Site C hydroelectric project: predicted changes in Peace River morphology and sediment transport

Craig Nistor[a], Violeta Martin[b]

Knight Piésold Ltd., Vancouver, BC, Canada

[a]cnistor@knightpiesold.com
[b]vmartin@knightpiesold.com

ABSTRACT

The 1100 MW Site C Hydroelectric Project involves the construction of a large dam on the Peace River in British Columbia, Canada. The Environmental Impact Statement (EIS) for the project considered technical, socio-economic and environmental aspects and described the predicted effects in the context of previous hydroelectric development and future climate change. Studies were based on long-term field observations and comprehensive modeling. The geomorphology and sediment transport study completed for the EIS predicted changes in channel morphology and suspended sediment loading during construction and operations, which could have ramifications for domestic and industrial water users and aquatic resources. Suspended sediment and turbidity gauging were used to characterize baseline conditions in the Peace River and its key tributaries. A three-dimensional hydrodynamic model was used to simulate suspended sediment dynamics and deposition within the Site C reservoir. During operations the reservoir will trap most of the incoming sediment, with the initial reservoir volume predicted to be reduced by 2.5% after 50 years. The corresponding reduction in mean annual suspended sediment load is predicted to be 54% immediately downstream of the reservoir, but only 2% 300 km downstream at the Town of Peace River, Alberta, because of large sediment inputs from tributaries.

1. INTRODUCTION

The Site C Clean Energy Project is a hydroelectric project currently under construction on the Peace River in northeastern British Columbia (BC), Canada. The Site C Project is being developed by the publically owned power utility, BC Hydro. The Site C Project will comprise a 60 m high earthfill dam, an 1,100 MW generating station, and an 83 km long reservoir (Figure 1). Site C will provide approximately 5,100 GW-hours of energy per year to BC Hydro's integrated electricity system.

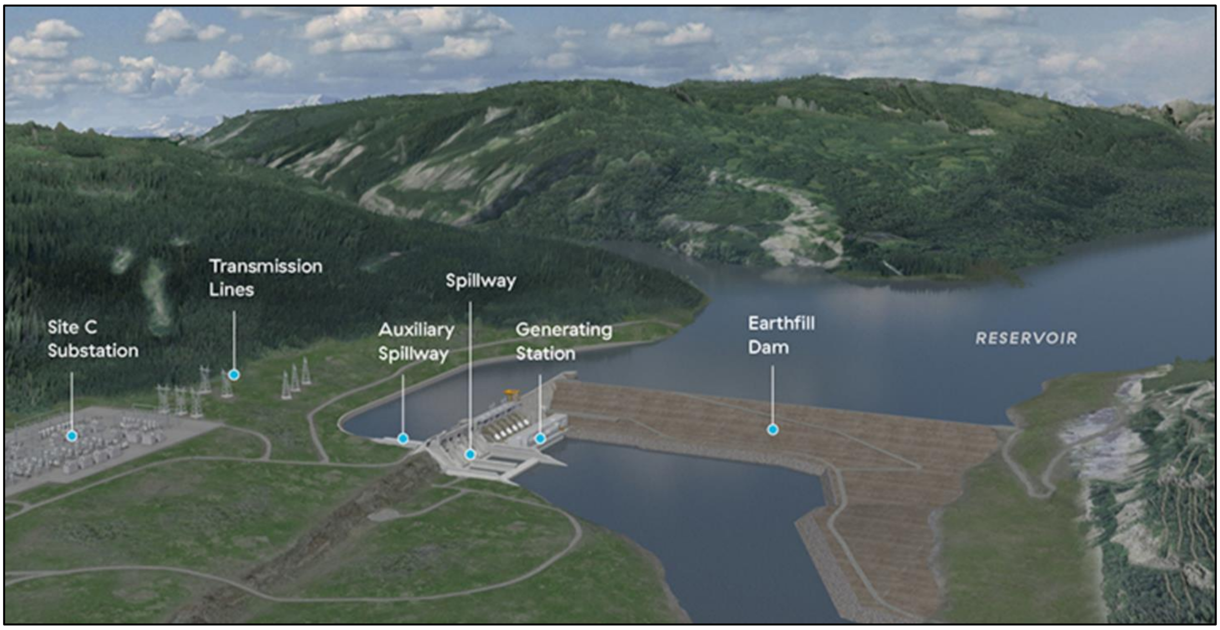


Figure 1 Artist's rendition of the Site C dam, generating station and spillways (BC Hydro 2017).

