Peace Project Water Use Plan

Peace River Trial Side Channels

Implementation Year 2019 Final Report

Reference: GMSWORKS-3

Peace River Side Channel Restoration Hydrotechnical Monitoring - 5 Year Post Construction Inspection

Study Period: September 2019

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10 November 2020

BC HYDRO
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Re: Peace River GMSWORKS3 Trial Side Channel KM 102.5R
Hydrotechnical Monitoring 2019

1 EXECUTIVE SUMMARY

The right bank side channel along the Peace River at station 102.5 was re-established through channel excavation in April of 2014. This work was done as a trial to increase habitat value downstream of the G.M. Shrum Generating Station (GMS); that is, a part of the GMSWORKS-3 program. To support the trial, a monitoring plan was established. Northwest Hydraulic Consultants Ltd. (NHC) inspected and surveyed the side channel (102.5R) on 30 September 2019. This document presents the findings of that inspection with respect to hydraulic habitat characteristics and general site stability.

The results of the monitoring show that the bed of the channel has aggraded 1.25 m to 1.5 m since construction. As a result, the channel no longer meets the design criteria, which is to provide a minimum depth of 30 cm. Instead, the channel is expected to be dry for much of the year. Fine grained sediment (i.e. silt and sand), primarily sourced from the Pine River, is expected to continue to deposit within side channel 102.5R; however, at a reduced rate now that the channel infilled to roughly half way to the preconstruction level.

This trial for increasing habitat on the Peace River suggests that re-established side channels along the Peace River are likely to infill with sediment. This is further supported by the observed response of the loss of natural side channels post regulation. The rate of infill is likely to vary by site, with this site expected to infill more rapidly than others due to its location immediately downstream of a tributary sediment source; that is, the Pine River. The GMSWORKS-3 program, under which this trial was implemented, has been suspended as per the Comptroller of Water Rights due to the development of the Site C project. Alternative main channel habitat has been developed as part of the Site C project.

Monitoring included inspection of bank stability, particularly at three specific locations:

1) Bank erosion on the left bank at the mouth of the 102.5R side channel (Northeast Bank Erosion) was a concern upon project completion due to rapid initial rates of erosion. Migration of the

channel appears to have ceased with any ongoing loss of material since 2015 primarily limited to regrading of the slope.

2) Erosion along the right bank of the pre-existing side channel downstream of the 102.5R channel (Peace Island Park Erosion) has continued with the top of bank retreating roughly 0.5 m/y since 2016. The bank is still over steep and susceptible to further regrading and erosion.
3) Erosion along the south bank of the main channel of the Peace River (Peace River South Bank Erosion) initiated at the downstream end of the island as early as 2010. This erosion has since migrated upstream and now threatens the BC Hydro utility line towers.

Erosion along the north side of the island downstream of 102.5R (item 3 above) has progressed by as much as 17 m since June 2016, and as of September 2019, was within 43 m of the BC Hydro utility line towers and only 22 m from supporting guy wires. Annual erosion rates have ranged from 2 to 6 m/y at this location; however, measurements from successive GoogleEarth satellite images suggest erosion rates at the downstream end of the island as rapid as 10 m/y from 2010 to 2015. One or more years with high and sustained Peace River flow and or high sediment yield (e.g. from the Pine River or Site C construction) could foreseeably result in similar or greater erosion rates at the riverbank near the towers. These observations suggest erosion could threaten the guy wires in as little as 1 to 3 years and reach the towers within as little as 2 to 5 years. Therefore, **mitigation measures should be developed to ensure the protection of the towers.** This could include increased frequency of inspection, remote monitoring, or constructing physical works to amour the bank or redirect flows.

2 INTRODUCTION

2.1 Background

Since regulation from the W.A.C Bennett and Peace Canyon Dams (PCN) in 1967, the Peace River has experienced a decrease inside channel habitat. It is expected that this reduction is a result of sediment infilling and vegetation encroachment following the reduction of peak flood flows (Church, 2005). The 2007 Water Act Order for the Peace Project Water Use Plan (2007) mandated that BC Hydro improve fisheries habitat of the Peace River by modifying existing side channels on a trial basis. Side channel 102.5R (102.5R) was selected as a trial site and excavated in 2014 under GMSWORKS3 to investigate the feasibility of improving side channel habitat through channel excavation as an alternative to adjusting the flow regime (BC Hydro, 2008). The success of re-established side channels can be compared with other options for improving fish habitat based on the habitat value or aquatic productivity gained from re-establishing the channel, the lifespan of the channel, and the cost of the channel.

Site 102.5R is located on the right bank of the Peace River 102.5 km downstream of the PCN dam. The channel transects a moderately sized right bank semi-permanent vegetated island[1] and can be accessed through Peace Island Park, approximately 600 m upstream of the Highway 97 bridge over the Peace River. A plan view figure of 102.5R with respect to the Peace River, Pine River and Highway 97 can be seen in Figure 2.1; Figure 2.2 is at a larger scale to better illustrate the overlaid orthophotos and areas of erosion.

[1] This land mass is characterized as an island to remain consistent with past reports and Dr. Michael Church's nomenclature for the Peace River (Church, 2005)

The site was selected, despite the high sediment load from Pine River, based on its accessibility, presence of a historic channel, and location downstream of the Site C project. The channel is 500 m long, bisects the island, flowing from northeast to southwest, and confluences with a pre-existing and active side channel that runs parallel to the Peace River adjacent to Peace Island Park. The site is located 1 km downstream of the Pine River confluence, the most substantial tributary between PCN and the site, and a large source of fluvial sediment. Before 102.5R was developed, the side channel was found to provide habitat for two sportfish (Mountain Whitefish and Northern Pike), three sucker (Longnose, Largescale, and White Suckers), four minnow (Longnose Dace, Redside Shiner, Spottail Shiner, and Trout-perch), and one sculpin (Slimy Sculpin). In the summer of 2013, sampling found the most numerically important fish were unidentified young-of-the-year suckers (81.7%), followed by lower numbers of Longnose Dace (6.8%); other fish species represented ≤ 3.0% of the sample (NHC, 2013). Construction of the channel was to develop persistent, turbid cool water supporting a wide range of life stages for northern pike, perch, and sucker (NHC et al., 2010).

The GMSWORKS-3 program, under which this trial was implemented, has been suspended as per the Comptroller of Water Rights due to the development of the Site C project (BC Hydro, 2019). Alternative habitat offsetting has been developed as part of the Site C project.

2.2 Project History

During April of 2014, 4Evergreen Resources LP (4EG) developed 102.5R following designs provided by NHC via drawings 300187 Rev 2, GMSWORKS-3 Peace Side Channel Restoration (NHC, 2013). Construction of the channel was completed by the end of April and the channel activated on 25 April 2014.

An adaptive monitoring strategy was developed to monitor the hydrotechnical functionality – specifically connectivity, depth of flow, and potential for stranding. The scope of work for hydrotechnical monitoring includes topographic and bathymetric surveys and on-site observations of bank stability, instream vegetation and channel migration. Monitoring criteria and maintenance triggers were provided for each parameter, as summarised in Table 3.1. Following adaptive monitoring philosophy, the frequency of monitoring beyond 2016 was to be dependent on the magnitude and rate of changes seen in monitoring criteria (NHC, 2015a).

2.2.1 Project Performance

A baseline topographic survey was conducted on 24 April 2014 for the 102.5R as-built record. Post-construction hydrotechnical inspections, including topographic and bathymetric surveys, were conducted 22 September 2014 and 17 June 2016 (NHC, 2016). Topographic and bathymetric surveys collected during both inspections found bed aggradation had occurred: an average of 0.5 m had occurred within 5 months after construction (22 September 2014) and 0.75 m within 26 months after construction (17 June 2016).

