission lines, construction areas, and access roads.

4.4.5.1.1 Right-of-Way Clearing

Clearing would be required for the transmission line right-of-way, access roads and laydown areas (see Volume 1 Appendix A Vegetation, Clearing, and Debris Management Plan).

Clearing would be required beyond the edge of the right-of-way to remove danger trees. These are trees that either would pose a safety risk during construction or a reliability risk for the lines after construction. The extent of this tree management area (see Figure 4.26) would depend on the height of the trees and the slope of the terrain in relation to the transmission line conductors and transmission line towers. Vegetation would be allowed to regrow within the tree management area.

Clearing in the transmission corridor would involve felling, yarding, and disposing of tall-growing vegetation within the clearing boundaries. Various methods, both manual and mechanical, would be used for these activities. The choice of method would depend on site conditions and the contractors' work methods and equipment.

The access roads and associated laydown areas would be sited as close to the transmission lines as possible.

Due to the proximity of trees to the existing 138 kV transmission lines, the clearing adjacent to the lines couldn't be started until the lines are de-energized, for safety reasons. Therefore, clearing work would occur twice: prior to the construction of each of the two 500 kV transmission lines.

4.4.5.1.2 Tower Foundations and Anchor Installation

Depending on terrain and soil conditions, a variety of foundation and anchor types would be used for the project, including steel grillage footings and rock foundations.

Steel grillage footings would be pre-assembled and flown or trucked to each tower site. A small excavation would be required for the grillage, with some larger excavations and backfill required depending on soil conditions. Excavations would typically be conducted by rubber-tire backhoe; blasting may also be necessary in situations where hard rock or large boulders are encountered within the excavations.

Rock foundations would require drilling in the rock to install and grout anchor bolts. Then a small concrete foundation would be poured on top. In rock, after removing overburden with a light rubber-tired backhoe, light drilling equipment would be used to provide holes for grouted anchor rods for both the foundation and anchors. Approved corrosion protection would also be applied to metal parts of the foundation and anchors.

4.4.5.1.3 Concrete and Grout Production and Placement

The use of concrete along the transmission line corridor would be limited to tower rock footing pours, requiring concrete to be placed inside a wooden form. Concrete would be produced by a local supplier and, depending on the ease of access to specific sites, would either be transported by concrete truck or by helicopter.

Grouting of anchor dowels would be required at rock footing sites. Grout would be trucked in bags to the site and mixed on-site using a small mixer. In areas that would only be accessed by helicopter, the grout would be premixed at a staging location and transported to site via helicopter.

4.4.5.1.4 Assembly and Erection of Transmission Structures

Assembly of the structures would be done by either crane or helicopter, depending on access.

For assembly by crane, additional site preparation work would be carried out at each structure site to provide a level bench to assemble the mast and bridge components of the structures and locate the erection crane. The structure components would be delivered to the site and assembled at the structure location. The assembled tower would then be lifted by a crane to a vertical position over the foundation.

For assembly by helicopter, the structures would be assembled in a common staging area and lifted to the site by helicopter. The structure would be secured to the foundation, guy wires would be attached, and the structure would be plumbed.

4.4.5.1.5 Installation of Counterpoise

Counterpoise may be required for safety and to protect the circuit in the event of lightning strikes. Counterpoise installation would involve burying a single- or double-galvanized wire in a trench, approximately 0.5 m deep and 0.3 to 0.6 m wide, and excavated into mineral soils. Where practical, the counterpoise would be laid within trenches along access road routes for ease of installation. In rocky areas, the counterpoise wire would be attached to exposed rock between pockets of mineral soil. The need and locations for counterpoise would be determined during detailed design of the transmission line.

4.4.5.1.6 Conductor Stringing

Conductor stringing would involve installing sheaves on structures, stringing pilot lines by helicopter, pulling the conductors, and sagging and clipping the conductors to the insulators.

The first activity would be establishing level puller or tensioner sites along the alignment from which the conductor would be installed. The geometry of the pull section would influence the spacing and location of the puller or tensioner sites. Puller sites would just be large enough to site the pulling machine and pilot line tensioner. The tensioner sites

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would be larger to accommodate the tensioner, reels of conductor for the pull, crane for lifting the reels, and pilot line winder.

While establishing the work sites, crews would install insulators, hardware, and sheaves on the structures. This work would require pickup trucks or light-duty crane trucks, and the insulators or sheaves would be raised to the structure by winch. After the insulators had been installed, a helicopter would pull a pilot line from which the larger sock line is pulled through the sheaves, and then the conductor would be pulled through. When pulling the conductor, it would be necessary to have a complete line of sight over the length of the pull section in case of a mechanical problem or if an obstacle is encountered.