Site C will be the third hydroelectric project on the Peace River. The two existing projects, constructed in the 1960s and 1970s, are located upsteam of Site C. As the third project on one river, Site C will gain significant efficiencies by taking advantage of water storage in the upstream reservoirs. Natural river flow rates in the region exhibit strong seasonality, with high flows due to snowmelt and rainfall in the spring and early summer, and low flows throughout the long winters when energy demand is greatest. The largest of the two upstream reservoirs (Williston Reservoir, impounded by the W.A.C. Bennett Dam) has a surface area of 1,773 km^2 and is capable of shaping the annual flow regime of the Peace River. Spills from Williston Reservoir are rare. This means that Site C will generate approximately 35 per cent of the energy produced at the W.A.C. Bennett Dam, with only five per cent of the reservoir area.

BC Hydro received final approval for Site C in December 2014. Construction started in summer 2015 and is expected to be completed in 2024. A comprehensive Environmental Impact Statement (EIS) was prepared for Site C that described the predicted effects of the project – in the context of previous hydroelectric development and future climate change – and described how the effects will be mitigated, as part of a commitment to sustainable water resource management in the Peace River watershed (BC Hydro 2013). The fluvial geomorphology and sediment transport study for the EIS (Knight Piésold 2012) predicted changes in channel morphology and suspended sediment dynamics during the construction and operations phases of the project. These predictions were then used to support the effects assessments for water quality, aquatic productivity, fish habitat, and instream infrastructure in the Site C Reservoir and downstream from the Site C Dam.

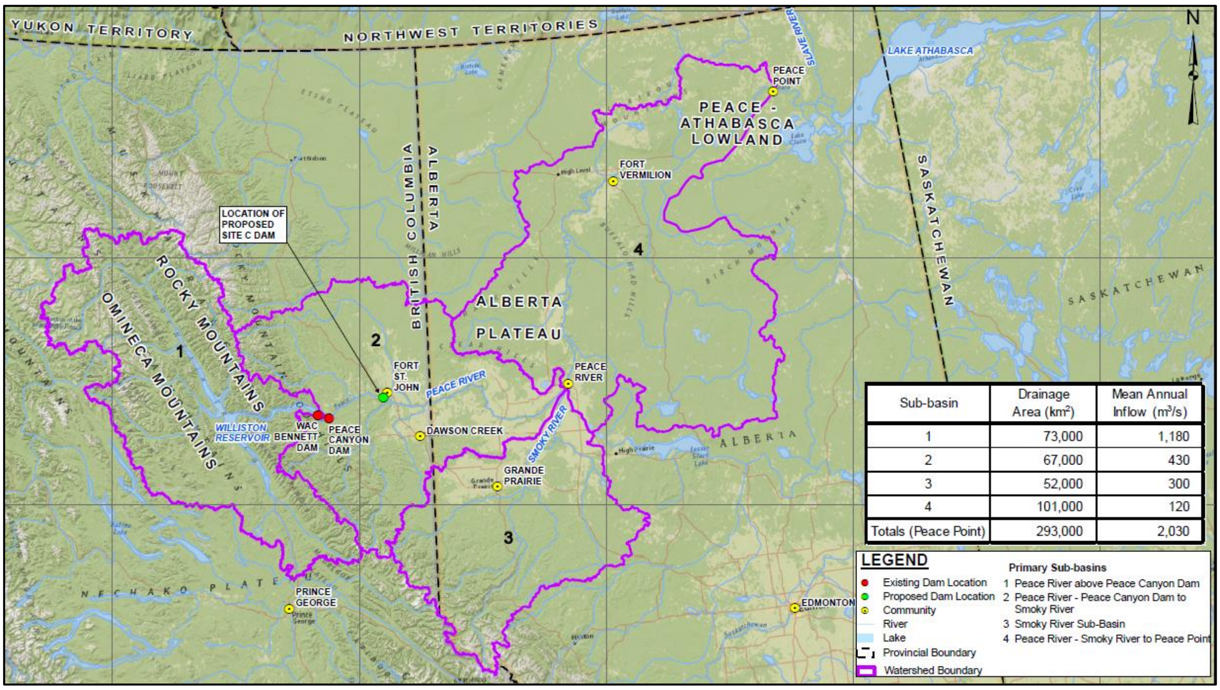
This paper describes pertinent characteristics about the regional study area and the future Site C flow regime, and an overview of the baseline studies and analyses that were undertaken to predict changes in channel morphology and sediment transport during the operations phase of the project.

2. STUDY AREA

2.1 Physical Setting

The headwaters of the Peace River lie in the Omineca and Rocky Mountain ranges of north-central BC, as shown on Figure 2. The Peace River flows eastward through the Rocky Mountains where it is regulated by the two existing hydroelectric dams. The WAC Bennett Dam was commissioned in 1967 and impounds Williston Reservoir with a surface area of 1,773 km^2. The Peace Canyon Dam, commissioned in 1980, is located 20 km downstream of the WAC Bennett Dam and impounds the much smaller Dinosaur Reservoir with a surface area of only 9 km^2. Downstream of the dams, the Peace River flows eastward and northeastward across the Alberta Plateau and the Peace-Athabasca Lowland, joining the Slave River in northeastern Alberta. The Site C Dam is located 85 km downstream of the Peace Canyon Dam, near Fort St. John, BC. The study area for the fluvial geomorphology and sediment transport study for Site C extended from the Peace Canyon Dam to Peace Point, Alberta, a small community and Water Survey of Canada (WSC) gauging station located 1,000 km downstream of Site C.