2.2.2 Bank Stability

On 30 April 2014, 5 days after channel initiation, NHC was notified by BC Hydro that erosion was occurring along the left bank at the mouth of 102.5R (northeast bank erosion). NHC conducted a site inspection and collected topographic survey data on 1 May 2014 and again on 4 September 2014. Comparison of bank line surveys suggests that the northeast bank of 102.5R migrated approximately 20

m to the southeast within the first week, after which migration rates slowed to 3 m of further migration over the next 15 weeks (NHC, 2015a). The rate of erosion at the northeast bank of 102.5R was found to have slowed to 1.5 to 2.0 m/y by September 2016 and the total distance from the area of erosion to the utility line towers to be 76 m (NHC, 2016).

Bank erosion was also noted at Peace Island Park along a section of pre-existing side channel downstream of the outlet of 102.5R. The erosion may have become more active since the re-establishment of 102.5R side channel, but lack of baseline photos or survey prevent comparison with pre-project conditions. This site has continued to be monitored with no additional erosion noted in 2016; 21 months following the September 2014 inspection.

Figure 2.1 Satellite image of the Peace River and Pine River at the 102.5R side channel.

Figure 2.2 Satellite image of 102.5R side channel, overlaid with 2019 drone photos, illustrating areas of erosion that were specifically inspected.

3 SCOPE OF WORK

3.1 Objectives

The objectives of the current study are to follow the hydrotechnical monitoring requirements established in 2015 and are summarized in Table 3.1 (NHC, 2015a) using the topographic and bathymetric survey data and site observations collected during the 2019 site inspection.

3.2 Methods

Three survey methods were used to collect topographic and bathymetric information; these are:

i) Trimble R10 RTK (real time kinetic) survey grade GPS to collect ground surface and shallow channel bed topography,

ii) Post processed photogrammetry from Phantom 4 Pro drone survey of the terrain, and

iii) Bathymetric survey of submerged channel bed using Sonarmite sounder and R10 RTK GPS mounted on an inflatable boat.

NHC conducted the site inspection and surveys on 30 September 2019 and 1 October 2019 during relatively low water levels in the Peace River. As a result, it was possible to conduct much of the survey on foot. The bathymetric portion of the survey was conducted in the main channel of the Peace River at the mouth of 102.5R and in the vicinity of the Peace Island Park erosion site. Topographic and bathymetric survey data was amalgamated into a single dataset during post-processing. The datum and projection used for the topographic and bathymetric survey are:

- Horizontal Datum: NAD 83 CSRS
- Projection: UTM Zone 10 North
- Vertical Datum: CGVD28
- Geoid: HT2.0

Equipment:

- Trimble R10 RTK GPS Rover corrected with Fort St John Can-Net base station
- TSC3 Controller
- Ohmex Sonarmite 200 kHz echosounder
- Hypack Hydrographic Software
- DJI Phantom 4 Drone

The topographic and bathymetric surveys focused on bed elevations and bank extents of 102.5R and the pre-existing side channel along Peace Island Park. Every point of data collected during the survey has its own inherent uncertainty depending on satellite view, rod level, and Can-Net corrections. For data collected using the RTK, vertical uncertainty ranged from 1 to 5 cm and was typically close to 2 cm. All RTK and drone surveyed data can be assumed to have an error of no greater than ± 5 cm. Bathymetric surveys have a higher degree of uncertainty and have an error of ± 10 cm.

The 2019 surveys followed the same strategy as those taken in 2014 and 2016. Channel cross sections were surveyed every 50 meters across 102.5R at the same locations as previous surveys to allow for direct comparison of bathymetric and topographic profiles. Cross sections in 102.5R are labelled 1, 1.5, 2, 3, 4, 4.5 and 5 starting at the southwest end of the channel and increasing incrementally (Table 4.1 & Appendix B). Top of bank extents were surveyed at the northeast bank erosion site in 102.5R and Peace Island Park erosion site in the pre-existing side channel to the south of the island.

Visual inspection of the banks and channel were documented with field notes and photographs. Select photographs of the site are attached in Appendix A, labelled by cross-section.

The drone photogrammetry was processed with the survey data to produce a 3D surface and digital elevation model (DEM) of 102.5R. Figure 3.1 shows the extent and relative elevations from the DEM. See appendix B for presentation of the collected topographic and bathymetric survey data. The orthophotos are presented in Figure 2.1, Figure 2.2 and in Appendix B Drawings.

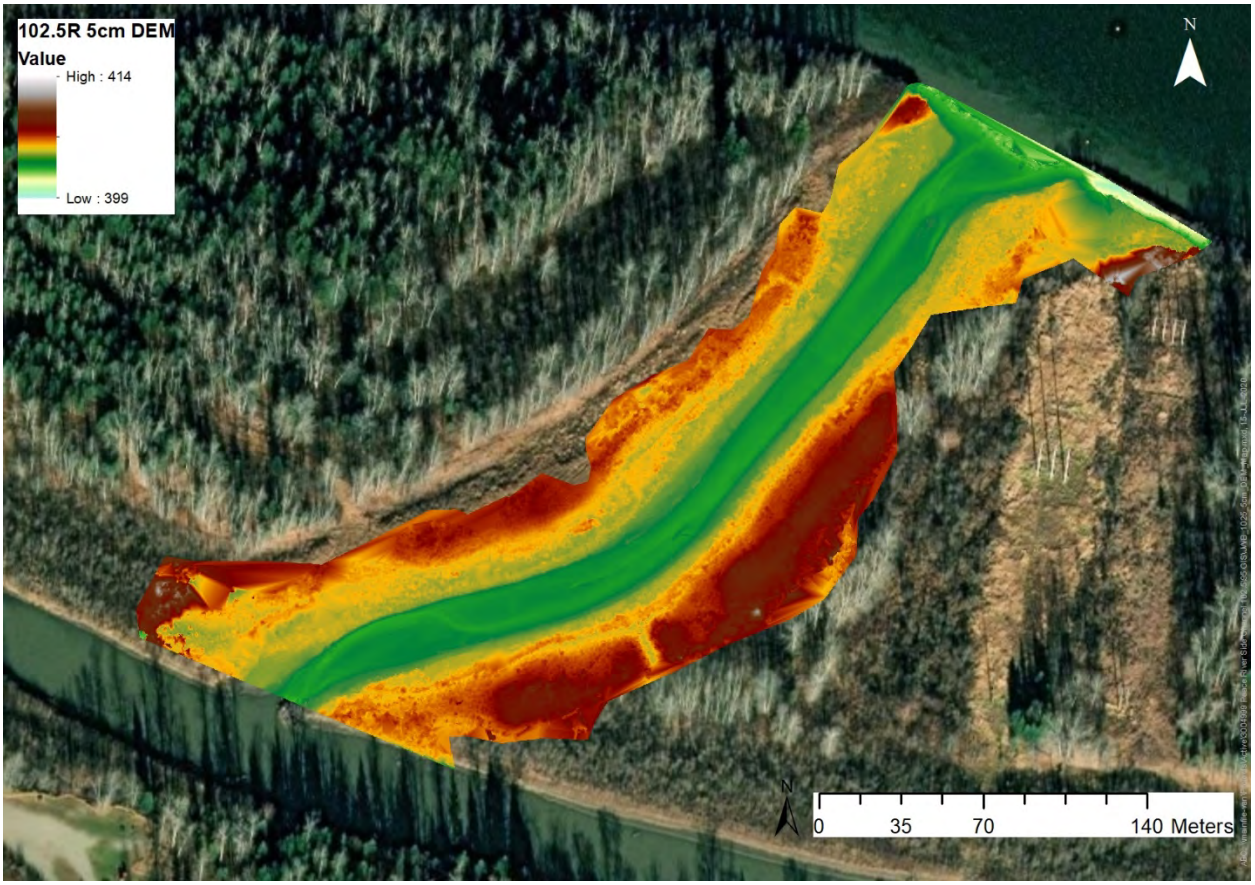

Figure 3.1 Side channel 102.5R, elevation colour shading based on DEM from 2019 drone survey.