Sagging of the conductor would then be undertaken, which would require using a bulldozer to provide tension to pull the conductor into the sag position. Following sagging, each conductor would be marked and fastened to the insulator assemblies and the sheaves would be removed. Other activities would include dead-ending, which pins the conductor ends to dead-end structures, and splicing, joining lengths of conductor with a hydraulic press, and installing spacers to bundled conductors.

Where a ground wire or fibre optic cable would be required, this would be installed at the same time as the conductors.

4.4.5.1.7 Upgrades to Peace Canyon Substation

To connect the proposed new transmission lines and substation at Site C to the BC Hydro integrated electrical system, the following upgrades would be required at the Peace Canyon substation:

- Expand the existing 500 kV switchgear building to accommodate two new 500 kV gas-insulated line terminations
- Install two new 500 kV gas-insulated line terminations (designated 5L5 and 5L6) and associated gas insulated switchgear inside the switchgear building
- Construct steel structures for new transmission line terminations

The upgrades will be within the limits of the existing BC Hydro facilities. The site of the switchgear building extension was cleared during the construction of the Peace Canyon Project. The vegetation that has regrown since then would be cleared and grubbed.

4.4.5.1.8 Decommissioning of the 138 kV Transmission Lines

The existing 138 kV transmission lines between the Site C substation and G.M. Shrum would be decommissioned after completion of the Site C substation and energization of the first 500 kV line between the Site C and Peace Canyon substations.

Some of the line near G. M. Shrum may be retained to supply potential load customers in the area; otherwise, the line termination equipment at G.M. Shrum would be removed.

The existing 138 kV transmission lines are constructed of treated wood poles and steel-reinforced aluminum conductors. The wood poles are sufficiently old that they could not be reused, so would be sent to a pole recycling facility for disposal or recycling. Conductors and conductor hardware would be recycled at a local scrap metal recycling facility. Glass insulators would be kept as spares, provided they are in good condition, and porcelain insulators would be disposed of at a local landfill.

The equipment needed to remove the poles would include a crane for lifting the poles, log trucks for shipping poles to the pole recycler, dump trucks for removing hardware and conductor to the disposal facility, and a rubber-tired backhoe for excavating pole butts where required.

The poles would be cut off and the pole butts left in the ground where possible. Where the poles are located near an environmentally sensitive area, such as a watercourse or wetland, or where the poles are located where a new tower foundation is required, the butts would be removed, the soil excavated to remove contaminants, and the excavations backfilled with clean material.

4.4.5.1.9 Reclamation

The temporary access roads, laydown, and staging areas used for construction of the transmission lines would be reclaimed.

4.4.5.2 Site C Substation

4.4.5.2.1 Site Preparation and Grading

The substation site would be cleared and grubbed.

The substation site would be graded and structural fills installed as required to support the equipment foundations.

Grading would require the use of bulldozers, excavators, and dump trucks to excavate any unsuitable foundation material, which would then be replaced with structural fill obtained from the dam site area.

4.4.5.2.2 Ground Grid and Fencing

The ground grid for the substation would consist of copper ground rods installed using a small drill rig and copper conductors installed by excavating shallow 1 m deep trenches in a grid pattern over the entire substation site.

Chain-link fencing would be installed around the perimeter of the substation for safety and security.

4.4.5.2.3 Concrete Placement

Concrete would be required for all equipment and control building foundations, which would be obtained from the Site C batch plant and placed using concrete trucks and pumpers.

4.4.5.2.4 Installation and Testing of Electrical Equipment

Once the equipment foundations had been constructed, the electrical equipment would be installed. This would include the assembly of the substation control building, the assembly of the power transformers and filling them with oil, the installation of steel support structures, and the installation of other high-voltage electrical equipment.

Equipment installation would require the use of cranes and crane trucks to lift and position equipment and equipment supports.

The transformer installation would require the use of a large low-bed trailer to ship the transformer tanks to the site, and the use of either a large crane or a hydraulic jacking system to move the transformer onto its foundation. Transformer oil would be shipped to site in tanker trucks. The oil would be treated at site (removal of impurities and water) using a portable transformer oil treatment plant. During oil treatment, the oil would be stored in double-walled steel tanks; then the oil would be pumped into the transformer tanks. The transformers would be located within an oil containment system with a capacity greater than that of the transformers to completely contain a potential spill.

Circuit breakers installed on-site would be insulated with sulphur hexafluoride (SF_6) gas, and the installation contractor would be required to follow BC Hydro's SF_6 gas management policies.