Four primary sub-basins of the Peace River watershed are shown on Figure 2. Sub-basin 1 (upstream of the two existing dams) generates over 50% of the runoff recorded at Peace Point, from a drainage area that represents only 25% of that at Peace Point, due to higher precipitation in the mountains compared to the plateau and lowland. Runoff in Sub-basin 1 is dominated by snowmelt in the late spring and early summer. However, outflow from Sub-basin 1 is regulated to match hydroelectric energy demand, with maximum flows in the winter and minimum flows in the summer, opposite from the reservoir inflow regime. Sub-basin 2 is the portion of the watershed between the Peace Canyon Dam and the Smoky River confluence. Sub-basin 3 is the tributary sub-basin of the Smoky River, the largest tributary of the Peace River in terms of drainage area and inflow (downstream of the dams). The Smoky River joins the Peace River at the Town of Peace River, Alberta. Inflows to the Peace River in Sub-basins 2 and 3 are greatest in the late spring and early summer when the greatest precipitation occurs, combined with seasonal snowmelt. Sub-basin 4 is the portion of the watershed between the Smoky River confluence and Peace Point. This sub-basin generates only 6% of the runoff recorded at Peace Point, despite having a drainage area that comprises 34% of drainage area at Peace Point, due to low precipitation and high evaporative losses from wetlands.



Sub-basin	Drainage Area (km^2)	Mean Annual Inflow (m^3/s)
1	73,000	1,180
2	67,000	430
3	52,000	300
4	101,000	120
Totals (Peace Point)	293,000	2,030

Figure 2 Peace River Watershed

Key tributaries of the Peace River between the Peace Canyon Dam and the provincial border of BC and Alberta are shown on Figure 3. The largest tributary to the future reservoir is the Halfway River, which represents around 66% of the drainage area and provides 76% of the inflow between the Peace Canyon Dam and the Site C Dam. The next largest tributary is the Moberly River, which joins the Peace River within 1 km upstream of the dam site and represents around 13% of the drainage area and inflow. The three largest tributaries between the dam site and the Smoky River confluence are the Pine, Beatton, and Kiskatinaw Rivers, all of which join the Peace River between the Site C dam and the BC/Alberta border.

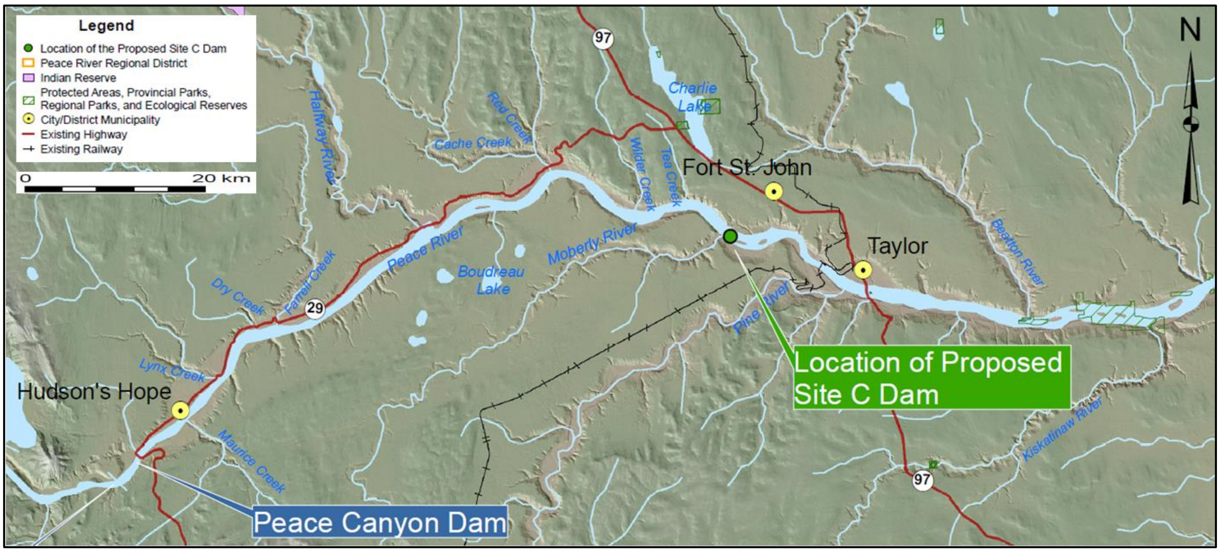


Figure 3 Peace River and tributaries: Peace Canyon Dam to BC/Alberta border (BC Hydro 2013)