3.3 Monitoring Criteria

Monitoring is to track operational functionality of the 102.5R side channel and to identify any negative project effects. Monitoring criteria and maintenance triggers are provided in Table 3.1. These criteria and maintenance triggers are based on two design principles:

- Hydraulic connectivity is provided along the length of the side channel through the full range of PCN normal operational flow.
- The mean depth along the thalweg should be 0.3 m or greater during low flow.

The channel was designed to provide 0.3 to 0.8 m of water depth during the lowest normal flow under the current Peace River operations. Water Survey of Canada (WSC) provides continuous measurement of flow and stage at the Peace River near Taylor gauge (WSC 07FD002). Based on the daily flow records over the past 20 years and hourly records over the past 2 years, low water appears to be between discharges of 400 and 500 m^3/s with a resulting water level of roughly El. 402.65 m within the constructed side channel (NHC, 2013). Based on this correlation it was previously determined that maintenance excavation of the channel should be considered if the thalweg elevation of the channel exceeds El. 402.65 m at any one location in the channel, or if the average elevation along the thalweg exceeds El. 402.35 m.

Table 3.1 Monitoring specifications and maintenance thresholds.

Channel Form	Monitoring	• Cross-sectional topographic and bathymetric surveys taken on existing cross sections (or every 50 m)
	Maintenance Triggers:	• Thalweg of the channel exceeds El. 402.65 m at any one location • Thalweg of the channel has an average elevation greater than El. 402.35 m
Localized Bank Failures	Monitoring	• Photographs of the banks along the re-established side channel • Photographs of the banks along the existing side channel (downstream of re-established side channel) • Observational notes and mapping of any identified erosion or bank failure
	Maintenance Triggers:	• Depends on the location, scale, and number of failures; typically, isolated failures less than 1 m x 1 m x 0.5 m (deep) do not require maintenance, but may benefit from seeding and planting
Erosion of Northeast Bank	Monitoring	• Survey top of bank at NE corner of entrance to side channel • Survey sections as required to capture the slope of the bank (sections surveyed every 50 m) • Photographs taken of the bank • Observational notes of flow patterns, deposition, and erosion at northeast bank
	Maintenance Triggers:	• Top of bank is less than 50 m from the BC Hydro utility towers • Rate of erosion since last inspection (metres per year) suggests the distance trigger will be met within the next two scheduled inspections • Noticeable change in flow patterns, deposition, or erosion
Bankline Vegetation	Monitoring	• Photographs of the bankline vegetation and ECM along the re-established side channel • Observational notes
	Maintenance Triggers:	• Lack of, or loss of, vegetation is resulting in erosion and supply of sediment to the channel
Instream Vegetation	Monitoring	• Photographs of instream vegetation along the re-established side channel • Observational notes
	Maintenance Triggers:	• Removal of instream vegetation should be considered if vegetation encroaches to limit open channel width to less than 20 m

4 ASSESSMENT

The assessment follows the adaptive monitoring strategy established in 2015 (NHC, 2015a). The following assesses whether 102.5R meets the design criteria and identifies the impacts or possible impacts related to the development of 102.5R.

4.1 Hydraulic Functionality

The hydraulic functionality is assessed based on conditions within 102.5R as they were observed and measured during the site inspection on 30 September 2019. If conditions no longer meet the design criteria or surpass the maintenance threshold designated in Table 3.1, then either maintenance work should be conducted, or the channel should be considered to not be meeting the habitat value objectives.

Table 4.1 presents a selection of data from the surveyed cross-sections. Cross sections are numerically named and increase incrementally in order from southwest to northeast. Reference points from each cross section are selected for comparison from the center of the channel (0), offsets 10 m towards the left bank (-10), and offset 10 m to the right bank (10). The cross-section locations are shown in plan view on sheet 1 of Appendix B, which also contains a table comparing all four site surveys to the design elevations.

Table 4.1 Surveyed elevations of 102.5R from April 2014 and September 2019.

Cross Sections starting at southwest end	23 April 2014 As-built Elevations (m)			30 September 2019 Survey Elevations (m)			Elevation Difference {2019 minus 2014} (m)		
Offset:	-10	0	10	-10	0	10	-10	0	10
1	402.66	401.75	403.22	403.30	403.22	404.46	0.64	1.47	1.24
1.5	-	-	-	402.91	403.08	404.41	-	-	-
2	402.96	401.75	402.98	403.07	403.05	403.87	0.11	1.3	0.89
3	402.71	401.75	402.86	402.96	403.05	404.00	0.25	1.3	1.14
4	402.85	401.75	402.82	403.24	403.01	403.99	0.39	1.26	1.17
4.5	-	-	-	404.11	403.03	403.04	-	-	-
5	403.24	401.72	402.4	403.29	402.96	403.56	0.05	1.24	1.16

The point comparisons in Table 4.1 did not capture the maximum thalweg elevation (lowest portion of a channel cross section) as the reference point is the center of the channel and the thalweg has laterally migrated since development. The maximum thalweg elevation was determined using the DEM (Figure 4.1) and is now 402.85 m with an average of approximately 402.75 m. This is 20 and 40 cm, respectively, above the maintenance triggers, and the average is higher than the 2016 maximum thalweg elevation of 402.63 m (NHC, 2016). The bed has aggraded approximately 1.25 to 1.5 m since channel construction. Previous surveys showed that up to 0.5 m of deposited sediment occurred within the first 5 months. The rate of aggradation has since slowed to an average rate of 0.15 m to 0.30 m per year between 2016 and 2019 (sheet 2 of Appendix B).

During periods of low flow (i.e. during daily or seasonal flow cycles) the water depth in 102.5R is too low to meet the minimum design criteria of water depths of between 0.3 m and 1.5 m for discharges of 300 to 2000 m^3/s from Peace Canyon Dam (NHC, 2013). It is also expected that at multiple times through the year the channel is dry.

Several large pools were evident during site inspection (Photo 5, Photo 6, Photo 8, Photo 10, Photo 12, and Photo 14). Fish stranding may occur in these pools, leaving fish susceptible to suffocation and predation. No evidence of fish stranding was seen during the site inspection.

To estimate the percent of time 102.5R is dewatered, water levels (stage) from the WSC Peace River near Taylor station 07FD002 (600 m downstream of 102.5R) was extrapolated to 102.5R by offsetting stage values to match the surveyed water level of El. 402.59 m at 30 September 2019 at 15:45. The extrapolated stage for the period 13 November 2018 to 13 November 2019 is plotted in Figure 4.1 and compared to the maximum thalweg El. of 402.85 m. For this period of data, the channel was above the

maximum thalweg (El. 402.85 m) 60% of the time. For 42% of the time, stage in the channel was at or above the design parameter of 30 cm of depth (El. 403.15 m). The longest period that the depth was continuously greater than 0.3 m in 2019 was from late January to late February.

The plan form of the 102.5R side channel – that is the extent of banks and channel position – has remained relatively consistent since the 2016 inspection. Within the channel, the thalweg has migrated laterally and resulted in redirection of flow and local flow concentrations. Erosion has subsequently resulted in a number of isolated bank failures (less than 5 m in length and less than 1 m deep), such as those seen on the left bank at Section 4.5 (middle of 102.5R) and on the right bank at Section 1.5 (south end of 102.5R) (Photo 7 to Photo 14). The migrating thalweg and isolated bank failures do not indicate overall channel instability and are not seen as a threat to project.

There has been concern that vegetation encroachment may initiate further fine sediment deposition. However, minimal instream vegetation was observed.