Testing and commissioning would require the use of high-voltage testing equipment to confirm that the electrical equipment is installed properly and is ready for energization.

4.4.6 Highway 29 Realignments

All road construction would be performed in accordance with the current version of the B.C. *Standard Specifications for Highway Construction*.

The Cache Creek segment would have to be completed prior to Stage 2 diversion, since after diversion water levels would be above the bridge level during large floods. The other five segments would have to be completed prior to reservoir filling. The construction schedule for the six segments is shown in Figure 4.42.

Construction activities for Highway 29 would include works within the existing and proposed highway rights-of-way, at gravel pits and borrow sites located within the inundated areas, and at the proposed riprap quarries.

Site preparation would be completed at each segment and at laydown, borrow, quarries and gravel pit locations. Clearing and grubbing would remove all commercial and non-commercial vegetation.

Activities for construction of the six realigned segments of Highway 29 would be as described in Sections 4.4.1 and 4.4.2, with typical site preparation, quarrying and excavating, and road construction, respectively.

Grading to construct the roadbed and causeways would be completed at each segment, including the connections to new and existing driveways, local roads, temporary construction roads, and temporary traffic detours. Unsuitable native material or surplus excavated material would be disposed of within the proposed highway right-of-way or in designated areas within the inundated zone.

The Highway 29 running surface would be asphalt pavement. Asphalt plants would be located in the gravel pits.

Most of the new highway segments and bridges would be located away from the existing highway, enabling construction to take place with minimal effect to the existing highway and traffic. Temporary detours would be necessary where portions of the new highway overlap the existing highway. At these locations, traffic flow would be managed, and could include sections of alternating single-lane traffic controlled by flag persons or short-term closures. Standard traffic control measures, such as signage, road markers, and flag persons, would be used for guiding traffic during construction.

The asphalt pavement and sub-base would be removed from abandoned sections of Highway 29 within the reservoir. Some reclaimed asphalt would be recycled for use in the new construction. Abandoned sections of the highway located outside of the reservoir would either be converted to local access roads or decommissioned and restored to natural conditions. The existing bridges at Farrell Creek and Halfway River may remain in place. Lynx Creek and Cache Creek bridges would be dismantled. The existing bridge at Cache Creek may be returned to BCMOTI for reuse.

All temporary construction roads and laydown areas would be deactivated and reclaimed.

4.4.7 Quarried and Excavated Construction Materials

The activities common to quarrying rock and excavating of earthen construction materials are described in this section.

4.4.7.1 Riprap and Bedding Production

The quarries identified in Section 4.3.5 would be used for the production of riprap and bedding. Drilling and blasting would be used to break the rock. The blast hole pattern and explosive loading would depend on the rock characteristics and the size of riprap required.

After each blast, the rock would be sorted by equipment into stockpiles of the required riprap sizes. This could include loading rock into a quarry rock separator. Bedding would be selected from the finer rock or screened if required to produce the specified gradation.

The yield of a quarry (ratio of volume of usable materials to total excavated volume of material) depends on factors such as the joint spacing in the rock and the drilling and blasting techniques employed. The surplus materials listed by quarry in Table 4.8 and Table 4.9 would be unsuitable for use in the Project only because they do not meet the specified gradations for riprap and bedding. Such materials could be suitable for use by others in the future, e.g., crushed for rail ballast, road base, or asphalt aggregate.

4.4.7.2 Excavating

Blasted rock and earth construction materials would require excavation and may require further processing prior to being transported to the site.

Excavation would typically be performed by excavator, loader, bulldozer, or scraper.

4.4.7.3 Moisture Conditioning

The moisture content of impervious material may require adjustment in order to meet compaction requirements.

Water would be added to increase the moisture content using such methods as a tank and spray bar mounted on a vehicle or irrigation sprays. The material would be wetted and then mixed by a bulldozer or grader until a consistent moisture content is obtained. Moisture could also be added by spraying the material while on the conveyor and then mixed during stockpiling.

To reduce moisture content, the material would be disced to expose more surface area to promote drying of the material. Several turnings of the material could be necessary to achieve the correct moisture content. Another method would be to stockpile the material and allow the water to drain to the bottom.

4.4.7.4 Crushing and Screening

Crushing of granular materials involves mechanical breakage of particles into smaller sizes. A primary crusher and secondary crusher would be used in combination with screening. After crushing, the material would be passed through one or more screens of specified size. Screened materials would then be stockpiled.

4.4.7.5 Washing

Material may require washing to remove fine-grained particles in order to meet the specified gradation.

4.4.7.6 Stockpiling

Processed material would be stockpiled until required, or for blending with other materials, drying, or confirming of specification prior to using.

