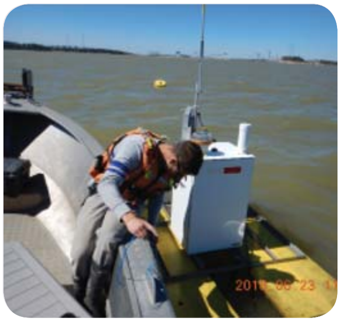
Keeyask Generation Project

Sediment Management Plan for In-stream Construction

Sediment Management Plan Report

SMP-2019-01



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KEEYASK GENERATION PROJECT

SEDIMENT MANAGEMENT PLAN FOR IN-STREAM CONSTRUCTION

REPORT #SMP-2019-01

ANNUAL REPORT

April 2018 – March 2019: Year 5 Construction

Prepared by

Manitoba Hydro

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SUMMARY

This *Sediment Management Plan for In-stream Construction* (SMP) was developed for the construction phase of the Keeyask Generation Project (the Project) to minimize the impacts of in-stream sediment generated from construction activities on the Nelson River. Excessive amounts of sediment generated during construction could change the water quality and be harmful to fish and fish habitat.

Sediment in the river is measured every 15 minutes at locations up and downstream of the construction site using an automated system to track sediment changes during major in-stream work, such as placing rock in the river to build cofferdams. The readings are sent to a computer where personnel watch and compare the amount of sediment between up and downstream in real time. The change in sediment observed is compared to predetermined action levels, which were determined by the Keeyask Hydropower Limited Partnership in consultation with provincial and federal regulators. Should the action levels be exceeded, site personnel would work with the contractor to reduce the amount of sediment entering the river during the particular construction activity, for example, slowing down rock placement in the water to reduce the amount of sediment produced.

Sediment monitoring has been conducted in accordance with the SMP since the Project began in July 2014 and there were no exceedances of the action levels as a result of in-stream construction until 2018. While commissioning the Keeyask Spillway in August 2018, there were three, separate exceedances of the one hour average of >25 mg/L above the background concentration of sediment in the river. These exceedances occurred over the course of two days at a single SMP location (SMP-2L). In accordance with the SMP, each time the threshold was surpassed, site personnel took action by way of halting gate opening until the sediment had dissipated such that the concentration measured at SMP-2L dropped below the threshold. Once this occurred, commissioning resumed.

Spillway commissioning was predicted in the Project EIS to cause an exceedance of the SMP action levels. However, the magnitude and duration of the exceedances measured were less than predicted.

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1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station at Gull Rapids on the lower Nelson River in northern Manitoba. The Project is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, where Gull Lake flows into Stephens Lake, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam. Construction of the Project began in July 2014.

The principal structures for the Keeyask Generating Station are:

- North and South Dykes;
- North, Central and South Dams;
- Powerhouse complex including the intake and tailrace channels; and
- Spillway including an approach channel and discharge channel.

The *Keeyask Generation Project: Response to EIS Guidelines*, (EIS) completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. The *Sediment Management Plan for In-stream Construction* (SMP) (KHLP 2014) was developed for the construction phase of the Project, to minimize the impacts of in-stream sediment from construction activities in the Nelson River. It describes the monitoring and management of Total Suspended Solids (TSS) inputs into the waterway that may occur as a result of shoreline erosion, in-stream construction, river management, and commissioning of the Spillway and the Powerhouse. The SMP comprises a real-time sediment monitoring program, which is being implemented for in-stream construction activities in the Nelson River, throughout construction.

This report summarizes the results for the sediment monitoring that took place during in-stream construction in the Nelson River from April 2018 to March 2019.

1.1 CONSTRUCTION SUMMARY

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams in the north and central channels of Gull Rapids (Figure 1). These cofferdams resulted in the dewatering of the north and central channels and the diversion of all flow to the south channel. Construction of the Spillway Cofferdam (SWCD), which extends into the south channel of Gull Rapids, was completed in 2015. The rock placement for the inner and outer groins of the Tailrace Cofferdam (TRCD) started in late 2016 and the impervious fill placement was completed in fall 2017. An opening was created to allow fish to move freely over the winter of 2017/18. The opening was closed in spring 2018 and dewatering of the TRCD occurred in July, at which time fish salvage was completed. In preparation for commissioning of the Spillway, the SWCD was watered-up on both sides of the structure in June 2018. Removal of the SWCD started in early July and continued into August. The Spillway was commissioned between

August 3 and 7, 2018. Closing the south channel with the upstream South Dam Cofferdam (SDCD) commenced at the beginning of August and river closure was achieved on August 16. This closure and the work that continued to seal the cofferdam forced the entire river flow through the Spillway. The downstream SDCD was completed in September and the area between the two cofferdams was dewatered allowing for fish salvage to be completed by late September 2018. Work continued on the upstream SDCD until it was complete in late fall 2018.

The permanent upstream and downstream boat launches were also constructed this year, however only the downstream launch was in-stream work.

As in previous years, an ice boom was installed in Gull Lake to assist in the formation of a stable ice cover.

1.2 FLOWS AND WATER LEVELS

From October 2017 to October 2018, Split Lake outflows have ranged from about 2,800-4,000 m^3/s. Flows typically fell in the range of about 3,000-3,500 m^3/s, which is near the historical annual median flow of approximately 3,300 m^3/s. The flows were generally higher in the 2017-2018 winter period but gradually declined at the end of winter from about 3,800 m^3/s at the end of February to about 2,800 m^3/s by the beginning of May. From early May to the beginning of July, flow gradually increased to about 3,500 m^3/s and remained at that level in July. The flow subsequently declined to about 2,800 m^3/s by the end of September. Water levels varied in conjunction with the flows, ranging from about 153.4-155.2 m ASL on Gull Lake.

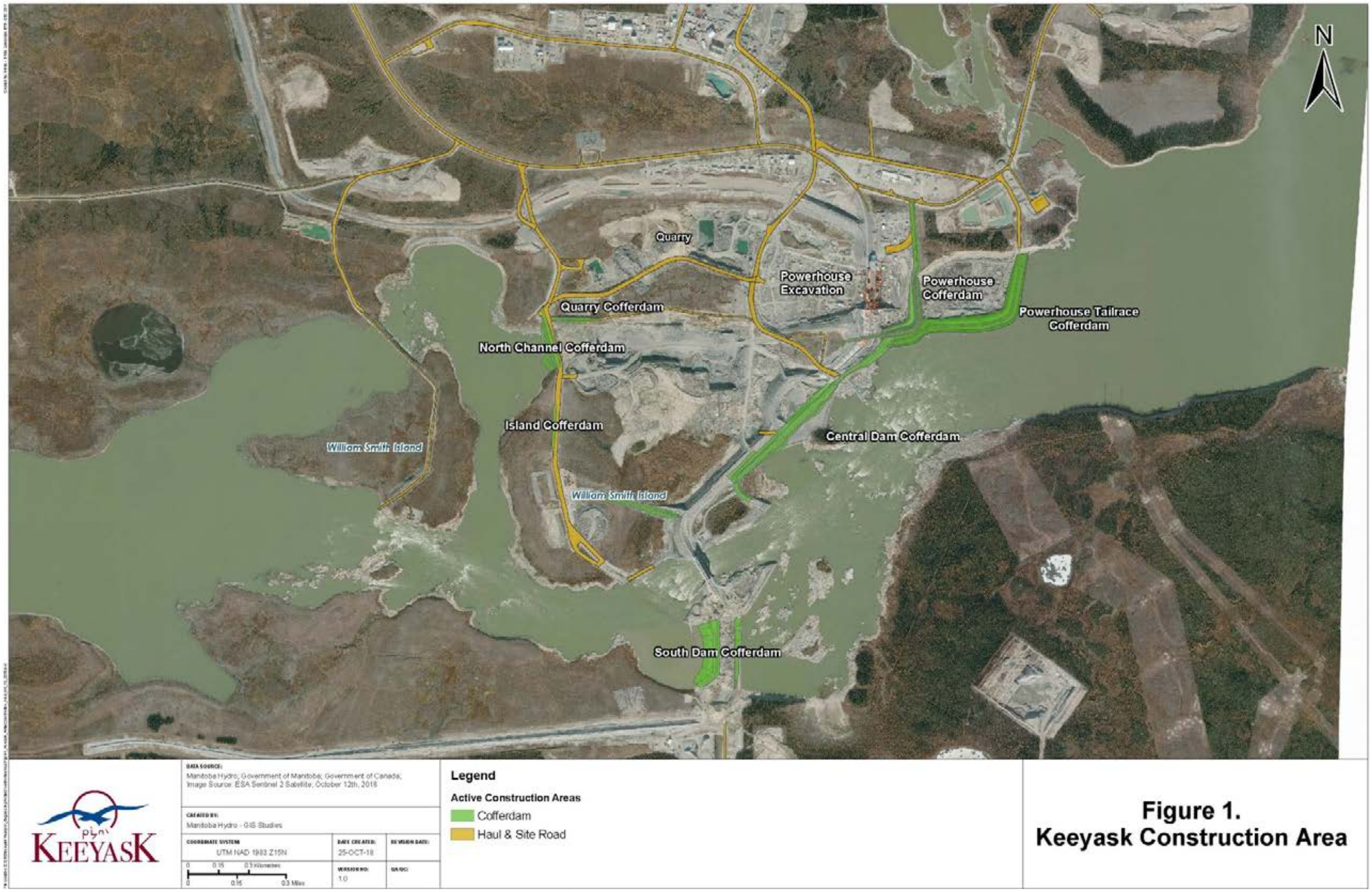

Figure 1: Map of the Keeyask Generating Station site, October 2018

2.0 SEDIMENT MONITORING PROGRAM

As part of the Keeyask Generation Station Project, a detailed real-time sediment monitoring program was developed for the construction phase to monitor sediment inputs from in-stream construction activities in the Nelson River. The *Keeyask Generation Project Sediment Management Plan for In-stream Construction* (SMP) (KHLP 2014) outlines the monitoring and management of Total Suspended Solids (TSS) that may occur as a result of in-stream construction and commissioning of the Spillway and the Powerhouse.