2.2 Valley Morphology and Sediment Yield

The Peace River flows within an incised valley as it crosses the Alberta Plateau between the Peace Canyon Dam and Fort Vermilion, Alberta. The depth of incision is greatest near the Rocky Mountains, averaging around 200 m between the Peace Canyon Dam and the BC/Alberta border, and decreasing in the downstream direction to around 50 m near Fort Vermilion. Downstream of Fort Vermilion, the river drops through a bedrock chute onto the Peace-Athabasca Lowland. From there to the Slave River confluence, the Peace River flows within a wider, less incised valley.

On the Alberta Plateau, the Peace River has incised through a sequence of Pleistocene sediment deposits that are comprised of mostly glacio-lacustrine clays, silts and fine sands, with some inter-bedded glacio-fluvial deposits of gravels and sands. The river has cut down through the complete thickness of these surficial materials and into the underlying Cretaceous shale bedrock. Peace River tributaries have also cut down through these materials as they approach the Peace River valley. The exposed surficial materials along the Peace River and tributary valleys are prone to surface erosion and mass movement. The weakly lithified shale bedrock is also prone to rapid weathering and erosion and contributes substantial quantities of fine-grained material to the Peace River and its tributaries. A typical example of weathered shale colluvium along the Peace River is shown on Figure 4.

The Site C dam site is situated in the deeply incised section of river valley. The geologic conditions described above present challenges to the construction of the dam. A large slope excavation, involving the removal of approximately 8 million m^3 of mostly glaciolacustrine overburden material, will be required to stabilize the left (north) valley slope adjacent to the dam. Comprehensive water and erosion management measures will be required around the dam site to control erosion in the fine-textured materials and limit sediment delivery into the Peace River.

Sediment yield in the Peace River watershed is greatest on the Alberta Plateau. This is a typical pattern in large river basins in western Canada, where the majority of sediment is generated by erosion of thick Pleistocene deposits of surficial materials laid down by glacial meltwater and ice, as opposed to the contemporary erosion of mountains. Church (2015) used historical suspended sediment records collected by the WSC and BC Hydro to estimate annual sediment yields for the four primary sub-basins of the Peace River watershed. The estimated sediment yields for Sub-basins 2 and 3, where the Peace River and its tributaries are most deeply incised into the Alberta Plateau, are on the order of 200 to 300 t/km²/yr. This is an order of magnitude greater than the sediment yields for Sub-basins 1 and 4, in the mountains and lowlands, respectively. Most of the sediment yield in Sub-basin 1 is trapped in the Williston Reservoir.

Figure 4 Typical weathered shale colluvium along the Peace River near Site C.

2.3 Channel Morphology

The Peace River has a cobble and gravel bed from the Peace Canyon Dam to the Smoky River confluence. Downstream of the Smoky River confluence, the river bed is sandy gravel, transitioning to completely sand farther downstream. The downstream fining of bed material along the river is primarily a function of river gradient, which decreases from 0.0005 (50 cm/km) near the Peace Canyon Dam to 0.0001 (10 cm/km) near Peace Point, as well as the large sand load introduced by the Smoky River.

From the Peace Canyon Dam to the BC/Alberta border, the Peace River flows within a nearly continuous alluvial valley-bottom fill, but the channel impinges against the valley walls in many locations; the river channel has a wandering to low-order braided planform with abundant gravel bars and wooded islands. From the border to the Smoky River confluence, the river valley is narrower and the channel more continuously confined by valley walls; the river channel has a dominantly single-thread planform. From the Smoky River confluence to Peace Point, the river channel is mainly unconfined and has a meandering planform, with eroding banks on the outside of bends and point bars or islands on the inside of bends.

Most of the sediment delivered to, and transported by, the Peace River is fine-textured (clay, silt and fine sand) and is transported in suspension. This material behaves as wash load and is not stored in appreciable quantities on the river bed in the steeper parts of the river that comprises of cobble and gravel bed material. Downstream of the Smoky River confluence, sand is stored on the river bed and the interaction between the bed material and suspended sediment transport is more pronounced.

Gravel is supplied in relatively small quantities to the Peace River and its tributaries by the erosion of glaciofluvial and alluvial deposits along the main channels and by mountain sources in the headwaters of tributaries located near the Rocky Mountains. Since the onset of flow regulation in the Peace River, bedload transport has essentially ceased in the cobble-gravel section of the river under normal operational conditions (Church 2015). Cobble-gravel bedload inputs from tributaries have since been accumulating in prograding fans at the tributary confluences and in aggradation zones immediately downstream from the confluences. Formerly active bed material deposits (bars) in the cobble-gravel section have stabilized and have been encroached by vegetation. The aggradation zone immediately downstream from the Moberly River confluence is shown on Figure 5.