4.4.7.7 Surplus or Unsuitable Materials

Surplus or unsuitable materials at off-site sources would be disposed of at the source, as described in the applicable construction materials development plans (see Section 4.3.5). Unsuitable materials excavated from within the dam site area would be relocated as described in Section 4.4.3.

4.4.7.8 Reclamation

A reclamation plan would be developed for each quarry and excavated materials source.

Table 4.11 Activities to Occur at Quarries and Materials Sources

	Drill and Blast	Excavate	Sort	Condition Moisture	Crush	Screen	Wash	Stockpile
85th Avenue Industrial Lands		■	■	■				■
Wuthrich Quarry	■	■	■			■		■
West Pine Quarry	■	■	■			■		■
Portage Mountain/ Bullhead Mountain	■	■	■			■		■
Other Sources	■	■	■		■	■	■	■

4.4.8 Access Roads and Rail

4.4.8.1 Construction Phase Activities

All access road construction works would be undertaken in accordance with the current version of the B.C. *Standard Specifications for Highway Construction*, the *Forest Practice Code – Forest Road Engineering Guidebook*, and any applicable standards for operational equipment, and in conformance with pipeline regulatory requirements. Construction of rail works would be in conformance with CN Rail standards and guidelines.

Construction of access roads would be in accordance with typical site preparation, quarrying, and excavating, and with road construction activities described in Sections 4.4.1 and 4.4.2.

Construction of access roads would require small quantities of riprap and bedding for drainage works such as erosion protection at culverts and ditches as well as granular material. Some fill material would come from the excavations for the road grade and the remainder would be sourced off-site.

The granular materials for the north bank access roads to the dam site area would come from the dam site area or commercial pits. Riprap and bedding would come from the quarries at Wuthrich or Portage Mountain. Where riprap and bedding from Wuthrich are used early in the Project, it may be replaced with the more durable rock from Portage Mountain later in the Project.

The granular material for the Project access road on the south bank would come from the Del Rio Pit and the dam site area. Materials for upgrading the existing roads on the south bank would come from the Del Rio Pit or commercial pits. Riprap and bedding would come from the West Pine Quarry.

Road grading would be required for each access road. Unsuitable native material or surplus excavated material would be disposed of within the proposed right-of-way or in designated areas within the inundated zone. The grading, drainage, and finishing requirements would vary depending on access requirement and whether the facility would be temporary or permanent. Road use and maintenance agreements would be established with the forestry and oil and gas resource road licence holders. Crossing agreements may need to be established with pipeline owners and operators. Upgrades may include pipeline bridging, isolation, or protection.

Standard traffic control measures would be used for guiding traffic during upgrades to existing roads.

Access road construction depends on the component activity schedule. Based on current forecasting, the current access road construction schedule is presented in **Error! Reference source not found.**.

As described in Section 4.3.7, the Project access road would remain in service after construction. All temporary construction service roads would be decommissioned, or reclaimed and restored to their pre-existing service level following construction, or would be inundated by the reservoir when filled. The abandoned section of Old Fort Road would be decommissioned and returned to natural conditions.

4.4.8.2 Transportation of Extraordinary Loads

Dam components would need to be transported from the port of entry to Site C dam utilizing highways within Alberta and British Columbia. Some of these components would require routing consideration based on weight and dimensions and possible highway infrastructure limitations.

BC Hydro engaged a the service of a specialized industrial mover to evaluate possible rail and road transportation routes for the extraordinary loads. The evaluation concluded that for the larger dimension components the ports of Duluth, Minnesota and Houston, Texas would be suitable facilities for accepting these loads. Transportation would be via highway through the United States, into Canada at Coutts Alberta, then into British Columbia.

The proposed routing, along with the potential load parameters were provided to staff with the British Columbia Ministry of Transportation & Infrastructure Commercial Vehicle Safety and Enforcement Branch Provincial Permit Centre in Dawson Creek, B.C. The type of loading required for the Project is not unusual and there are numerous companies which specialize in transporting extraordinary dimension loads who are familiar with the permitting process required by state and provincial jurisdictions generally, and British Columbia specifically.

Based upon information from the British Columbia Ministry of Transportation & Infrastructure, Provincial Permit Centre, Commercial Vehicle and Safety Enforcement Branch, transportation of the components required by the Project would not require upgrades or new construction of roadways or structures along the proposed haul routes. However, the following would have to be taken into account by the industrial movers:

- On some bridges there may be clearance issues with railing heights and possible width restrictions that would not require structural improvements but would require possible temporary removal of railing to increase height clearance and width
- Any transport configurations must meet the 85 tonne route bridge restrictions and would be required to go through the extraordinary load application process
- Seasonal load restrictions would affect timing of transporting over weight loads
- There would be a requirement to cross bridge structures with traffic closed and travel down the centre lane for loads that are too wide to cross with oncoming traffic. Travel time restrictions such as Monday to Friday, travel time of day restrictions, pilot car requirements and a traffic management plan would be Part of the approval process.