Turbidity (Tu) is monitored through the use of turbidity loggers at three locations (with a total of five monitoring stations). The turbidity data are converted to TSS values based on the derived relationship between Tu and TSS, as explained in the SMP. Monitoring locations are discussed in more detail in sections 2.1, 2.2, and 2.3.

The monitoring locations are consistent with the baseline monitoring sites that were used in the environmental assessment studies. While it is intended that monitoring be undertaken at these locations, the actual locations may be adjusted in the field based on factors such as the safety of personnel and equipment, accessibility, and ambient conditions (*e.g.*, high river flow, high water velocity, unsafe ice).

2.1 OPEN WATER MONITORING STATIONS

During the month of June 2018, the open water monitoring stations were installed on the Nelson River. Five monitoring stations (SMP-1, SMP-2L & SMP-2R, SMP-3L & SMP-3R) were deployed as outlined in the SMP to collect turbidity data for the Project. A backup station (SMP-1A) was installed near SMP-1 as a precaution, so background data would be continuously available in the event that SMP-1, which is the sole upstream monitoring station, failed or became damaged. At each station, sensors were installed two meters below the water's surface (designated TSSS) and two meters above the bottom of the channel (designated TSSB). Figure 2 shows the location of each of the SMP open water monitoring stations. The stations are described in more detail below:

- SMP-1 is located upstream of all construction activities in the Nelson River and monitors ongoing background conditions.
- SMP-2 is located approximately 1.5 km downstream of the future Powerhouse. Data loggers are installed on the left and right sides of the channel (SMP-2L and SMP-2R). This location was chosen, as it is a near-field location within the mixing zone prior to fully mixed conditions.
- SMP-3 is located approximately 9 km downstream from the construction site in the fully mixed zone of the primary flow channel, along the deepest part of the river. This location was chosen because the majority of the flow passes through this south channel and it is

where increases in TSS will mostly occur. Data loggers are installed on both the left and right sides of the channel (SMP-3L & SMP-3R).

Figure 2: Open water monitoring stations for the Keeyask Sediment Management Plan

Open water monitoring equipment was removed in fall 2018, near the end of the open water season, on the following days:

- SMP-1 on September 15; and
- SMP-2L, SMP-2R, SMP-3L, SMP-3R on October 1.

Since construction began, flow velocities have increased at the site of SMP-2R, likely due to changes in the river's flow pattern driven by the presence of the Project. The station's location has been moved roughly 450m downstream of the original site due to multiple capsize events in previous years.

SMP-2L was also moved prior to Spillway Commissioning to best capture the flow of the river and potential sediment plumes.

2.2 SHOULDER SEASON MONITORING STATIONS

Shoulder season monitoring was not implemented in 2018 and will not be implemented in future years because efforts in previous years to monitor TSS during the ice on and off transition periods have not been successful. Each year, moving ice has destroyed the communication cables between the in-stream turbidity sensors and the data loggers installed on shore. There is no feasible layout at these times of the year to prevent this from occurring. Where results were obtained, frazil ice produced in the Nelson River between Clarke Lake and Gull Rapids caused interference and damaged the turbidity monitoring sensors, which produced unreliable data.

2.3 WINTER MONITORING STATIONS

The SMP describes modifications to the open water program required in winter with ice conditions. Monitoring stations were installed upstream at SMP-1 and downstream at SMP-3 during the winters of 2018 and 2019. In both winters, monitoring equipment was not installed at SMP-2 due to unfavorable ice conditions that would cause interference with instrumentation. For the 2018/2019 reporting period, monitoring stations were in place as follows:

- Winter 2018:
    - SMP-1: April 1 – April 22, 2018
    - SMP-3L: April 1 – April 30, 2018
    - SMP-3R: April 1 – April 30, 2018

Winter 2019:

- o SMP-1: January 28, 2018 – March 31, 2019
- o SMP-3L: January 26, 2018 – March 31, 2019
- o SMP-3R: January 26, 2018 – March 31, 2019

2.4 ACTION AND TARGET LEVELS

As outlined in the SMP, the management of TSS levels during construction incorporates two action levels measured in the mixing zone at SMP-2:

1. Four, consecutive, 15-minute averaged measurements over 25 mg/L above background TSS at monitoring site SMP-1; and
2. One, 15-minute averaged increase of 200 mg/L above background TSS at monitoring site SMP-1.

Both action levels are below acutely lethal thresholds of TSS for freshwater fish, which range from hundreds to hundreds of thousands of mg/L. The action levels at SMP-2 are set such that action is initiated to reduce construction sediment inputs, in order to maintain a 24-hour average increase of 25 mg/L or less at SMP-3, relative to SMP-1 (background TSS).

An exceedance of these action levels initiates an investigation to identify the source of the TSS, implement secondary mitigation strategies for unanticipated events, and/or modify in-stream construction procedures as outlined in the SMP.

2.5 MANUAL SAMPLING

2.5.1 TURBIDITY / TSS RELATIONSHIP VALIDATION

As outlined in the SMP, the *in situ* turbidity logger data measured at each monitoring site and the relationship used to calculate TSS from turbidity were confirmed through manual monitoring of turbidity using handheld loggers and collecting water samples for TSS analysis at the same time. Manual sampling in the summer season began in June and ended in mid-September of 2018. Turbidity measurements and TSS samples were collected near the surface, middle, and bottom of the water column in the vicinity of each SMP monitoring station. The results are provided in Table 1. Winter sampling is slightly different as it only involves one sample taken at the surface of the water column. This sampling ran from February to April 2019.

2.5.2 DETECTING SEDIMENT PLUMES IN THE MIXING ZONE

To confirm the SMP-2 stations (*i.e.*, left and right locations) were positioned such that the deployed loggers would detect an increase in turbidity from a passing sediment plume, if any, turbidity measurements were taken along a cross section of the river at twenty sites near SMP-2. Discreet measurements were collected along the transect once during the open water season (Figure 3), when in-stream work was not occurring (July 4, 2018; Table 2), and again during in-stream work.

In past years during in-stream construction, turbidity measurements were taken at the discreet locations illustrated in Figure 3 over the summer, corresponding with the timing for constructing major, in-water structures such as cofferdams. During Spillway commissioning, readings at the SMP-2 and SMP-3 sites were to dictate whether or not the Spillway gates could continue to rise and so as per the SMP, additional turbidity monitoring was performed as a means to aid in decision-making related to gate opening. Site personnel conducted passes back and forth across the river in a boat while dragging a turbidity sonde to confirm the SMP-2 sensors were capturing the changes in the sediment plume generated by opening the various gates (Figure 4). Several passes took place daily during commissioning near the two SMP-2 locations, or closer to Gull Rapids.

Also during Spillway Commissioning, a separate turbidity monitoring site, K-SWCOMM-4, was selected on the shore, very close to the spillway (400 m away). Monitoring at this location comprised of a person who took turbidity measurements at 5 to 10 minute intervals directly opposite from the end of the Spillway discharge channel. If an exceedance of the action level threshold was detected at the SMP-2 sites during real-time monitoring, then measurements taken further upstream at K-SWCOMM-4 were used to determine whether or not the peak of the sediment plume had already passed that location. If the readings taken at SWCOMM-4 showed the sediment peak had not passed, the Spillway gates would be lowered to reduce TSS, but if the peak had already passed, the gates would be left in their current position but not raised further. The gates were held until the conditions at SMP-2 no longer exceeded the action level threshold.

Two additional turbidity sondes were deployed during Spillway Commissioning in the vicinity of the SMP-2 locations to provide additional measurements of the sediment plume passing that location. The first (site K-SWCOMM-1) was located mid-way between sites SMP-2R and SMP-2L, and K-SWCOMM-2 north of SMP-2L. These extra sites were not used for real-time decision making but the data obtained were reviewed afterwards and compared with the data from the SMP-2R and SMP-2L sites in order to corroborate the values for TSS obtained at the SMP-2 sites.