Figure 5 Peace River aggradation zone below Moberly River confluence.

3. SITE C FLOW REGIME AND RESERVOIR

The Site C Dam will be constructed approximately 85 km downstream of the Peace Canyon Dam, creating an 83 km long reservoir that will be on average two to three times the width of the current river. The maximum normal operating range between the maximum and minimum normal reservoir levels will be 1.8 m. However, most of the time, it is expected that the reservoir will be operated in the top 0.6 m of the range. The combined turbine capacity of the Site C generating station will be 2,540 m^3/s, which is roughly double the mean annual discharge. The water residence time in the reservoir will be around 22 days under mean annual flow conditions.

The operation of Site C will be co-ordinated with the operation of the upstream existing facilities on the Peace River. The operational releases from the Peace Canyon Dam are bounded by the minimum flow requirement of 283 m^3/s and the maximum licensed discharge of 1,982 m^3/s, and represent the inflows to the upstream end of the Site C Reservoir. Occasional spills in excess of 1,982 m^3/s have occurred in the past, but are rare due to the large storage capacity of the Williston Reservoir. The mean annual inflow to the Site C Reservoir from the drainage basin between the Peace Canyon Dam and the Site C Dam is around 100 m^3/s, most of which is contributed by the Halfway River. The Site C generating station will consequently have a 25% larger turbine capacity than the Peace Canyon generating station. This, along with an active storage volume around six times larger than that of the Dinosaur Reservoir, will provide Site C with operating flexibility to limit the occurrence of spills (BC Hydro 2013).

Annual peak flows near the Site C dam site under the current regulated flow regime typically range between 2,100 m^3/s to 2,300 m^3/s. These flows will increase to around to 2,500 m^3/s during normal operations. Large floods in the Halfway River occasionally generate peak flows around 3,000 m^3/s in the Peace River; the new reservoir will have the potential to store part of these inflows and keep peak flows downstream of the dam below 2,500 m^3/s (BC Hydro 2013).

The Site C Reservoir will fill the Peace River valley to a depth of around 30% of the valley depth near the dam site, diminishing in depth in the upstream direction. The reservoir will flood the lower parts of tributary valleys creating reservoir embayments, the longest of which will be the Halfway River embayment (15 km in length). The reservoir shoreline will be formed in hillslope materials that are not currently exposed to standing water. Wave erosion is expected to create a wave-cut platform along the new shoreline. The reservoir shoreline will be formed in a variety of geological materials, including fine-textured glaciolacustrine deposits and bedrock colluvium that will contribute suspended sediment to the reservoir through shoreline erosion.

4. BASELINE STUDIES

4.1 Suspended Sediment

A suspended sediment gauging program was conducted in 2010-2011 to characterize baseline conditions in the Peace River within the future reservoir section and in the proximal downstream section where changes in suspended sediment were expected to be the greatest. This information was combined with the historical records presented by Church (2015) to characterize the study area down to Peace Point.

Eight suspended sediment gauging stations were operated on the Peace River and selected tributaries: two on the Peace River near the Site C Dam and near the BC/Alberta border, three on the largest tributaries flowing into the Site C Reservoir section (Halfway River, Moberly River, and Farrell Creek), and three on the largest tributaries between the Site C Dam site and the Smoky River confluence (Pine, Beatton, and Kiskatinaw Rivers), all of which join the Peace River upstream of the BC/Alberta border.

The suspended sediment gauging stations employed continuously recording turbidity sensors to obtain surrogate records for sediment concentration. Depth-integrated suspended sediment samples were collected manually on channel transects, supplemented by automated pump samples collected near shore. Turbidity-concentration rating curves were developed and used to transform continuous turbidity records into concentration records that were then converted into discharge-concentration rating curves. Separate relationships were derived for the rising and falling limbs of the seasonal snowmelt/rainfall hydrograph, as distinctly higher concentrations were observed on the rising limb (for a given flow condition) than on the falling limb, at all stations. This is attributed to seasonal cycles of sediment source replenishment and depletion. The discharge-concentration rating curves were used to generate long-term daily suspended sediment concentration and load series from long-term daily streamflow records.