4.5 Operations

4.5.1 Dam, Generating Station, and Spillways

The Project would be operated, managed, and maintained in accordance with:

- The terms and conditions of all permits, licences, and approvals issued for the Project
- Canadian and international dam safety practices
- The Operations Environmental Management Program, described in Volume 5 Section 35 Summary of Environmental Management Plans

4.5.1.1 Dam Safety

British Columbia is one of four provinces in Canada with a formal dam safety program. There are approximately 1,900 dams in the province, including some of the largest structures in Canada. These dams are regulated under the British Columbia Dam Safety Regulation, with oversight by the Dam Safety Program, B.C. Ministry of Forests, Lands and Natural Resource Operations. The Dam Safety Section, under the Comptroller of Water Rights, is responsible for administration of the provincial dam safety program and regulation of major dams (9 m or higher) throughout the province. BC Hydro's Dam Safety Program complies with the British Columbia Dam Safety Regulation. Dam safety management of the Project would be undertaken as Part of BC Hydro's Dam Safety Program and would comply with the British Columbia Dam Safety Regulation.

Dam operation, maintenance, and surveillance encompass a number of activities and constraints so that the reservoir-retaining structures are managed safely. An Operation, Maintenance, and Surveillance Manual documents:

- Procedures and practices required to operate the dam safely under various conditions
- Prioritization of the maintenance activities that should be carried out for dam safety
- Surveillance, including visual inspections and instrument monitoring, as a means of checking whether the dam is performing satisfactorily and as intended by the design

Operation, Maintenance, and Surveillance Manuals would be prepared for the cofferdams and the permanent reservoir retaining structures and associated equipment. Operation, Maintenance, and Surveillance Manuals would follow the CDA Dam Safety Guidelines (CDA 2007) and comply with the B.C. Dam Safety Regulations. The Operation, Maintenance, and Surveillance Manuals would be submitted to the B.C. Comptroller of Water Rights with the Operation, Maintenance, and Surveillance Manual for the cofferdams submitted prior to diversion of the river through the diversion tunnels and the Operation, Maintenance, and Surveillance Manual for the dam submitted prior to reservoir filling. In both cases the Operation, Maintenance, and Surveillance Manuals would be submitted in sufficient time to make any changes that the Comptroller of Water Rights may require prior to impounding water.

The goal of surveillance is to identify deviations in performance so that corrective action or risk mitigation measures can be implemented before adverse consequences result. Instrumentation would be installed to measure the performance relative to the expected performance based on the design analyses. Instrumentation would include devices that measure water pressures in the foundation or body of the dam and buttress (piezometers) and devices that measure deformations. During and after reservoir filling, the readings from the instrumentation would be checked against expected values. If the readings indicated unsatisfactory performance, remedial work would be undertaken. For example, as described in Section 4.3.1, a drainage system would be installed as Part of the seepage control measures to limit seepage pressures acting on the buttress. The effectiveness of this drainage system would be monitored by piezometers. If measured seepage pressures are higher than expected from the design, additional drain holes would be drilled until the pressures were within expected values. As described in Volume 5 Section 37 Requirements for the Federal Environmental Assessment, the buttresses would be designed to be stable even if the seepage control measures are completely ineffective. Therefore, there would be sufficient time to undertake any remedial measures required.

In accordance with the CDA Guidelines, Emergency Preparedness Plans describe the notifications to be issued and, in general terms, the actions expected from downstream responders in the event of a dam failure or passage of a major flood. Emergency Preparedness Plans are not response documents but contain essential information such as inundation maps and flood arrival details, so that local authorities can develop their own response plans. In the event of an emergency at the dam, the local authorities and other downstream stakeholders would be contacted. The CDA recommends that distribution of Emergency Preparedness Plans should generally be limited to those who have a legal and defined emergency response role. BC Hydro limits the distribution of Emergency Preparedness Plans for security reasons.

Emergency Preparedness Plans would be prepared for the cofferdams and the permanent reservoir-retaining structures. Emergency Preparedness Plans would follow the CDA Dam Safety Guidelines and comply with the B.C. Dam Safety Regulations. The Emergency Preparedness Plans would be submitted to the B.C. Comptroller of Water Rights, with the Emergency Preparedness Plans for the cofferdams submitted prior to diversion of the river through the diversion tunnels and the Emergency Preparedness Plans for the dam submitted prior to reservoir filling. In both cases, the Emergency Preparedness Plans would be submitted in sufficient time to make any changes that the Comptroller of Water Rights may require prior to impounding water.