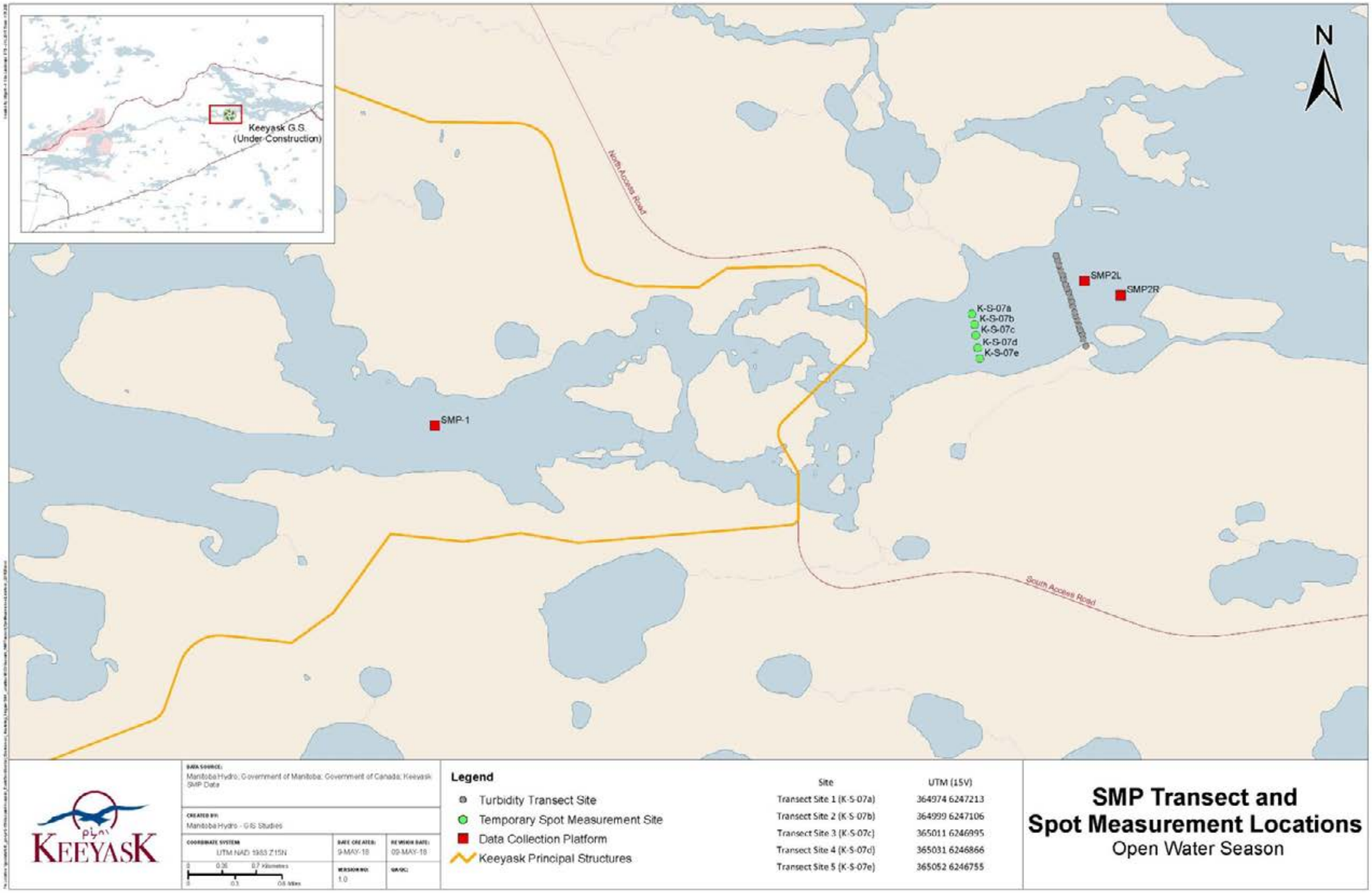

Figure 3: Map of turbidity measurements for cross-section of the Nelson River at SMP-2 sites and spot measurement sites (K-S-07) between Gull Rapids and the SMP-2 sites (July 4, 2018)

Figure 4: A crew moves along a transect with sonde set at depth of 2m travelling from north to south across the Nelson downstream of the safety boom. The Spillway structure can be seen in the background, with 4 of 7 gates raised. On the right is the powerhouse construction area.

Based on the data collected, there were no variations in the turbidity detected across the river when there was no in-stream work taking place. Information on sediment and turbidity measured during the various construction activities, including Spillway commissioning, are discussed in the remainder of the document.

3.0 IN-STREAM WORK

3.1 SPILLWAY COFFERDAM REMOVAL

The upstream and downstream portions of the Spillway Cofferdam were constructed starting in 2015 and were each comprised of an inner and outer rock groin filled with an impervious core of fine material (clay). Prior to removing the rock groins, the approach and discharge channels were cleaned to reduce the material available that would contribute to the suspended sediment load during Spillway Commissioning (Figure 5). On July 4 2018, in-stream work began to breach the rock groins of the downstream cofferdam and begin removal of the impervious material (Figure 6). Removal of the upstream cofferdam began shortly afterwards and both were removed by August 5. As shown in Figure 7, care was taken to reduce the amount of sediment released to the river by removing the impervious core in stages, within the relatively tranquil confines of the rock groins, followed by removing the groins themselves.

Figure 5: The Spillway Approach Channel after cleaning

Figure 6: Removing the downstream Spillway Cofferdam in July 2018

Figure 7: Excavators remove material from the impervious core and rockfill from the outer groin, July 11, 2018. A small sediment plume can be seen entering the Nelson River in the foreground, although no TSS exceedances were observed at SMP monitoring sites

In-stream SMP monitoring was carried out during removal of the upstream and downstream portions of the Spillway Cofferdam and the results are shown in Figure 8 and Figure 9. Both figures show that the action levels were exceeded at SMP-2 on five occurrences during that time; however, the increased values were not caused by the cofferdams removal.

On July 4, 2018, an exceedance of action levels occurred at the bottom sensor of SMP-2R (Figure 8). As required by the SMP, action was taken to determine the source of exceedance. After visiting the SMP-2R location, site personnel found the sensor cable was dragging on the bottom and generating sediment around the sensor; this was corrected and the results returned to normal. From July 6 at 16:45 CDT to July 8 at 4:15 CDT, an exceedance of the action level occurred at the bottom sensor of SMP-3R (Figure 9), and was also determined to be caused by a sensor cable dragging on the bottom (Figure 10). An exceedance at the bottom sensor of SMP-2L on July 10 was a result of aquatic vegetation becoming tangled with and interfering with the turbidity sensor, while the exceedances at SMP-2L on July 31 were a result of sensor maintenance. The exceedances of the SMP action levels on Figure 8 between August 3 and 6 are legitimate, however they were caused by Spillway Commissioning, which coincided with the last couple of days of the SWCD removal. (The SMP results associated with Spillway Commissioning are discussed in detail in Section 3.2.)

On July 4, 2018, turbidity measurements were taken along a transect near SMP-2 (Table 2) as described in Section 2.5.1. The turbidity results during monitoring along the transect were similar to turbidity values measured upstream from the Keeyask site, at SMP-1. No unanticipated or markedly high turbidity values were detected during this work.

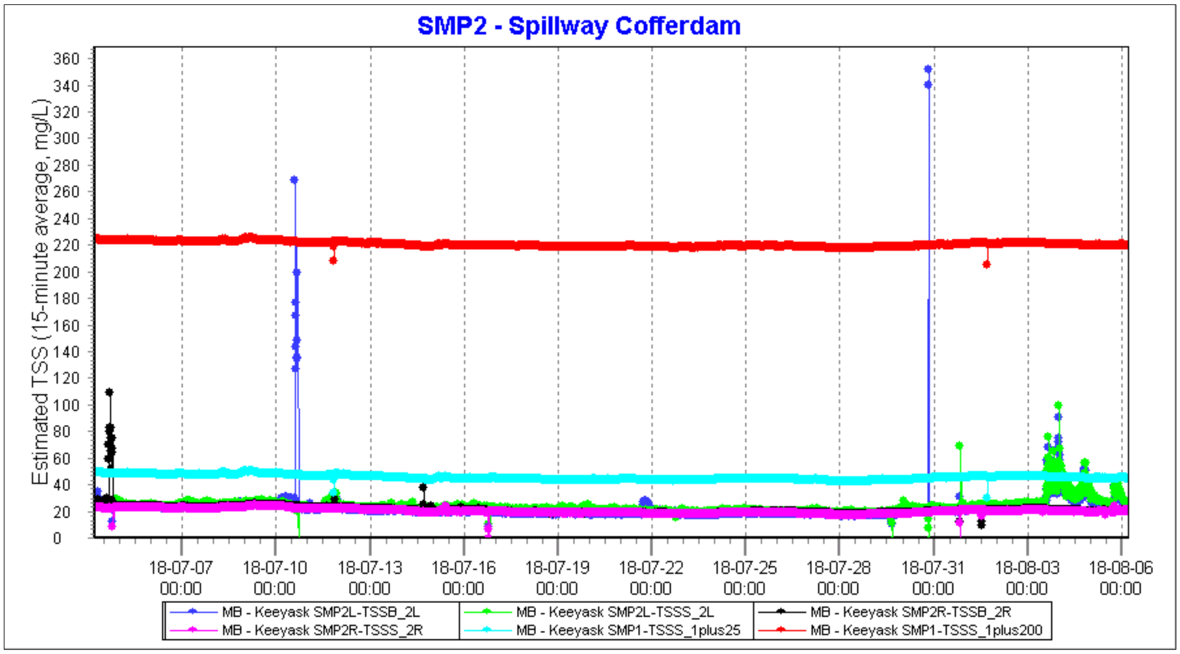

Figure 8: Estimated total suspended solids (TSS) values (15-minute average, mg/L) from July 4, 2018 through August 5, 2018 at monitoring stations SMP-2L and SMP-2R compared with the action levels, which are shown in light blue and red.