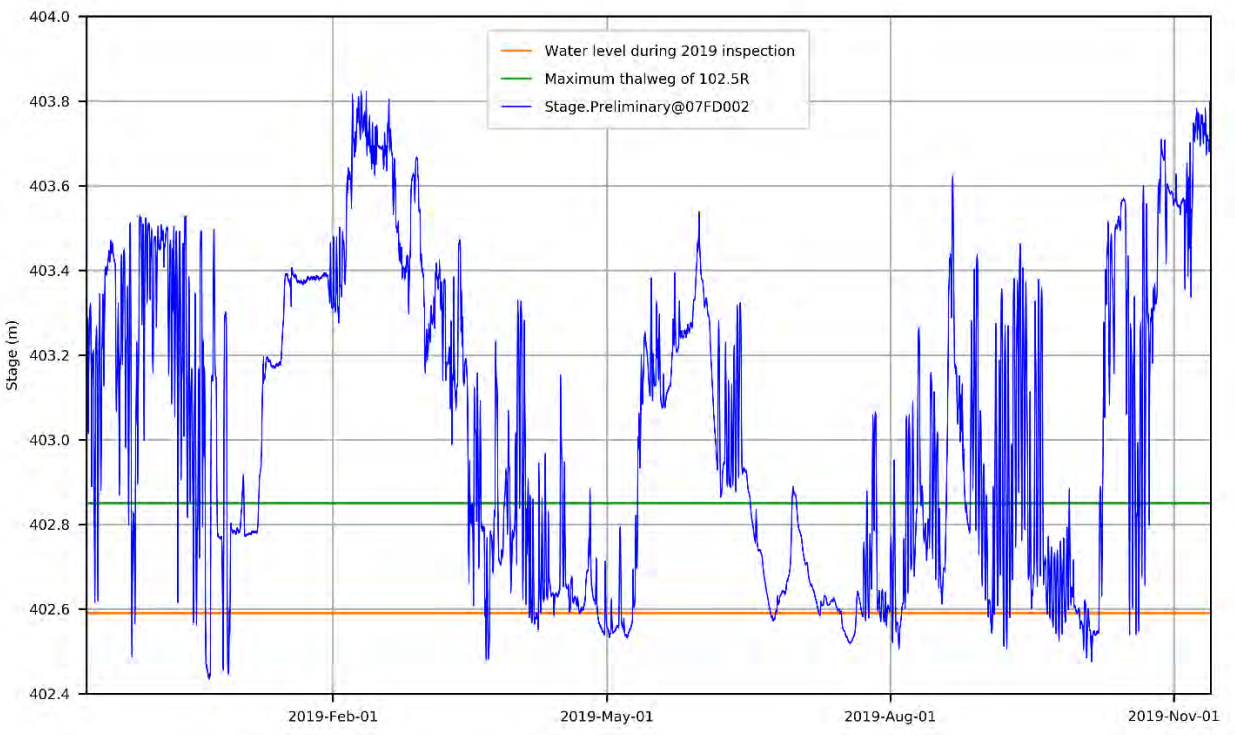

Figure 4.1 Extrapolated stage at 102.5R between 13 November 2018 and 13 November 2019 from WSC 07FD002.

4.2 Site Stability

Two areas of concern with respect to erosion were identified after the project construction was completed: the northeast bank (on the left bank at the mouth of 102.5R) and at Peace Island Park (right bank of the pre-existing side channel downstream of 102.5R). During the 2016 and 2019 inspections, photos were taken as well as bathymetric and topographic surveys of bank line extents and cross sections, which can be seen on sheet 3 and 4 of Appendix B.

4.2.1 Northeast Bank Erosion

Most of the noted bank retreat (20 m) at the northeast site occurred within the first week of active flow through the channel as the bank adjusted to increased flow through 102.5R. The rate of erosion slowed considerably over the next 3 weeks and by 2016 was found to regress at a rate of 1.5 to 2.0 m/y. The 2019 inspection found a continued reduction in erosion rates. The toe of the slope appears relatively constant with regrading of the slope resulting in further regression of 1.0 to 1.5 m from 2016 to 2019 (rate of 0.3 to 0.5 m/y). The maximum bank retreat from 1 May 2014 to 30 September 2019 was 11.5 m. As of the 30 September 2019 site inspection, the bank is 75 m away from the nearest utility line pole and 75 m away from the nearest guide wire.

Given the reduction in the rate of lateral bank erosion and remaining distance to the utility line poles, erosion at the northeast site does not present an immediate threat to the BC Hydro assets.

4.2.2 Peace Island Park Erosion

Localized erosion was identified on a 10 m long section of bank on the pre-existing side channel downstream of 102.5R along the campground road at the northeast end of Peace Island Park. The June 2016 topographic survey found no further progression in the bank line erosion compared to the September 2014 topographic survey (NHC, 2016). However, the bank was found to be over steepened, devoid of vegetation and the soils were exposed, making it susceptible to further slope regression.

The September 2019 topographic survey found a maximum of 1.5 m of additional bank retreat since 2016 (sheet 4 in Appendix B). The bank continues to be over steepened and exposed; continued erosion at this location is expected even if toe erosion ceases because the over steepened bank will regress back to a more stable slope angle (Photo 35 to Photo 38). The banks that are upstream and downstream of this site are less steep, well vegetated, and appear more stable.

Unfortunately, there is no record of this site prior to the project, and no background topographic survey data of bank line extents. It is not known if the existing erosion was exacerbated by the re-establishment of the side channel; however, the lack of progression of this erosion between 2014 and 2016 suggests the re-established side channel has not substantially contributed to the erosion.

4.3 Peace River South Bank Erosion

A third area of erosion that is impacting the site is erosion of the riverbank on the north side of the island, that is the south bank of the Peace River downstream of the 102.5R side channel (Figure 2.1). This erosion was initially identified at the downstream end of the island in 2015 (NHC, 2015b). It appears to be a direct result of flow being directed towards the south bank from the development of a mid-channel bar (Figure 4.2). The bar appears to have migrated or grown upstream from its original location under the Taylor Bridge. Review of the past ©GoogleEarth images suggests that erosion at the downstream end of the island has been as rapid as 10 m/y (Figure 4.2).

A pattern of aggradation, bar development, lateral migration, and channel instability has been recognized in this reach for decades and can largely be attributed to the ongoing and uninterrupted supply of sediment from the Pine River and reduction in flushing flows from the Peace River since the construction of W.A.C. Bennett and Peace Canyon dams (Church, 2005).

Over the past couple of years, this erosion has migrated upstream. Immediately downstream of the 102.5R site, the bank has eroded 17 m since June 2016 leaving the base of the utility towers at a distance of 43 m from the top of bank as of 30 September 2019, and the guy wires 22 m from the bank (Photo 21 to Photo 34). The average erosion rate is 4 to 5 m per year since 2016. At this rate, the utility towers could be undermined or threatened within the next 5 to 10 years. An increased rate of erosion that approaches that seen downstream would expose the guide wires within 2 years and expose the tower foundations in as little as 4 years. Increased or sustained high flow or further bar growth, which can be reasonably expected to be possible with continued sediment loading from the Pine River and/or further reductions in flushing flows from Site C construction, could lead to further accelerated erosion rates.

Due to the potential for rapid erosion and a reduced buffer between the top of bank and the guide wires and utility towers, it is recommended that mitigation measures be developed as soon as possible. These could include increased monitoring frequency, installation of remote monitoring (such as real-time accessible field cameras), bank armouring, or flow redirection. NHC is working in the area and can provide support if required for any of these approaches.

Figure 4.2 Progression of erosion (estimated at 45 m) along downstream end of island from March 2010 (left image) to June 2015 (right image) (©GoogleEarth)

5 CONCLUSIONS AND RECOMMENDATIONS

Under GMSWORKS3, 102.5R was developed as a trial site with the objective of observing, documenting, and assessing the feasibility of excavating side channels on the Peace River for the purposes of improving fish habitat as an alternative to adjusting the flow regimes.