4.5.1.2 Generation Operations

Similar to BC Hydro’s other generating facilities on the Peace River, the Project would be operated to respond to provincial electricity demand. The generation and flow of electricity would be controlled by BC Hydro’s System Control Centre.

Reservoir water levels and downstream flows during operation of the Project are characterized in Volume 2 Section 11.4 Surface Water Regime.

4.5.1.3 Spillway Operation

The gated spillway would discharge water (spill) whenever the inflow to the reservoir exceeded the available capacity of the generating units. The gates would be operated to maintain the maximum normal reservoir level, which would only be exceeded when all of the operating spillway gates are open. Spill from the Project is described in Volume 2 Section 11.4 Surface Water Regime.

As described in Section 4.3.1.5, the spillway would have a capacity of 10,100 m^3/s at the maximum normal reservoir level. Extrapolation of flood frequency relationships beyond 1,000 years is generally discouraged (CDA 2007); however, extrapolation suggests that the annual probability of exceeding the maximum normal reservoir level with all spillway gates open is less than 1 in 10,000.

The spillway gates and undersluices would be capable of drawing the reservoir down to elevation 444 m, at which level the undersluices could pass upstream flows of 1,600 m^3/s. The facility discharge to accomplish this drawdown would likely be limited to 5,000 m^3/s to limit downstream flooding and scour. With a mean daily inflow of 1,250 m^3/s (equal to the mean annual flow at the site) and a maximum discharge of 5,000 m^3/s, it would take approximately 9 days to lower the reservoir from the maximum normal reservoir level to elevation 444 m. A drawdown to elevation 444 m for inspection, maintenance, and repairs in the approach channel would likely be scheduled for the summer between the flood hazard season and high winter flows for generation. The approach channel lining would be designed and constructed to have a life of over 100 years; therefore, a drawdown for repairs is unlikely.

4.5.1.4 Maintenance

Maintenance policies and procedures would be implemented to ensure that structures and equipment are maintained in a safe operating condition. Regular maintenance work, including periodic servicing, such as greasing and overhauling equipment, clearing drains, and removing debris, would be done in conjunction with scheduled inspections.

Non-regular maintenance work such as painting, repairs, or equipment replacement would be undertaken as deemed necessary by either inspection or by equipment aging.

Debris accumulated on the trashracks on the power intakes and at the spillway headworks would be removed. Wood debris would be disposed of through a combination of burning, composting, or landfilling, in accordance with provincial regulations in place at the time of disposal. Other debris would be disposed of in landfill, in accordance with provincial regulations in place at the time of disposal.

Regular inspection and maintenance would be undertaken on spillway equipment, including spillway gates, electrical hoist equipment, gantry travel equipment, controls and limit switches. Regular maintenance would include draining and refilling hoist gearboxes, lubricating moving parts, and replenishing the grease supply for the hoist screw lubricators.

Maintenance of structural steel elements, such as the gates, gate guides, hoists, hoist structures, and conduits, would also be undertaken on a regular basis.

Periodic maintenance would be expected to include the following tasks:

- Preventative maintenance inspections and tasks such as:
    - Annual servicing of cranes, gantry hoists, compressors, pumps, fans, and cooling water intakes
    - Semi-annual servicing of filters and intake gate hoists
    - Quarterly elevator inspection and servicing
    - As-required brush and slip ring maintenance
- Annual unit(s) inspection requiring units(s) outage, during which the following is typically performed:
    - Generator winding dielectric and corona testing
    - Transformer oil testing and winding insulation testing
    - Medium voltage bus, and auxiliary systems contacts and connections cleaning, adjustment, and setting
    - Mechanical systems – speed switch, governors, shaft packing, vacuum valve – inspection and general maintenance
    - Turbine runner and fixed-Part inspection

- Trash rack inspection and cleaning
- Bearing oil system inspection

4.5.2 Reservoir

4.5.2.1 Reservoir Operation

The reservoir would have one of the narrowest normal operating ranges of reservoirs in BC Hydro's system, with relatively little fluctuation in water levels throughout most of the year (see Volume 2 Section 11.4 Surface Water Regime for reservoir level fluctuations). Key reservoir levels are shown in Table 4.2.

In exceptional circumstances such as extreme floods, the proposed reservoir could rise above the maximum normal level for short periods. As described in Section 4.5.1, this would be a very rare occurrence.