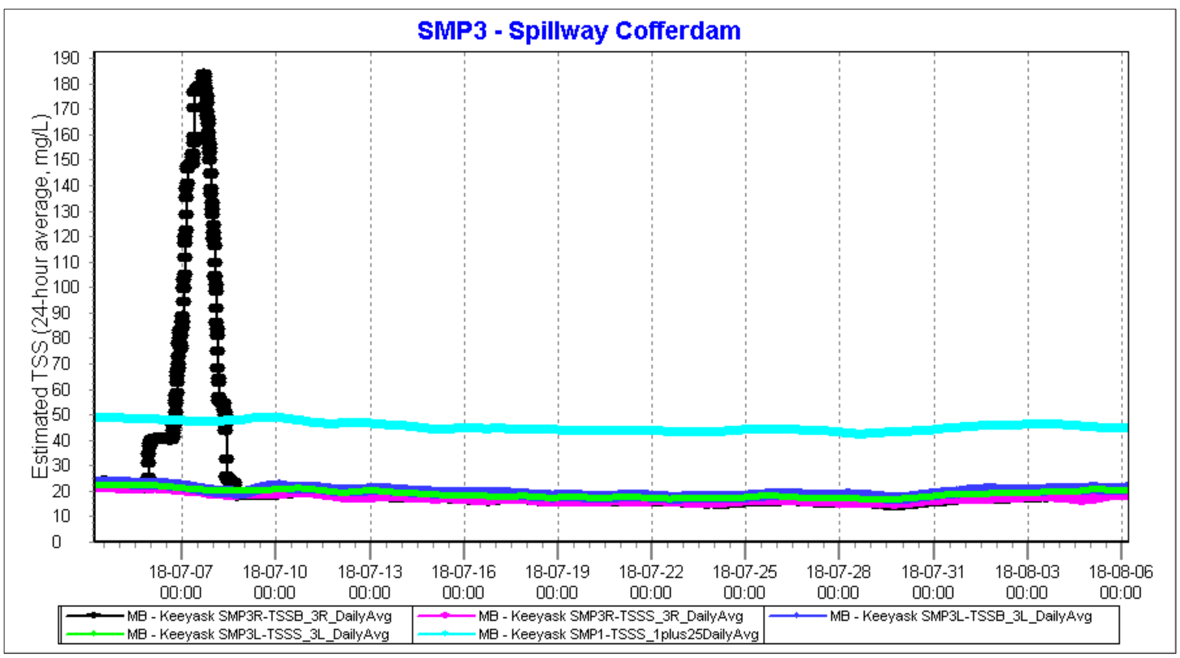

Figure 9: Estimated total suspended solids (TSS) values (24-hour average, mg/L) from July 4, 2018 through August 5, 2018 at monitoring stations SMP-3L and SMP-3R compared with the action level, which is shown in light blue.

Figure 10: A sensor weight that dragged along bottom of Stephens Lake at SMP-3R and resulted in elevated turbidity values at the bottom sensor. The cable was shortened to the correct length on July 7, 2018.

3.2 SPILLWAY COMMISSIONING

Commissioning the Spillway (Figure 11) was a major milestone during the Keeyask Project, and one of two major events where potential increases in TSS were predicted to be large enough to produce a measurable effect on the Nelson River (the other event is commissioning the Power House). Commissioning took place between August 3 and 7, 2019. As described in Section 2.5.2, many steps, in addition to watching the SMP results in real-time at SMP-2 and SMP-3, were taken to follow the plume while commissioning each gate to provide timely data necessary to make quick decisions in order to mitigate the impacts on aquatic life in the Nelson River.

Figure 11: Looking east (downstream) towards the Spillway structure after commissioning; all 7 gates are open.

Commissioning began by raising Gate 1 on August 3rd, 2018 at 7:45 am. It was anticipated the majority of the residual sediment in the approach channels of the Spillway, as well as the cofferdam remnants, would be flushed through the first two gates. Therefore, Gate 1 was moved in one metre increments while downstream crews monitored the turbidity in the river, as described in Section 2.5.2. If the calculated, real-time TSS at SMP-2 did not increase towards the threshold level of 25mg/L above background, the operators were notified and the gate was opened wider. This communication procedure was followed until all of the gates were fully open.

Figure 12 shows the TSS concentrations at SMP-2, as an average measured every 15 minutes, for the duration of Spillway Commissioning. As illustrated, the four peaks in the TSS that crossed the threshold of >25 mg/L above the TSS measured upstream occurred at SMP-2L, at both the top and bottom sensor.

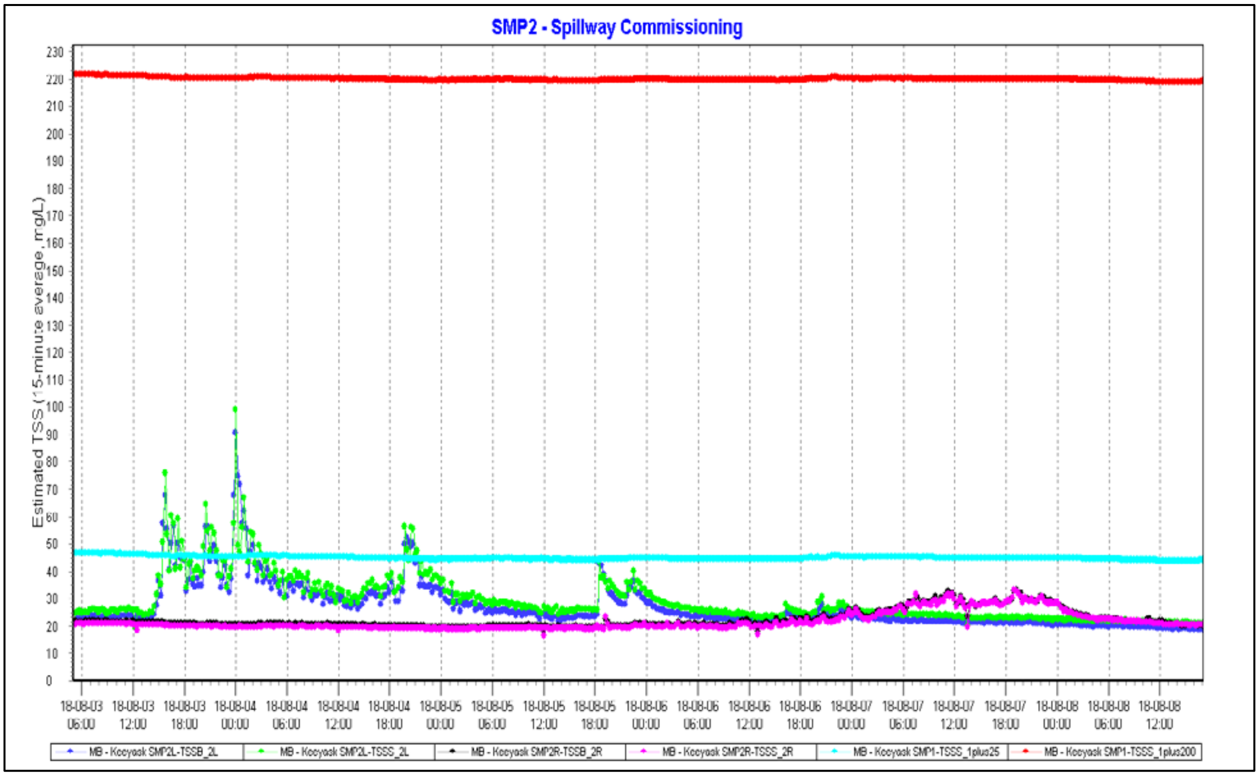

Figure 12: Calculated total suspended solids (TSS) concentrations in mg/L measured as 15-minute averages, mg/L) from August 3, 2018 through August 8, 2018 at monitoring stations SMP-2L and SMP-2R compared with the action levels, which are shown in light blue and red. Note that the time is plotted in Greenwich Mean Time (GMT), which is five hours ahead of local time (Central Daylight Time). Therefore, the range of the x-axis is from 00:00 CDT on August 3 to 12:00 CDT on August 9, 2018.