The 2019 inspection and monitoring survey has shown that the bed of side channel 102.5R has aggraded to the point where it is no longer meeting the design criteria. Maintenance, in the form of re-excavation of the side channel, would need to be conducted in order to maintain the design parameter of having minimum depth of 30 cm in the channel during low flow periods. However, aggradation is expected to continue at this site, and any excavations to maintain a functional channel would be expected to be an ongoing and repetitive requirement. Without any maintenance action the channel will increasingly

become less functional under the GMSWORKS-3 program; it will continue to aggrade, likely becoming completely infilled and eventually be abandoned (similar to the pre-excavation state).

Alternative sites, if available, may experience aggradation at a reduced rate if not located immediately downstream of a prolific sediment source, such as the Pine River in this case. Deeper excavation at 102.5R, although more challenging and costly, could also limit the frequency of maintenance excavation, although aggradation will eventually occur. Easier to maintain habitat offsetting could include main channel complexing or constructed side channels that excludes sediment from their inflow (i.e. groundwater or screened inlet) and incorporate an upstream sediment basin to localize deposition.

The GMSWORKS-3 program, under which this trial was implemented, has been suspended as per the Comptroller of Water Rights due to the development of the Site C project (BC Hydro, 2019). Instead, alternative main channel habitat has been developed as part of the Site C project.

Previously identified erosion, at the northeast point of the 102.5R side channel and downstream at the Peace River Park, have slowed to less than 0.5 m/y. However, erosion along the north side of the island has progressed upstream to the 102.5R channel. This erosion is a result of a migrating mid-channel bar in the Peace River channel that has been diverting and is expected to continue to divert river flows. **This erosion could be as rapid as 10 m/y or more. As of the 2019 inspection, the front of the erosion is within 43 m of the utility towers and within 22 m of guide wires that support the towers. Mitigation measures should be taken to avoid damage to the BC Hydro utility towers.**

6 CLOSURE

We appreciated this opportunity to work with you on this project and hope this report meets your needs. However, feel free to call (604.980.6011) or email (dmuir@nhcweb.com or Jbauer@nhcweb.com) to discuss.

Sincerely,

Northwest Hydraulic Consultants Ltd.

Prepared by:

Jake Bauer, GIT.
Geomorphologist

Reviewed by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D.P. MUIR 27657

2020 Nov 19

Dale Muir, P.Eng.
Principal

DISCLAIMER

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **BC Hydro and Power Authority** for specific application to the **2019 hydraulic monitoring of the GMSWORKS-3 Peace River Trial Side Channel Restoration River KM 102.5R**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation and was prepared in accordance with generally accepted engineering practices.

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7 REFERENCES

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APPENDIX A
PHOTOGRAPHS

Re-Established Side Channel 102.5R

Photo 1 Section 5, view west from left bank at the mouth of 102.5R (northeast bank erosion)

Photo 2 Section 5, view east from right bank at the mouth of 102.5R 5R (northeast bank erosion)

Photo 3 Section 5, view southeast along channel bed

Photo 4 Section 5, sediment characterization of 102.5R channel bed

Photo 5 Section 4.5, view southeast from left bank

Photo 6 Section 4.5, view south from mid channel

Photo 7 Section 4.5, left bank slumps

Photo 8 Section 3, view east from right bank

Photo 9 Section 3, view southeast from right bank

Photo 10 Section 3, view northeast from right bank

Photo 11 Section 2, vegetation and right bank

Photo 12 Section 2, view north from right bank

Photo 13 Section 2, sediment characterization in channel bed

Photo 14 Section 1.5, view south west of right bank erosion

Photo 15 Section 1.5, view southeast along channel bed

Photo 16 Section 1.5, right bank erosion

Photo 17 Section 1, view east from right bank

Photo 18 Section 1, log jam on left bank of channel at confluence with pre-existing side channel

Photo 19 Section 1, view north of left bank

Photo 20 Section 1, view northwest from left bank

Northeast Bank of 102.5R and Right Bank of Main Channel

Photo 21 **Mid-channel bar in Peace River opposite entrance to the 102.5R side channel**

Photo 22 **Drone photo of BC Hydro utility towers and eroding right (south) bank of Peace River (north side of island)**

Photo 23 Peace River south bank erosion (north side of island) downstream of 102.5R

Photo 24 View east along south bank of Peace River (north side of island) downstream of 102.5R

Photo 25 View upstream along south bank of Peace River downstream of 102.5R

Photo 26 View of BC Hydro utility towers

Photo 27 View north of utility tower guide wires

Photo 28 View west along south bank of Peace River downstream of 102.5R

Photo 29 View east along south bank of Peace River downstream of 102.5R

Photo 30 Sediment characterization of eroding south bank of Peace River downstream of 102.5R

Photo 31 View of south bank from mid channel of Peace River downstream of 102.5R

Photo 32 View of south bank from mid channel of Peace River downstream of 102.5R

Photo 33 View of erosion of south bank of Peace River channel approximately 300 downstream from 102.5R

Photo 34 View of erosion of south bank of Peace River channel approximately 380 downstream from 102.5R

Pre-Project Side Channel and Peace Island Park

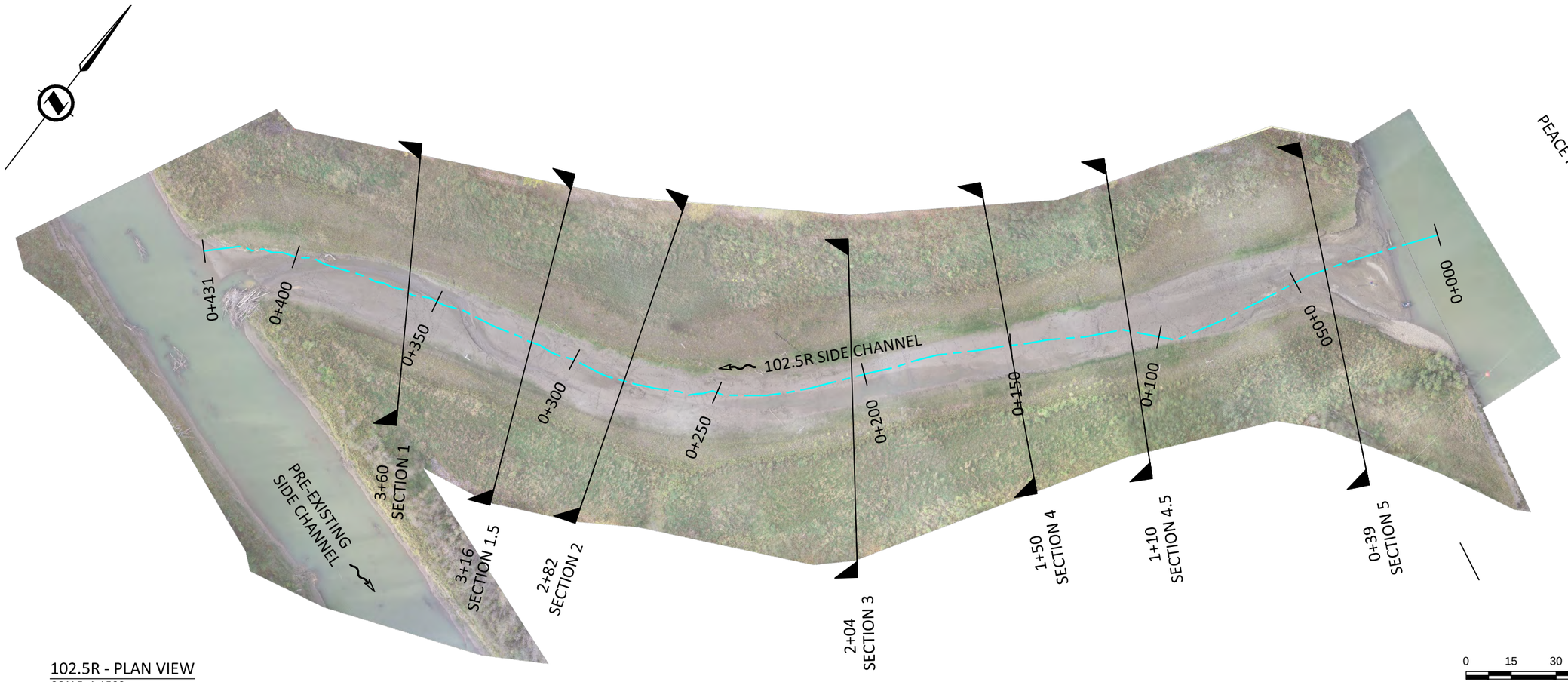
Photo 35 **View west, Peace Island Park bank erosion**