The reservoir could be drawn down below the minimum normal reservoir level for unusual system requirements or system emergencies. The current expectation is the lowest reservoir level at which the generating station could operate during a system emergency would be elevation 455 m.

The spillway undersluices have been designed so that the reservoir could be lowered to an elevation of 440 m for inspection and repairs of the dam, generating station, or spillways, but this would be a rare occurrence.

4.5.2.2 Debris Management

Maintenance of the debris boom logs, cable, and anchoring points in the reservoir would be undertaken as necessary, based on inspections.

Reservoir debris management is described in Volume 1 Appendix A Vegetation, Clearing, and Debris Management Plan.

4.5.2.3 Maintenance of Hudson's Hope Shoreline Protection

Maintenance of the shoreline protection features would require access for vegetation and earthwork maintenance. The berm may require minor repairs caused by severe weather events, or features may require repair. The slopes above the berm may require removal of mud and vegetation that has accumulated on the berm from the slopes above. The riprap may require repair periodically.

4.5.3 Substation and Transmission Line to Peace Canyon

Operation of the transmission system would involve transmitting electricity through the conductors between the Site C and the Peace Canyon substations. The flow of electricity on the transmission lines would be controlled by BC Hydro's System Control Centre.

Vegetation maintenance would be carried out to ensure public and worker safety and system reliability. Tall-growing vegetation that is capable of encroaching on the transmission line and hazard trees adjacent to the right-of-way that are capable of falling onto the lines would be removed or pruned as necessary to meet BC Hydro clearance standards.

Maintenance activities would include manual, mechanical, and chemical methods for maintaining vegetation at a low height to protect electrical facilities; each of these general methodologies has many options.

Overview inspections of overhead structures would be performed regularly and detailed inspections would occur approximately every five years. Overhead structure maintenance could be undertaken from the ground, or by helicopter in sensitive areas or where ground access is difficult or impossible.

Refer to Section 4.5.6 for operation and maintenance of transmission line access roads.

4.5.4 Highway 29

Upon completion of the new segment of Highway 29, the new facility would be operated and maintained as a provincial public highway by the BCMOTI.

4.5.5 Quarries and Excavated Construction Materials Sources

When aggregates are required for maintenance of the dam and associated private access roads, permits would be obtained as required by the regulations in place at the time or commercial pits would be used to source materials.

4.5.6 Access Roads

Provincial public roads would be operated and maintained by BCMOTI.

Permanent dam and generating station and transmission line corridor access roads would be operated and maintained by BC Hydro. These activities would include overview inspections, occasional culvert and bridge replacements, brushing, and repairing eroded areas on the road surface. The frequency of overview inspections would be determined based on road risk ratings and could range from six months to five years. The condition assessments made on these inspections would be used to prioritize the maintenance program in relation to safety and environmental considerations, business needs, and maintenance constraints.

4.5.7 Sustaining Capital Expenditure

The typical lifespan of major electrical and mechanical components in a hydroelectric facility ranges from 30 to 40 years for the generating equipment, and from 80 to 90 years for major mechanical components such as the spillway gates. The Project would be designed so that all electrical and mechanical components could be refurbished or replaced cost-effectively as they approach the end of their service life.

In addition, inspection, testing, and maintenance programs would be established to maximize the expected lifespan of these components between major refurbishment or equipment replacement cycles.

The components of the ancillary mechanical and electrical systems, such as water supply and lighting, typically have shorter lives. These systems would be maintained and components would be replaced as necessary during the course of normal maintenance of the Project.

The civil structures comprising the dam, generating station, and spillway would be designed to last indefinitely, with regular inspection, maintenance, and periodic repairs or replacements such as:

- Replacement of weathered or damaged riprap on the upstream face of the earthfill dam, and in the tailrace or discharge channel
- Repair of freeze and thaw damage to concrete
- Replacement of roof membranes
- Repair of approach channel lining

The frequency of such repairs and replacement would be expected to range from 25 years for roof membranes to 50 years, or more for freeze and thaw damage.

Recent examples of BC Hydro investing in its facilities on the Peace River to prolong their operational capacity include:

- The generator stator replacement and turbine overhaul project at the Peace Canyon generating station, which came into operation in 1980
- The spillway chute and flip bucket refurbishment at the W.A.C. Bennett Dam, which came into operation in 1968
- Units 1 to 5 turbine replacements at the G.M. Shrum generating station at the Bennett Dam

4.6 Project Decommissioning

BC Hydro expects that the Project would be operated for over 100 years, and that decommissioning of permanent structures is not currently contemplated.