The first peak in TSS observed on August 3 between 10:30 and 12:00 CDT (15:30 and 17:00 GMT) did not result in an exceedance of the action level of >25 mg/L above the background TSS for at least one hour even though the compressed timescale of the graph makes it appear as though it did. Figure 13 shows the TSS concentrations at SMP-2 during that time on an expanded timescale to illustrate this. Although the 15 minute average TSS measurements (represented by each point on the graph) moved above the 25 mg/L above the action threshold, the duration was for less than an hour.

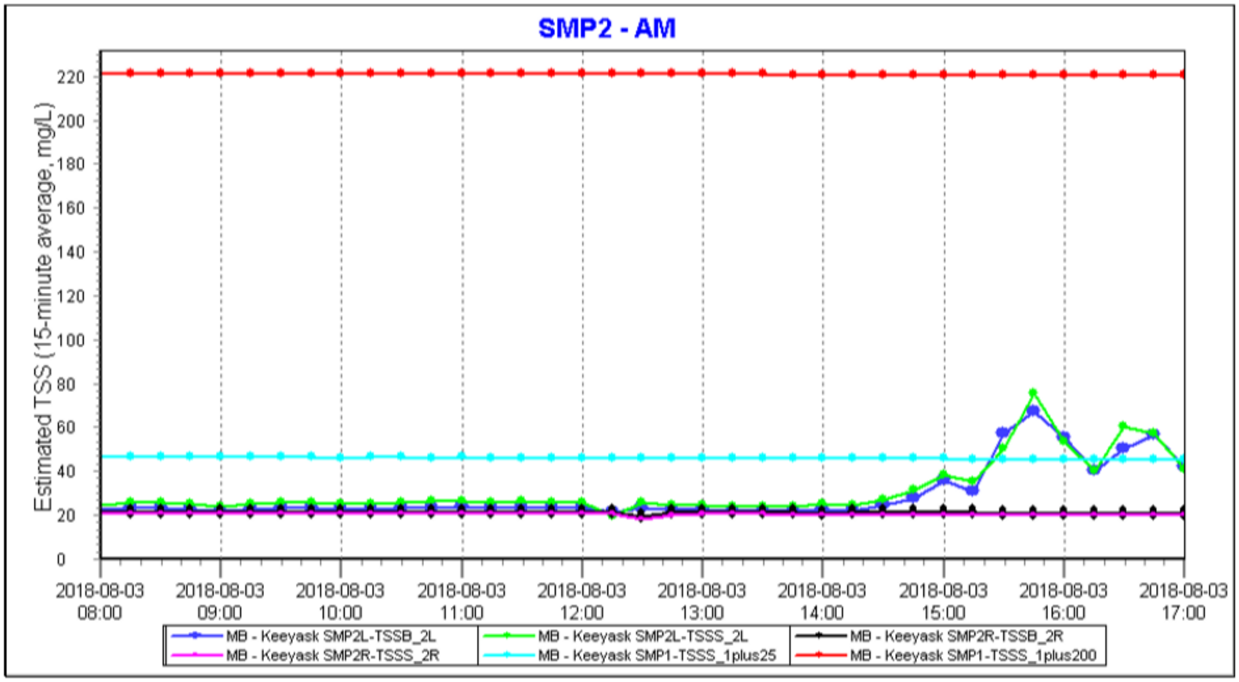

Figure 13: Excerpt from the Sediment Management Plan Daily report showing TSS on August 3, 2018 (first day of Spillway Commissioning) provided to Fisheries and Oceans Canada on August 4. The graph shows the TSS concentrations during 12 hours (GMT) at monitoring stations SMP-2R and SMP-2L.

The first exceedance of an SMP action level was observed at 15:15 and 16:45 CDT (20:15-21:45 GMT) at SMP-2L, when the average concentration of both the top and bottom sensors remained higher than 25 mg/L above the background TSS for over one hour (Figure 12). Once the exceedance occurred, the gate was held at the existing height until the TSS values dropped back below the threshold.

The second exceedance of an action level was similar to the first and occurred after Gate 1 was raised fully out of the water between 18:45 and 20:15 CDT (23:45 2018/08/03 - 01:15 2018/08/04 GMT). The average concentration measured at both the top and bottom sensors at SMP-2L was higher than 25 mg/L above the background TSS in the river for over an hour. Seven, consecutive measurements above the action threshold were observed at the bottom sensor and six, consecutive measurements were above the threshold at the surface sensor. As the gate was fully raised, no further movement took place and the TSS measured at SMP-2L fell below the threshold overnight.

Gate 2 was raised out of the water on August 4. A third exceedance of the action level concentration of greater than 25 mg/L above the background TSS in the river for one hour occurred between 14:45 and 16:15 CDT. Four, consecutive readings exceeded the threshold as measured at the surface sensor and five readings exceeded it as measured by the bottom sensor. This exceedance occurred after Gate 2 was fully raised out of the water.

Gates 3 through 7 were opened gradually over the next 4 days (Figure 14) and monitoring confirmed there were no exceedances of the action levels in the SMP.

Figure 14: Spillway Approach Channel (looking downstream) during Spillway commissioning on August 5, 2018. An excavator can be seen at right removing the remainder of the Spillway Cofferdam.

As is shown in Figure 15, Spillway Commissioning appeared to cause a slight increase in the TSS concentration measured at SMP-3 (at both the top and the bottom) between August 6 and 8; however, the maximum was well below the SMP threshold.

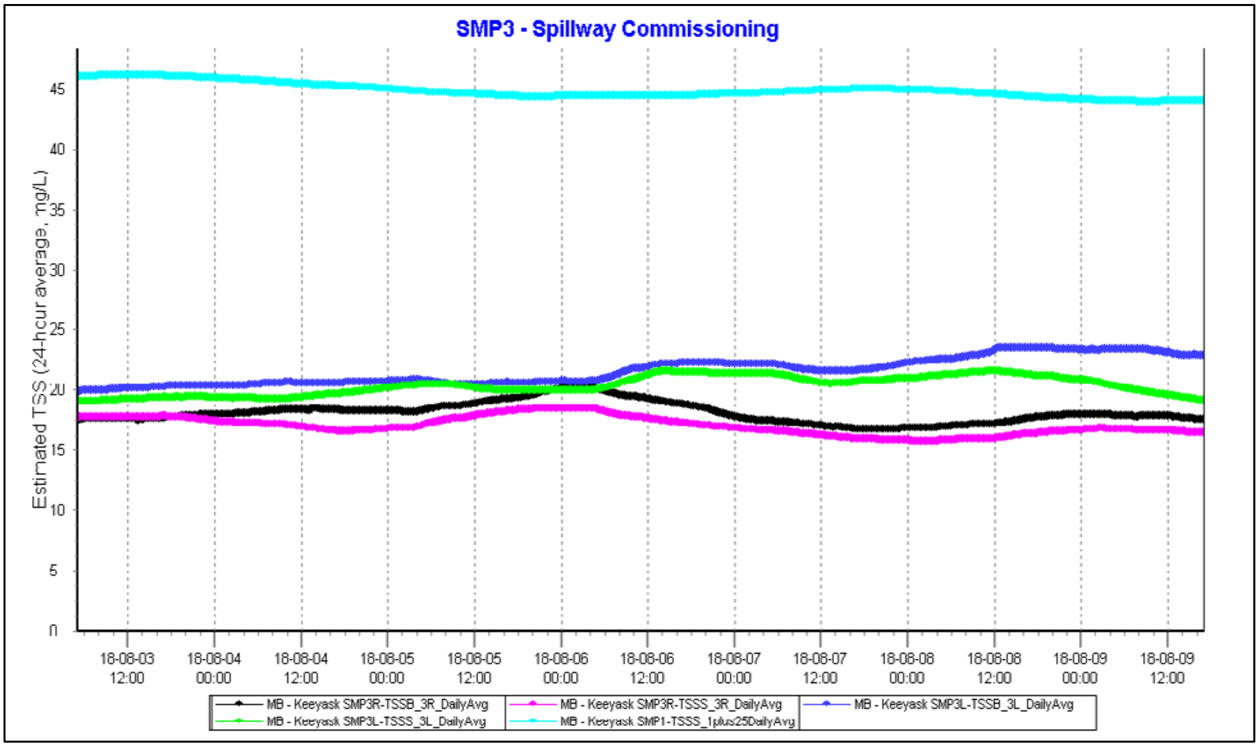

Figure 15: Estimated total suspended solids (TSS) values (measured as a 24-hour rolling average in mg/L) from August 3, 2018 through August 8, 2018 at monitoring stations SMP-3L and SMP-3R compared with the action level, which is shown in light blue. The time is plotted in Greenwich Mean Time (GMT), which is five hours ahead of local time (Central Daylight Time). Therefore, the range of the x-axis is from 00:00 CDT on August 3 to 12:00 CDT on August 9, 2018.