Photo 36 **Peace Island Park sediment characterization**

Photo 37 **View east, Peace Island Park bank erosion**

Photo 38 **View east, Peace Island Park bank erosion**

APPENDIX B
INSPECTION DRAWING



102.5R - PLAN VIEW
SCALE: 1:1500

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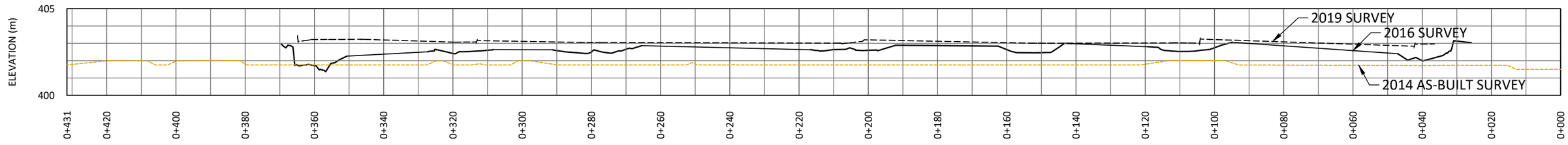
SCALE: 1:1500



102.5R - SECTION VIEW
SCALE: 1:1250

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REVISIONS		
0	20191119	ISSUED FOR INFORMATION

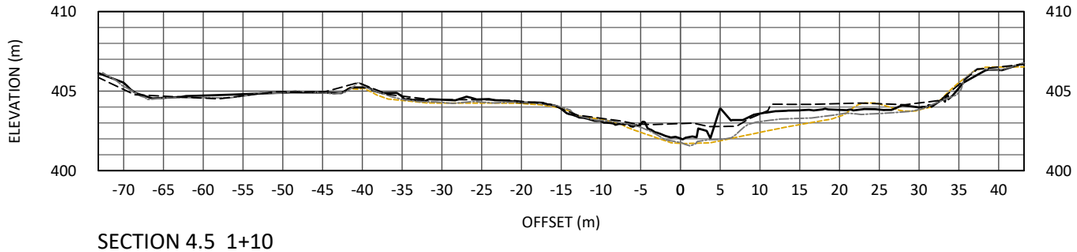
DRAWING INFORMATION	
DATE	30 Jun 2020
DESIGNED BY	
DRAWN BY	WES/CZZ
CHECKED BY	DPM
SHEET SIZE	B (11" x 17")

PEACE RIVER GMSWORKS3
TRIAL SIDE CHANNEL 102.5R

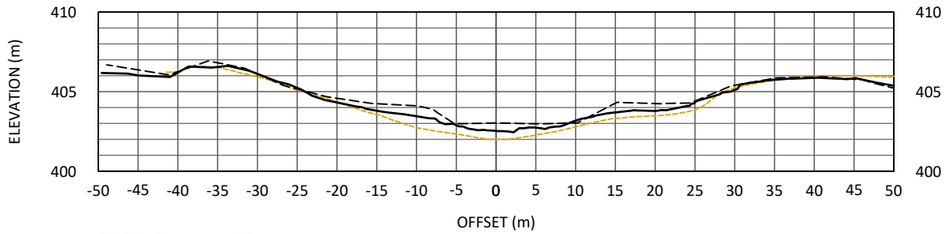
2018 HYDROTECHNICAL MONITORING
PLAN AND PROFILE

PROJECT NUMBER	3004999
DRAWING NUMBER	3004999-001
SHEET NUMBER	1
REVISION	1

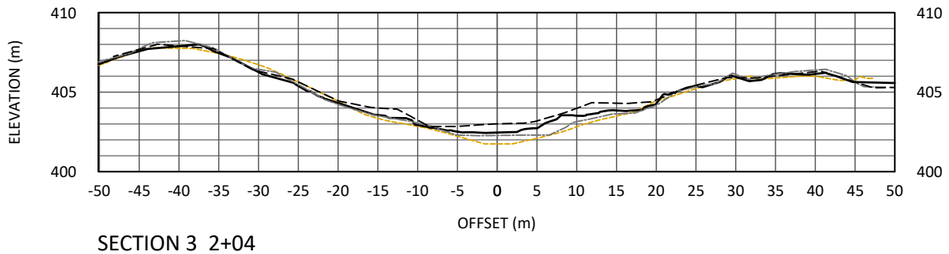
SECTION 5 0+39



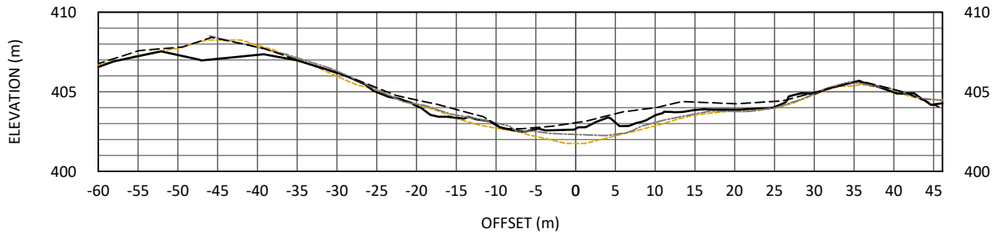
SECTION 4.5 1+10



SECTION 4 1+50



SECTION 3 2+04



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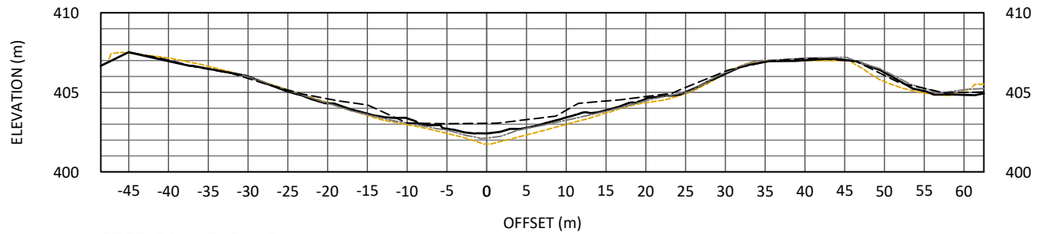
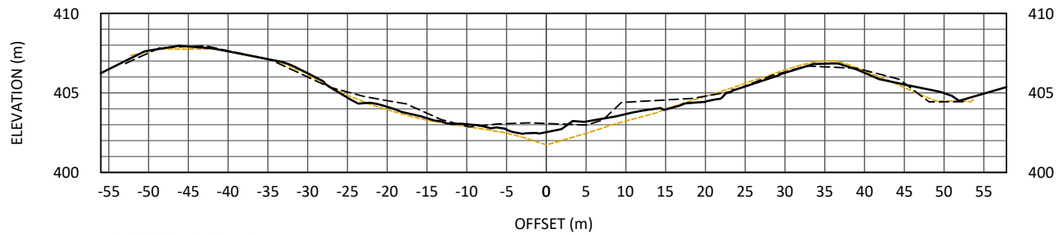
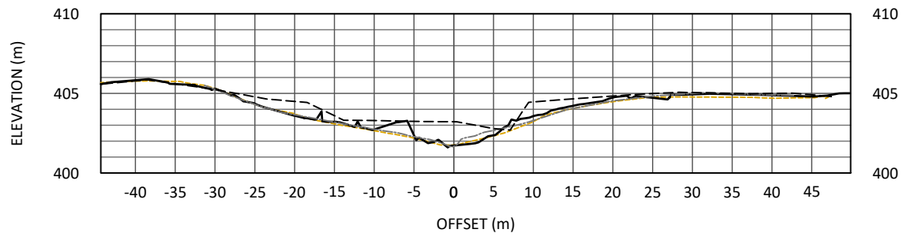
SECTION 2 2+82