Figure 6a

Figure 6b

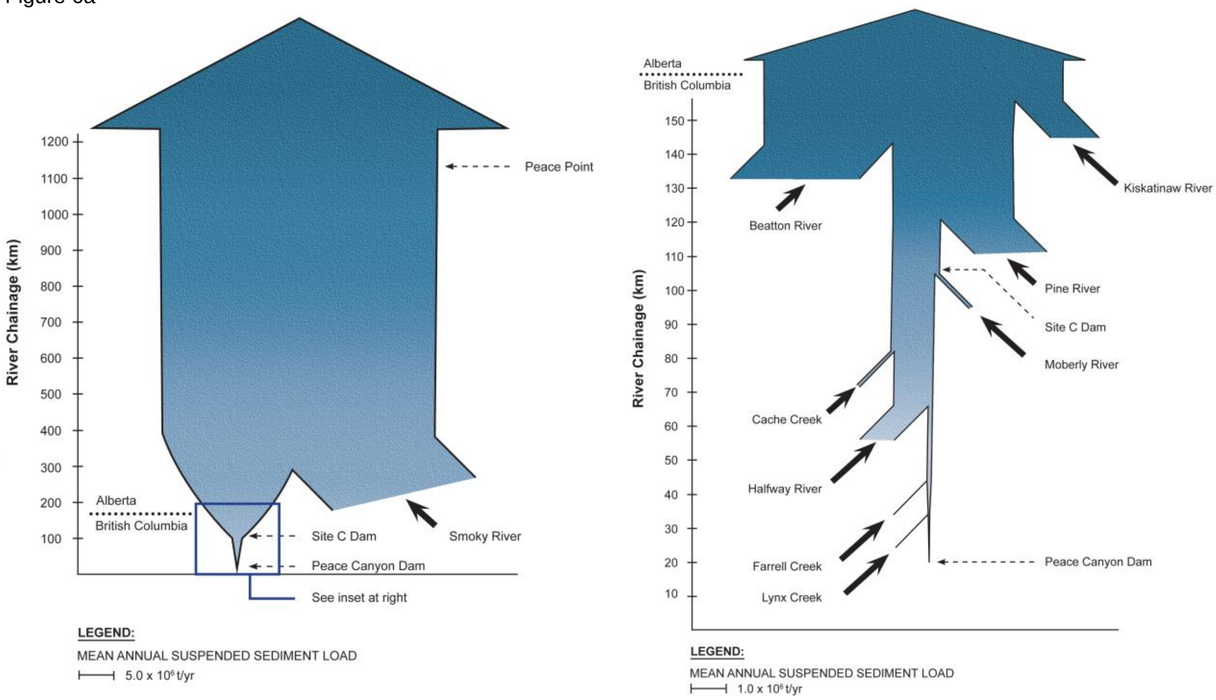


Figure 6 Peace River suspended sediment load.

The estimated mean annual suspended sediment loads at various locations along the Peace River are depicted on Figure 6. The width of the river polygons is proportional to the estimated suspended sediment load at any given location along the river. The estimated mean annual loads at the Site C Dam and at Peace Point are 1.4 million t/yr and 38 million t/yr, respectively.

Figure 6a shows the full linear extent of the river from the Peace Canyon Dam to Peace Point, and illustrates the importance of the Smoky River as a sediment source. Figure 6b shows the extent of the river from the Peace Canyon Dam to the BC/Alberta border. The inset figure illustrates the importance of the Halfway River as the largest sediment contributor to the Site C Reservoir section, and illustrates the large sediment inputs contributed by the Pine, Beatton, and Kiskatinaw Rivers within a relatively short distance (50 km) downstream of the Site C Dam site.

4.2 Channel Morphology

Church (2015) estimated the competent flow to mobilize cobble-gravel bed material in the Peace River to be around 3,000 m^3/s. This flow value is less than 50% of the mean annual maximum daily discharge prior to flow regulation, but greater than annual maximum daily discharges under normal operating conditions in the regulated flow period. This cessation of cobble-gravel bedload transport under the current flow regime that represents baseline for the Site C project, has been accompanied by fan progradation and channel aggradation near tributary confluences, as well as channel stability and vegetation encroachment between confluences.

The Site C Dam will be constructed immediately downstream of the Moberly River confluence, where the Peace River has been aggrading due to the accumulation of bed material delivered by the Moberly River (as shown on Figure 5). A bed material sampling program and bed mobility analysis were undertaken to characterize bed material mobility in this particular part of the river, and assess if channel morphology in this most proximal part of the river would be sensitive to small changes in peak discharge and/or the interruption of bed material delivery from the Moberly River.

Surface pebble counts and subsurface bulk sieve grain-size data were available for gravel bars in this area, from Church (2015) and Project engineering investigations. Additional data were collected for the Project baseline study to characterize the river bed surface material in the wetted channel. An underwater video system developed by Shuksan Consulting was used to collect images over a 6 km section of the river extending downstream from the dam site. Selected still images were analyzed for grain size using a software tool called Digital Gravelometer. Median grain sizes on the bars and in the wetted channel ranged from around 20 to 60 mm. Subsurface samples had median grain sizes around 25 mm.