3.3 TAILRACE COFFERDAM

On May 9, 2018, in-stream work was conducted to close a gap in the Tailrace Cofferdam (TRCD). This gap was left in place the previous year to allow fish to move in and out of the TRCD area until fish salvage could be conducted.

A Cat 390 excavator removed ice from the opening in the TRCD (Figure 16) on May 9. After the ice was removed, a bulldozer pushed large rock across to fill the gap and close the outer groin (Figure 17). The in-stream work related to the TRCD was finished on May 9 (Figure 18).

Figure 16: An excavator breaks and removes ice from the channel through the Tailrace Cofferdam, May 9, 2018

Figure 17: A bulldozer pushes large rock in place to close the opening in the Tailrace Cofferdam outer groin

Figure 18: The Tailrace Cofferdam outer groin after completion

SMP monitoring equipment was not deployed at the time of conducting this work, as all of the winter monitoring equipment had been removed in preparation for spring break-up. As discussed in Section 2.2, monitoring sediment in real-time during ice on and off is no longer done because it is logistically challenging and produces unreliable results. Measuring turbidity in the vicinity of the work area to calculate the TSS was not safe due to ice and heavy equipment in the area. Therefore, monitoring was limited to looking for sediment plumes while in-stream work was occurring. No sediment plumes were observed in the Nelson River in the vicinity of the construction.

3.4 SOUTH DAM COFFERDAMS

In-stream work took place from August 1 to September 24, 2018 to construct the Upstream and Downstream South Dam Cofferdams. Additional work occurred from October 8 to 28 to reduce seepage through the Upstream Cofferdam, and November 2 to 6 to place ice erosion protection.

To construct each of the South Dam Cofferdams (SDCD), a rock groin was pushed across the south channel of the Nelson River to join the Spillway area to the south shore (Figure 19). Sand was placed on the downstream side of the downstream rock groin, which was followed by placement of impervious material to blanket the sand (Figure 20). This created the Downstream SDCD. Sand and impervious material was placed in the same fashion on the upstream side of the upstream rock groin to create the Upstream SDCD.

Figure 19: Initial construction of the Downstream South Dam Cofferdam, looking east. A bulldozer pushes rockfill across the south channel of the Nelson River, August 5, 2018

Figure 20: Excavator placing impervious material over a sand layer along entire length of the downstream side of the South Dam Cofferdam, August 20, 2018

A greater than expected volume of water seeped through the Upstream SDCD after completion on September 24, 2018. To reduce the amount of seepage, a rockfill containment berm was constructed in October to enclose the seepage area (Figure 21) and filled with impervious material to reduce seepage. During placement of the impervious material, a gap was left in the containment berm to allow fish egress (Figure 22).

Additional work took place from November 2 to 6, when additional rock was placed as armouring along the top edge of impervious material on both cofferdams to protect against throughout the winter.

Figure 21: A bulldozer pushing rockfill to construct the containment groin at the Upstream South Dam Cofferdam, October 16, 2018

Figure 22: The containment groin at the Upstream South Dam Cofferdam, October 26, 2018. The channel for fish egress during placement of impervious material can be seen on the left

As discussed in Section 2.1, downstream SMP monitoring equipment was in place until October 1, but SMP-1 was removed on September 15. In order to determine the background concentration in the river to track changes in TSS downstream, water samples were collected from shore at the upstream boat launch and used to determine the “SMP-1 plus 25mg/L” and “SMP-1 plus 200mg/L” threshold levels shown on Figure 23 and Figure 24. Visual inspections for turbidity plumes were also conducted throughout the entire period that in-stream work was conducted.

As per Section 2.2, in-stream turbidity monitoring equipment was not in place during work to reduce water seepage through the Upstream SDCD, or during placement of ice erosion protection. Visual observations indicated that turbidity increases were limited to the work area.

During in-stream work, as expected, there were some instances of localized sediment plumes in the immediate vicinity of impervious material being placed along the upstream and downstream rock groins of the South Dam Cofferdams; however, the plumes quickly dissipated downstream from the work area. These localized sediment plumes were small and are not expected to have had measurable aquatic impacts.

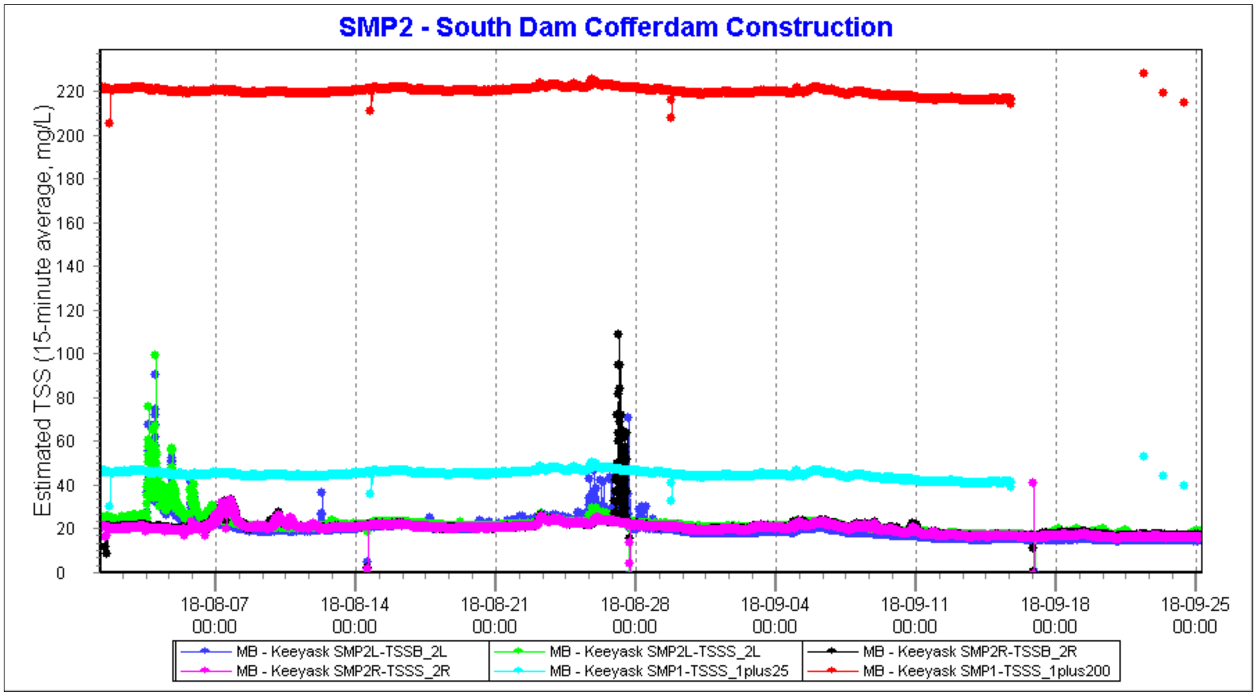

Figure 23: Estimated total suspended solids (TSS) values (24-hour average, mg/L) from August 1, 2018 through September 25, 2018 at monitoring stations SMP-3L and SMP-3R compared with the action levels, which are shown in light blue and red. Water samples were collected from shore to provide background data for the "SMP-1 plus 25mg/L" and "SMP-1 plus 200mg/L" action levels after SMP-1 was removed on September 15, 2018.

The peak in green on Figure 23 represents the TSS at the time of Spillway Commissioning. The peak in black that coincided with the end of August was not related to in-stream construction but was caused by algae which had become wrapped around the sensor. The algae were removed and the readings returned to normal.

In Figure 24, the green peak was caused by a wiper blade that had become stuck on the SMP-3L surface sensor; once it was repaired, the readings returned to normal.

There were no exceedances of the SMP action levels as a result of in-stream construction of the upstream and downstream SDCD.