SECTION 1.5 3+16



SECTION 1 3+60



1H:2V

TABLE 1

		DESIGN ELEVATIONS (m)			23 APRIL 2014 AS-BUILT ELEVATIONS (m)			22 SEPT 2014 SURVEY ELEVATIONS (m)			17 JUNE 2016 SURVEY ELEVATION (m)			30 SEPT 2019 SURVEY ELEVATIONS (m)		
XS	OFFSET	-10	0	10	-10	0	10	-10	0	10	-10	0	10	-10	0	10
1	3+60.2	402.75	401.76	403.63	402.66	401.75	403.22	402.75	401.66	403.29	402.71	401.72	403.54	403.30	403.22	404.46
1.5	3+15.55	402.88	401.75	403.23	-	-	-	-	-	-	403.03	402.53	403.66	402.91	403.08	404.41
2	2+81.92	403.00	401.66	402.99	402.96	401.75	402.98	403.06	402.13	401.25	403.16	402.41	403.42	403.07	403.05	403.87
3	2+04.24	402.85	401.66	402.99	402.71	401.75	402.86	403.03	402.31	403.07	402.90	402.63	403.51	402.96	403.05	404.00
4	1+50.35	402.86	401.56	402.88	402.85	401.75	402.82	403.06	402.28	403.15	403.94	402.46	403.52	403.24	403.01	403.99
4.5	1+09.84	402.74	402.00	402.79	-	-	-	-	-	-	403.45	402.53	403.17	404.11	403.03	403.04
5	0+39.21	403.44	401.44	402.43	403.24	401.72	402.40	403.16	401.78	403.08	403.11	402.02	403.59	403.29	402.96	403.56

LENGEND

- AS-BUILT 2014
- 22 SEPT 2014
- 17 JUNE 2016
- 30 SEPT 2019

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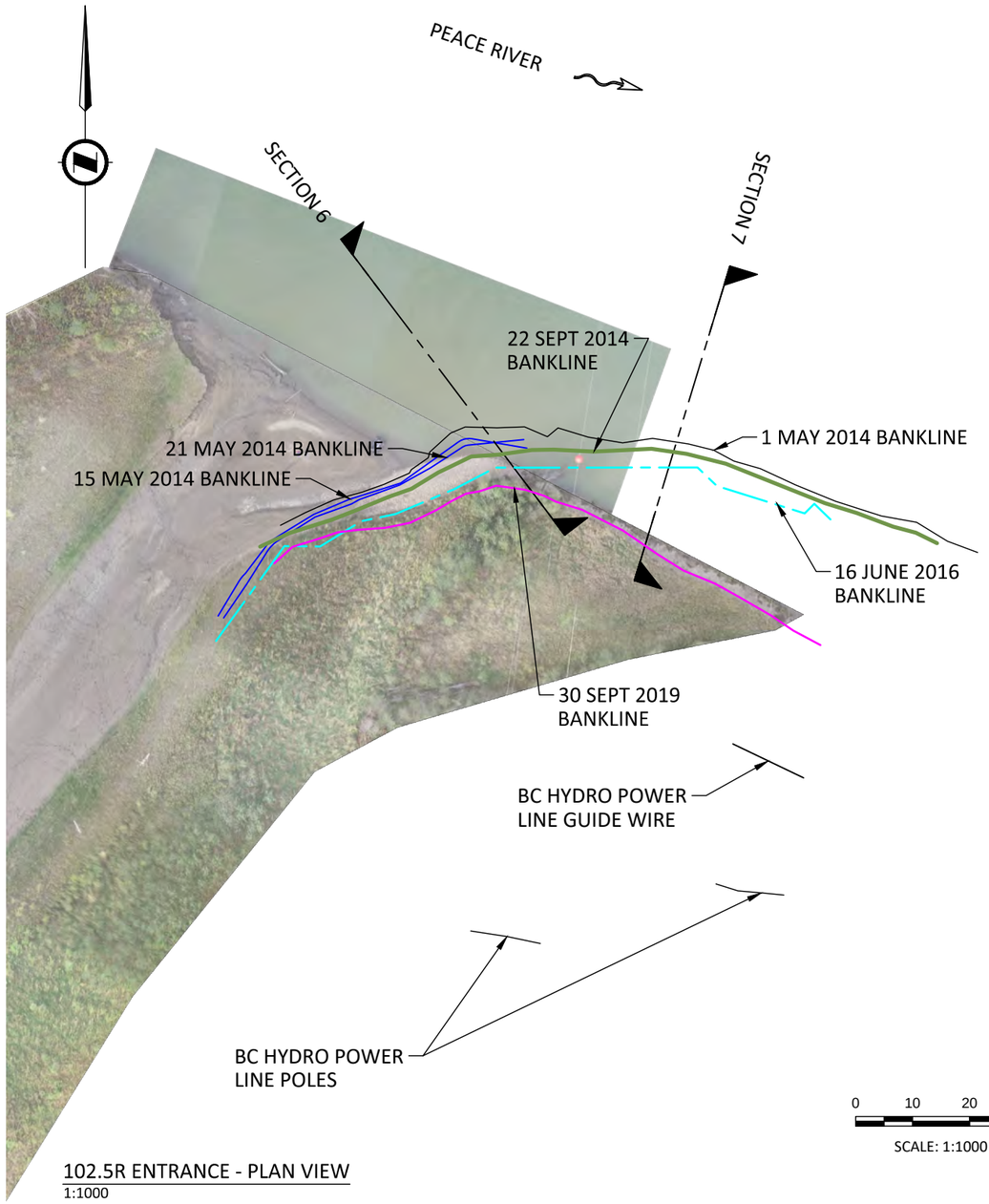
REVISIONS		
0	20191119	ISSUED FOR INFORMATION

DRAWING INFORMATION	
DATE	30 Jun 2020
DESIGNED BY	
DRAWN BY	WES/CZZ
CHECKED BY	DPM
SHEET SIZE	B (11" x 17")

PEACE RIVER GMSWORKS3 TRIAL SIDE CHANNEL 102.5R

2019 HYDROTECHNICAL MONITORING
SECTION VIEW

PROJECT NUMBER	3004999
DRAWING NUMBER	3004999-002
SHEET NUMBER	2
REVISION	1

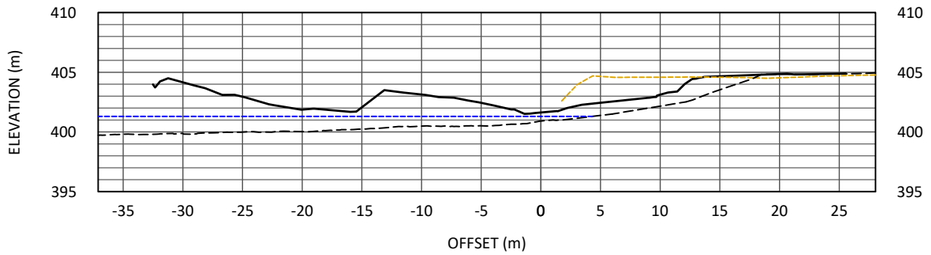


0 10 20 30

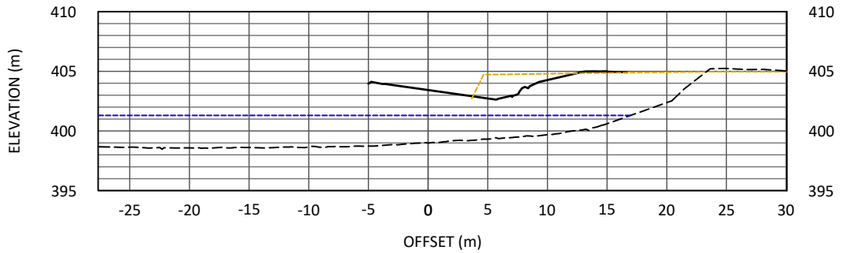
SCALE: 1:1000

102.5R ENTRANCE - PLAN VIEW
1:1000

SECTION 6



SECTION 7



102.5R - SECTION VIEWS
1:500

LEGEND

- 30 SEPT 2019
- 16 JUNE 2016
- 1 MAY 2014
- WATER LEVEL

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REVISIONS		
0	20191119	ISSUED FOR INFORMATION