A River2D model was used to assess the competence of various flows to initiate bed material mobilization under baseline conditions. Bed shear stresses computed in the model were compared against the Shields dimensionless critical shear stress value of 0.047, to determine competent flow conditions. The model results indicated that the river bed material would be largely immobile at a flow of 2,500 m^3/s (Project turbine capacity), suggesting that peak flow changes in the range of 2,300 to 2,500 m^3/s (from existing conditions to normal Project operations) would not result in any change in bed mobility. Some mobility was indicated at flows of 4,000 to 5,000 m^3/s, which represents the range of historical spills.

5. PREDICTED SEDIMENT DYNAMICS IN THE RESERVOIR

Suspended sediment dynamics in the Site C Reservoir during operations were characterized using two models.

- A GIS-based shoreline erosion model used to predict volumetric shoreline erosion rates in the first 50 years of reservoir life.
- A three-dimensional (3D) hydrodynamic model used to predict the transport and deposition of suspended sediment within the reservoir.

The shoreline erosion model was developed by JD Mollard and Associates (JDMA). The input parameters for the model included parameters related to shore zone geometry, shore zone material, wave energy, and water level range. The model simulated the erosion of a wave-cut platform and vertical bluff over time due to the application of wave energy to erodible valley slopes.

Water and sediment circulation within the Site C Reservoir was simulated using a proprietary three-dimensional hydrodynamic and sediment transport model, H3D, developed by EBA (a TetraTech Company). Baseline meteorology, hydrology, and suspended sediment transport data for the period 2000 to 2009 were used as inputs to the model for a decadal analysis of transport and deposition patterns. The first 10 years of predicted shoreline erosion were also used as inputs. The period 2000 to 2009 was selected as the reference baseline period because it represents recent (current) hydro-climatic conditions, and because this period contains a range of hydrologic conditions, including a large flood event in 2001 and low flow years in 2006 and 2009, so is suitable to represent a range of conditions that can be expected in the reservoir. A separate accelerated model run was conducted to examine deposition patterns over a 50-year period.

5.1 Sediment Input and Distribution in the Reservoir

The estimated annual input of fine sediment to the reservoir due to shoreline erosion is 1.1 million t/yr in Year 1 of reservoir operation, decreasing to 0.55 million t/yr by Year 10 as beach platforms develop, reducing the energy of wave impact. The mean annual input of fine-grained sediments from the shorelines in the first 10 years equates to 57% of the annual suspended sediment inputs from tributaries.

The reservoir is predicted to trap approximately 70% of the tributary and shoreline sediment inputs to the reservoir, while the remaining 30% would exit the reservoir at the dam and travel downstream. The reservoir would trap all incoming sand, most incoming silt, but little of the incoming clay-sized material. The mean annual outflow of suspended sediment from the reservoir is predicted to be 46% of the mean annual suspended sediment load of the Peace River at the Site C Dam under baseline conditions (i.e. a 54% reduction from baseline conditions). The grain-size composition of the reservoir outflux sediment will be primarily clay (98% clay, 2% silt), as compared to the composition observed in the river under baseline conditions: clay (37%), silt (55%), and sand (8%).

After 50 years, the thickness of sediment deposition throughout most of the reservoir is predicted to range from 0.3 m to 0.5 m, while the thickness of sediment deposition would be several metres near some of the more erodible shoreline sections and in the Halfway River embayment. This deposition would represent an infilling of 2.5% of the initial reservoir volume. The 15-km Halfway River embayment is predicted to infill completely in 150 to 220 years. Once the embayment has infilled, the Halfway River is expected to flow in a gravel-bed channel with a meandering or braided pattern in a valley-bottom floodplain down to its current confluence location, and will have a delta slope extending out into the main body of the reservoir.

6. PREDICTED CHANGE IN SUSPENDED SEDIMENT REGIME DOWNSTREAM OF SITE C

Changes in seasonal and annual suspended sediment load were computed for the Peace River at selected locations downstream of the Site C Dam site by applying the predicted difference in load between baseline and operations at the dam site, and assuming that this difference will propagate downstream.

6.1 Suspended Sediment Load

The predicted change in mean annual suspended sediment load immediately downstream from the Site C Dam is -54%. The relative magnitude of change will diminsh in the downstream direction due to the inflow of sediment from tributaries. The predicted changes in mean annual suspended sediment load immediately downstream from selected tributary confluences are presented in Table 1. The relative magnitude of change is shown to diminsh substantially at the first three major tributary confluences below the Site C Dam (Pine, Beatton, and Kiskatinaw Rivers), which are located within the first 50 km below the dam site. The relative magnitude of change downstream of the Smoky River confluence is -2% (283 km downstream), and remains the same at Peace Point (1,030 km downstream), due to the similarity of baseline load throughout the lower part of the Peace River below the Smoky River confluence.