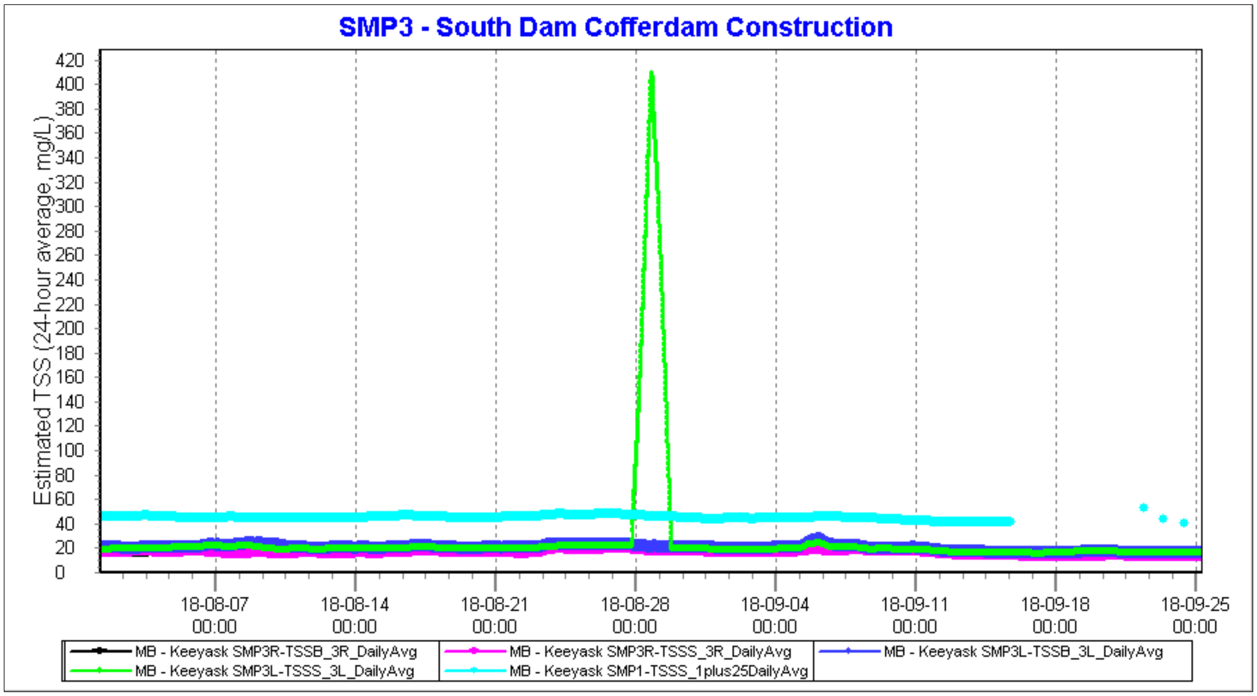

Figure 24: Estimated total suspended solids (TSS) values (24-hour average, mg/L) from August 1, 2018 through September 25, 2018 at monitoring stations SMP-3L and SMP-3R compared with the action levels, which are shown in light blue. Water samples were collected from shore to provide background data for the "SMP-1 plus 25mg/L" action levels after SMP-1 was removed on September 15, 2018.

3.5 TEMPORARY DOWNSTREAM BOAT LAUNCH

The temporary downstream boat launch is a rockfill ramp that extends into Stephens Lake, below Gull Rapids. The design of the boat launch cannot withstand the movement of ice during freeze-up and break-up and must be repaired each spring. In spring 2018, there was soft substrate at the base of the launch, which made it unusable (Figure 25). On May 31, 2018, rock was placed at the water's edge and down into the water to complete the repair (Figure 26).

Figure 25: The ramp of the temporary downstream boat launch prior to repairs. Soft substrate at the base and into the water made it unusable

Figure 26: The temporary downstream boat launch after rock placement

SMP monitoring equipment was not yet deployed during the repairs, as the boat launch is required for access to Stephens Lake to install it. Visual monitoring was conducted during in-stream work and no sediment plumes were observed in Stephens Lake in the vicinity of the in-water work.

3.6 PERMANENT DOWNSTREAM BOAT LAUNCH

In summer 2018, a permanent, downstream boat launch was constructed. Work began on July 20, 2018 when rockfill was placed in the river to create a wave break groin (Figure 27). While this occurred, an excavator shaped the riverbank for the ramp and large rock was placed along the shoreline for future erosion protection. Beginning on August 4, a concrete base was placed to construct the boat launch, but needed to be realigned afterwards, which slowed construction and the boat launch wasn’t compete until August 15 (Figure 28). Erosion protection and additional rock placement on the wave break continued until August 18, 2018.

Figure 27: A haul truck delivers large class rock to extend the wave break groin on July 27, 2018

Figure 28: An excavator removes the concrete "mattress" to adjust the alignment on August 10, 2018

In-stream SMP monitoring was carried out during construction of the Permanent Upstream Boat Launch. The action thresholds were exceeded at SMP-2 on four occasions during that time (Figure 29); however, the exceedances were not related to construction activities at the boat launch. The large peak on July 30 and 31 was caused by cleaning a sensor during regular maintenance. Spillway commissioning commenced August 3, which explains the second increase (see Section 3.2). There were no exceedances of the threshold at SMP-3 during the same period (Figure 30).

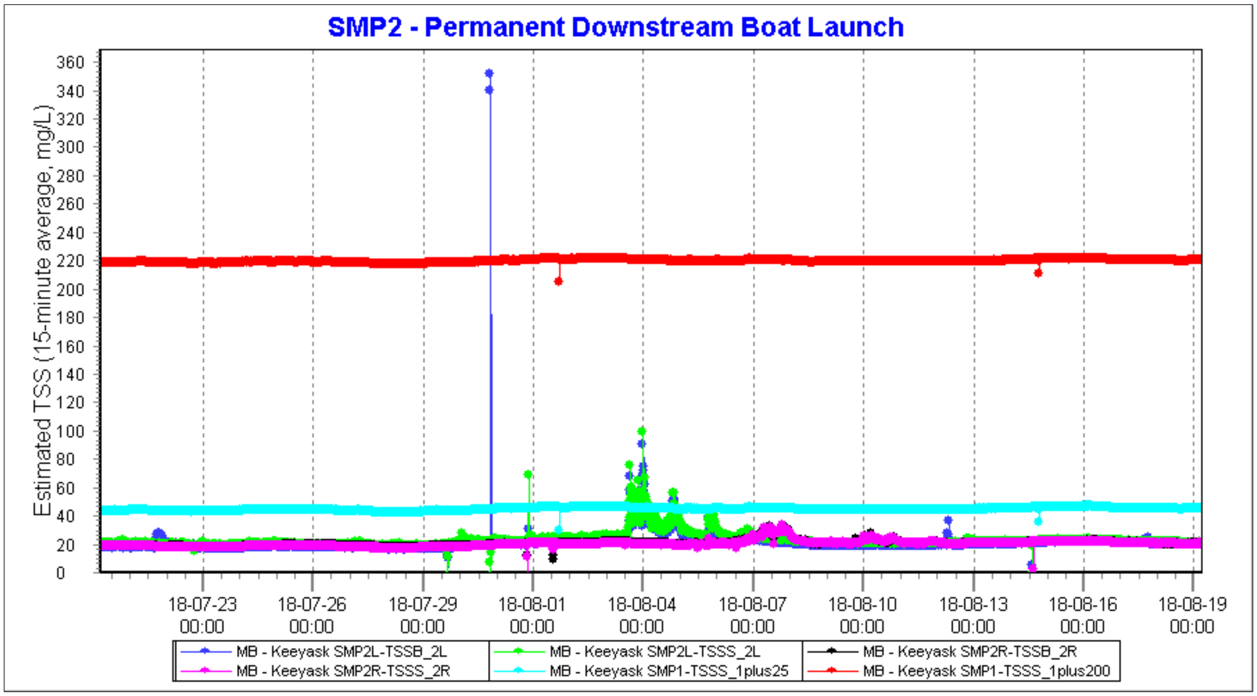

Figure 29: Estimated total suspended solids (TSS) values (15-minute average, mg/L) from July 20, 2018 through August 18, 2018 at monitoring stations SMP-2L and SMP-2R compared with the action levels, which are shown in light blue and red.