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DATE	30 Jun 2020
DESIGNED BY	
DRAWN BY	WES/CZZ
CHECKED BY	DPM
SHEET SIZE	B (11" x 17")

PEACE RIVER GMSWORKS3
TRIAL SIDE CHANNEL 102.5R

2019 HYDROTECHNICAL MONITORING
NORTH EAST BANK
PLAN AND SECTION VIEW

PROJECT NUMBER	3004999
DRAWING NUMBER	3004999-003
SHEET NUMBER	3
REVISION	1

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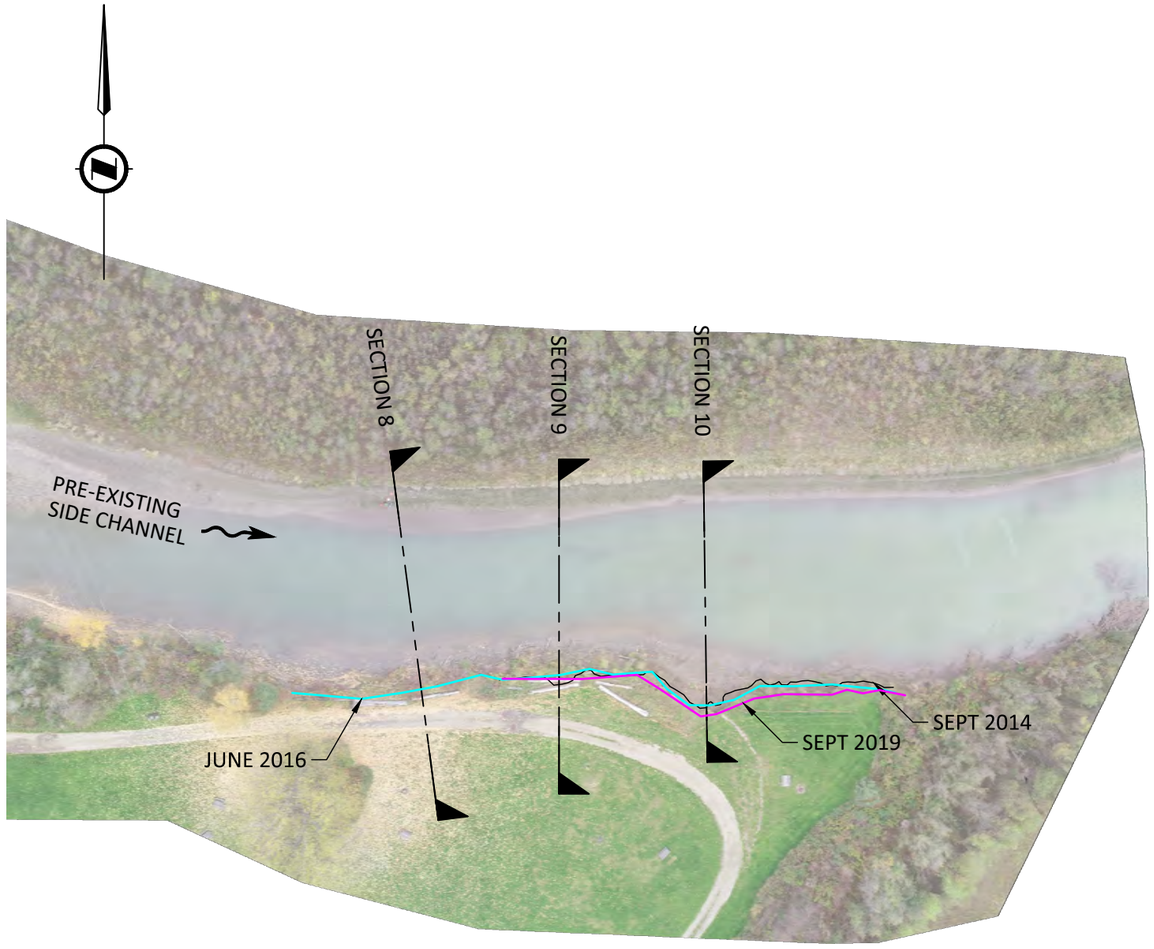

PEACE ISLAND PARK - PLAN VIEW
1:1000

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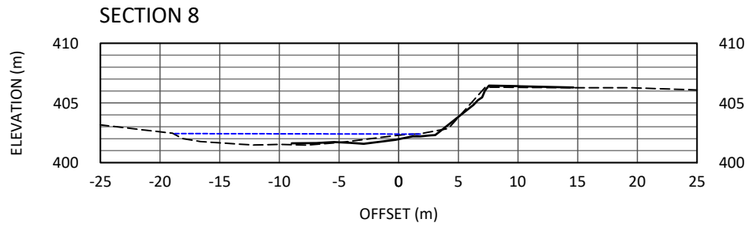
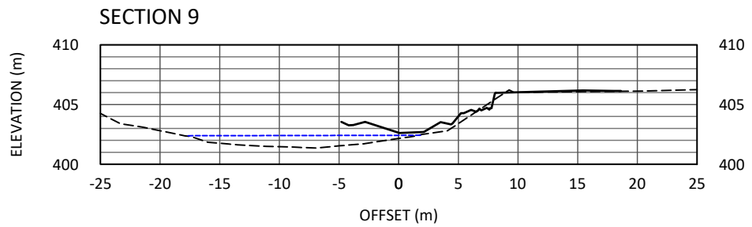
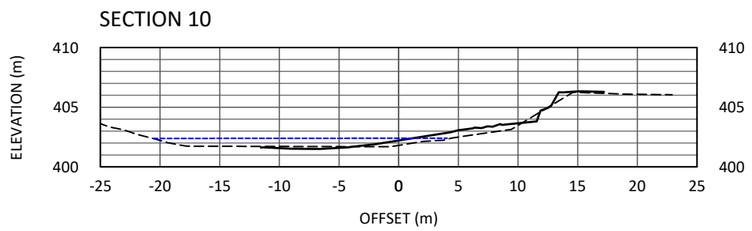
SCALE: 1:1000







PEACE ISLAND PARK - SECTION VIEWS
1:500

LEGEND

- WATER LEVEL
- 2016 SURVEY
- 2019 SURVEY

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REVISIONS		
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DRAWING INFORMATION	
DATE	30 Jun 2020
DESIGNED BY	
DRAWN BY	WES/CZZ
CHECKED BY	DPM
SHEET SIZE	B (11" x 17")

PEACE RIVER GMSWORKS3
TRIAL SIDE CHANNEL 102.5R

2019 HYDROTECHNICAL MONITORING
PARK EROSION
PLAN AND SECTION VIEW

PROJECT NUMBER	3004999
DRAWING NUMBER	3004999-004
SHEET NUMBER	4
REVISION	1

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