In addition to the dam, generating station, and spillway, the following permanent facilities would be retained and maintained:

- Substation
- Transmission lines
- Project access road
- Realigned Highway 29
- Hudson's Hope shoreline protection
- North bank access roads

Should a proposal be made to decommission the Site C dam and generating facilities in the future, BC Hydro would address a plan for decommissioning and restoration in accordance with the applicable regulations at that time.

An Environmental Protection and Monitoring Plan would be developed for decommissioning to implement applicable measures for environmental protection, and to restore the area to conditions deemed acceptable at the time of decommissioning. Further details on decommissioning would depend on regulations and practice at the time of a decision to decommission.

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Figure 4.33 Rev 1 Highway 29 Realignment – Cache Creek Segment

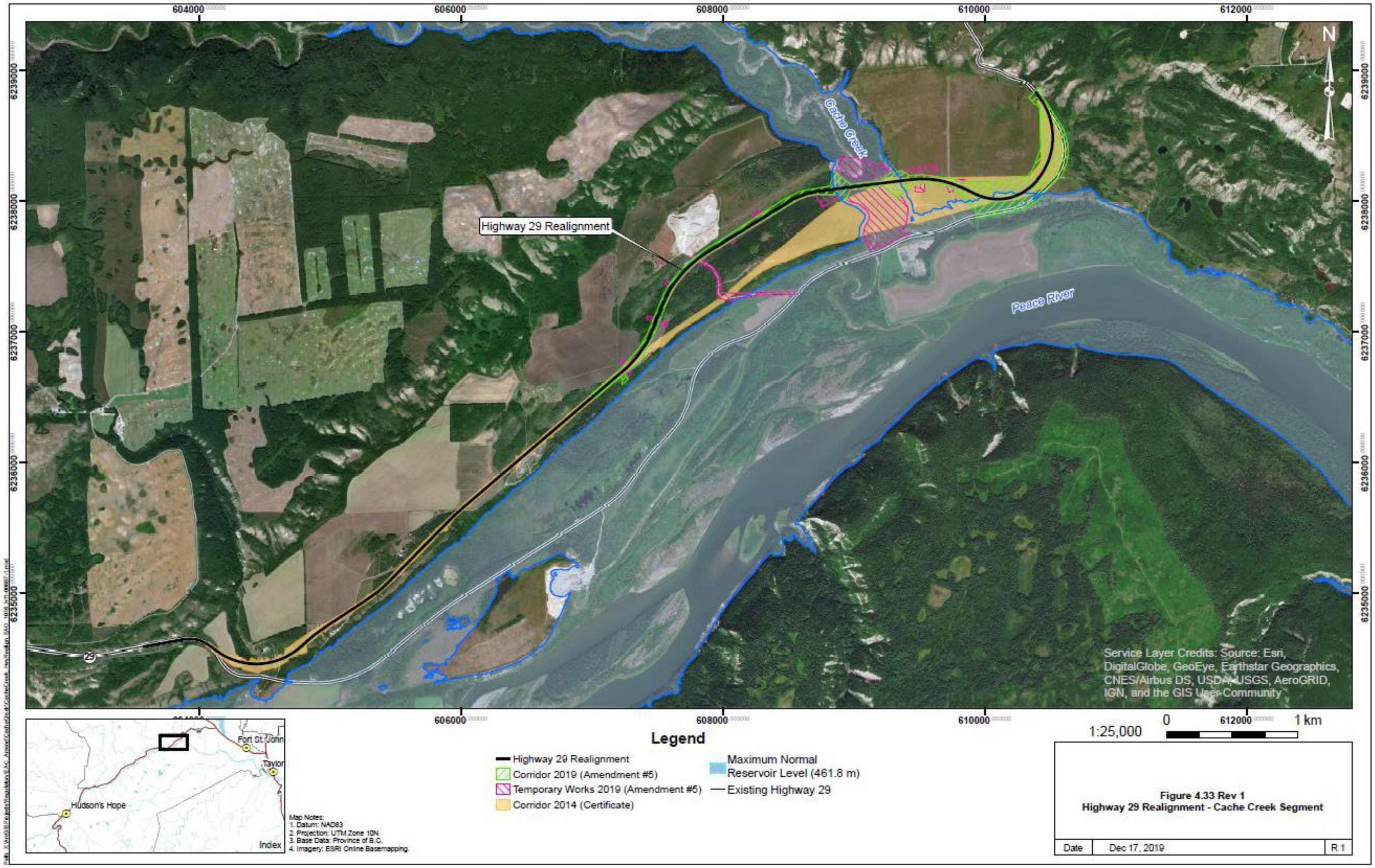

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Figure 4.34 Rev 1-Detail Highway 29 Realignment – Cache Creek Segment