Table 1 Predicted change in mean annual suspended sediment load.

Location	Predicted Change in Annual Load (%)
Peace River below Site C Dam	-54%
Peace River below Pine River	-21%
Peace River below Beatton River	-10%
Peace River below Kiskatinaw River	-8%
Peace River below Smoky River	-2%
Peace River at Peace Point	-2%

6.2 Suspended Sediment Concentration

The reduction in suspended sediment concentration and load downstream of the Site C Dam would occur primarily during periods of high tributary inflow to the Site C Reservoir, which mostly occurs during late spring and early summer due to snowmelt and rainstorms. In the spring (months of April through June), the median daily concentration is predicted to decrease from 40 mg/l (baseline) to 14 mg/l (operations). During other periods of the year (late summer, autumn, and winter), reservoir attenuation and shoreline sediment inputs would actually cause small increases in concentration and load. The largest increase in median daily concentration is predicted in the autumn (months of October through December), from 1 mg/l (baseline) to 7 mg/l (operations).

7. PREDICTED CHANGE IN CHANNEL MORPHOLOGY DOWNSTREAM OF SITE C DAM

The Peace River flow regime will not be substantially altered by Site C during the operations phase, and long-term research by Church (2015) has shown that the cobble-gravel section of the river (from the Peace Canyon Dam to the Smoky River confluence) has a stable channel and almost no bedload transport under the current regulated flow regime. Therefore, no Site C-related changes in bedload transport or channel morphology are anticipated throughout most of the cobble-gravel section of the Peace River downstream of the Site C Dam because the project will not change the current lack of bedload transport or the accumulation of bed material at downstream confluences. The potential exception to this is in the immediate downstream vicinity of the dam site, where the accumulation of bed material delivered by the Moberly River will be interrupted by the dam. Under high flow (spill) conditions, the mobilization of bed material in this zone could result in channel degradation.

A one-dimensional hydrodynamic model (HEC-RAS) was developed to predict bedload transport and channel erosion/deposition under a hypothetical extreme high flow condition of 5,000 m^3/s, sustained for a period of one year. The model extended 17 km downstream from the Site C Dam site to the Pine River confluence. For context, this flow condition is similar in magnitude, but eight times in duration, to the largest historical spill from the Williston Reservoir in the summer of 1996, which was an exceptional event. However, this flow condition is less than the mean annual flood on the Peace River prior to regulation. The 1996 Williston spill resulted in limited channel erosion or deposition in the cobble-gravel section of the river (Church 2015).

The HEC-RAS model run of the long duration extreme flood predicted that the Peace River bed would degrade by approximately 1 to 1.5 m in a 2 km section of the river downstream from the tailrace due to bed material mobilization and lack of replenishing bed material supply from upstream. Much of the scoured bed material would accumulate immediately downstream from the degradation zone in a 2 km aggradation zone, where the bed elevation would increase by a similar amount. Limited channel change was predicted farther downstream, suggesting that the channel changes would be localized. This result represents an upper bound channel change prediction for an extreme high flow scenario.

8. CONCLUSIONS

The Site C Dam will be the third dam and hydroelectric generating station on the Peace River. This paper presented the predicted changes in channel morphology and suspended sediment dynamics during operations that were described in the Environmental Impact Statement (EIS) for Site C. It is predicted that these changes will be limited to the new reservoir and to the proximal downstream section of the river.

The reservoir is predicted to trap 70% of the incoming sediment delivered from tributaries and from shoreline erosion induced around the reservoir perimeter. However, sediment deposition on the reservoir bed is predicted to reduce the initial reservoir volume by only 2.5% after 50 years.

The mean annual suspended sediment load of the Peace River immediately downstream from the dam is predicted to be reduced by 54% compared to baseline conditions. Farther downstream (300 km) at the Town of Peace River, Alberta, the predicted reduction in sediment load is only 2%, due to the large sediment inputs delivered to the Peace River by intervening tributaries.

The Peace River has a cobble-gravel bed extending for several hundred kilometres downstream from the Site C dam, and the sediment that will be trapped in the reservoir is much finer than the bed material in this section of the river. Long-term field observations indicate that the bed material in this part of the river is generally immobile due to flow regulation at the two existing dams, which has led to ongoing bed material aggradation at tributary confluences and vegetation encroachment on gravel bars. Site C operation will not change the flow regime of the river with respect to bedload transport competence, and so is not expected to cause any incremental change in channel morphology downstream from the dam under normal operating conditions.

These findings were used in the assessment of the Site C project effects on water quality, aquatic productivity, fish habitat, and instream infrastructure.

9. ACKNOWLEDGEMENTS

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