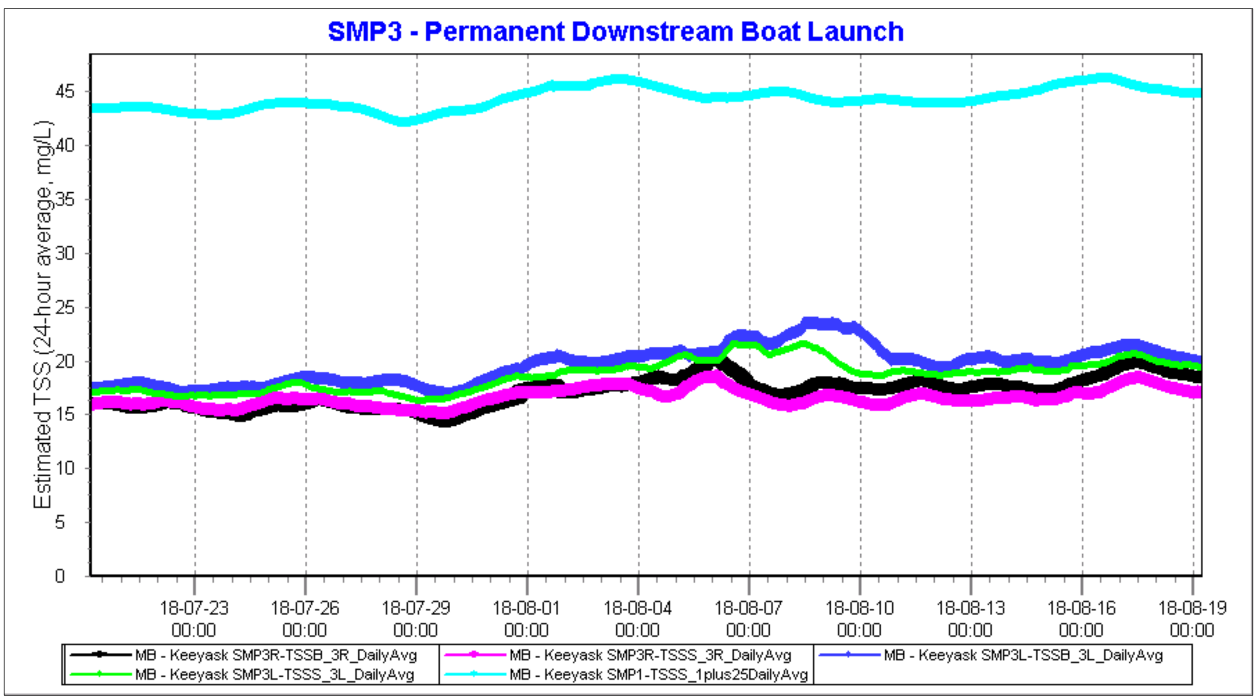

Figure 30: Estimated total suspended solids (TSS) values (24-hour rolling average, mg/L) from July 20, 2018 through August 18, 2018 at monitoring stations SMP-3L and SMP-3R compared with the action level, which is shown in light blue.

4.0 PREDICTED TSS LEVELS VS. MONITORING RESULTS

As described in the SMP, river management during construction will introduce additional sediment into the Nelson River due to shoreline erosion, construction and removal of cofferdams, and commissioning of the Spillway and the Powerhouse. The predicted effects of in-stream construction presented in the SMP (Figure 31) were based on the proposed construction timeline at the time that the analyses were performed and assumed fully mixed conditions at SMP-2. Additional modelling was done in 2018 to better quantify the potential effects of Spillway Cofferdam removal and commissioning on in-stream TSS at SMP-2.

4.1 SPILLWAY COFFERDAM REMOVAL

As noted above (Section 3.1) Spillway Cofferdam removal took place from Jul. 4 – Aug. 5, partially overlapping with Spillway Commissioning, which began on Aug. 3. Prior to commissioning, the downstream portion of the cofferdam was removed as was the inner rock groin and impervious core of the upstream cofferdam. About 1/3rd of the upstream outer rock groin was removed before commissioning, while about 1/3rd was removed after the first Spillway gate was opened and the remaining 1/3rd was removed after the second gate was opened.

Any measurable effects of Spillway Cofferdam removal would have been expected to occur when the impervious materials were removed prior to Spillway commissioning since they contained a large fraction of fine material. Monitoring in July showed that estimated TSS at the SMP-2L surface and bottom sensors was typically similar in magnitude to TSS at the SMP-1 site upstream (Figure 32). The data shown in Figure 32 are the raw data values recorded at the sites and show a number of anomalous low values and high spikes. The consistent differences of 1-2 mg/l observed between the sites were likely due to deviations within the sensors rather than actual differences in turbidity conditions between the locations. The plot for SMP-1 is a relatively smooth line, indicating steady turbidity conditions with little fluctuation (Figure 32). Conditions at SMP-2R were much the same as at SMP-1, so they were not included on the chart to avoid it becoming excessively busy. The plots for the SMP-2L surface and bottom locations, however, are 'noisy' due to frequent fluctuations of about 1-2 mg/l. These fluctuations are likely attributable to fine sediment from the Spillway Cofferdam removal. A few larger increases of short duration appear to occur several times (e.g., July 4, 7, 11), but these do not appear frequent. After July 23, the variability at SMP-2L is generally lower, likely because the downstream cofferdam had been almost removed by that time.

In the Keeyask EIS, it was estimated that in-stream TSS could potentially increase by 3-4 mg/l under fully mixed conditions (i.e., an increase in the entire flow volume) near SMP-2 over an approximate 20-day period of removal (Figure 31). A more detailed analysis was conducted prior to cofferdam removal that considered the properties of the cofferdam material, duration of removal and potential material loss rates. The results showed that TSS in the vicinity of SMP-2L could increase by up to 2 mg/l, and approach 1 mg/l at SMP-2R. The monitoring results show that the actual effects of Spillway Cofferdam removal were less than those estimated in the Keeyask EIS; the measured variability at SMP-2L ranged from 1-2 mg/L and there were no changes at SMP-2R.

4.2 SPILLWAY COMMISSIONING

Spillway commissioning was identified as an event that was likely to result in larger increases in TSS downstream of the Project. Remnant sediment material would be left behind in the excavated approach and discharge channels and cofferdam removal would results in some residual material left on the river bottom. These remnant materials would be displaced as flow passed through the Spillway, resulting in TSS increases downstream.

4.2.1 PREDICTED EFFECTS

The potential effects of Spillway commissioning are presented in the SMP document. They were based on a simplified analysis that considered the effects for an assumed quantity of remnant material, and a conservative flow, where all 7 Gates would be raised by 1 m, simultaneously, at the start. The results indicate there could have been a peak increase of about 250 mg/l at SMP-2 for a short duration, while the fully mixed 24-h average TSS at SMP-2 might be increased by approximately 25 mg/l (Figure 31).

More detailed sediment modeling was performed prior to Spillway Commissioning to help identify a potential sequence of Spillway gate operations that would help manage sediment increases that might occur downstream, at SMP-2. Quantities of remnant materials that might be left in the approach and discharge channels were estimated based on site conditions, while properties of these materials were estimated based on grain size distributions of material samples from the site. Similarly, the potential quantities of remnant cofferdam materials were estimated assuming 1 m of cofferdam material would be left on the river bed, while material properties were estimated from gradations of the materials used to construct the cofferdams.

Based on observations from commissioning the Wuskwatim Generating Station Spillway, it was expected that effects on TSS would be largest for the initial gate opening and would tend to diminish as a gate is raised and as more gates are opened. Various scenarios were tested until a final, potential commissioning scenario was identified. In this scenario, the first gate (Gate 7 at the south end of the Spillway) was opened in 1 m increments over two days to spread out its effects. Since effects are expected to diminish as more gates are opened, the next two gates (5 & 6) were opened more rapidly in the model, with both being completely raised on the third day. Likewise, the final four gates (1, 2, 3 and 4) were raised even more rapidly in the model, with all four raised on the fourth day. The sequence of gate operations is shown in the chart of predicted TSS increases at site SMP-2L and an additional site (K-SWCOMM-1) north of SMP-2L (Figure 33). Modeling indicated the peak effects of the sediment plume would occur in the area of SMP-2L and K-SWCOMM-1.

Model results show TSS peaks occurring at the two sites, SMP-2L and K-SWCOMM-1, about 1 to1.5 hours after a gate movement. The peak predicted increase was about 240 mg/l at SMP-2L and just over 300 mg/l at K-SWCOMM-1 after Gate 7 was raised 3 m (Figure 33). Effects diminished as the gate was raised until it is out of the water (i.e., 7 m opening) on the second day. Another high peak increase of about 250 mg/l occurred when gates 5 and 6 were both raised 1 m only 1 hour apart. Subsequent effects are much lower and after both gates are opened 3 m the peak increases are less than about 25-40 mg/l. Finally, on the last day, the peak predicted TSS increases were all less than about 10-20 mg/l for commissioning gates 3 and 4, and generally less than 5-10 mg/l for gates 1 and 2, even though these last two gates were raised simultaneously and rapidly. Throughout the modeled sequence, the increases at SMP-2R were less than 1 mg/l.

4.2.2 OBSERVED EFFECTS

Commissioning the seven Spillway gates began on Aug. 3 at Gate 1, the northernmost gate, which was incrementally raised until it was completely out of the water (7 m) on the first day. The remaining gates were subsequently commissioned as summarized in Table 3. TSS conditions during commissioning were estimated for site SMP-1, the upstream reference site, SMP-2L and SMP-2R, and two additional sites, K-SWCOMM-1 and K-SWCOMM-2, based on continuous turbidity measurements (Figure 34). Background TSS at SMP-1 was steady at approximately 20 mg/l during the commissioning period.

At SMP-2L and K-SWCOMM-1, the first TSS peaks were respectively about 72 mg/l and 78 mg/l, or about 52-58 mg/l above background, after opening the gate first to 1.1 m and then to 2 m an hour later (Figure 34). The next opening to 3.5 m occurred about 5 hours later, after TSS levels had dropped to about 35-40 mg/l (15-20 mg/l above background) and produced a smaller peak increase to about 60 mg/l (40 mg/l above background). Because observed effects were lower than predicted, the next incremental gate opening was larger at about 3.5 m, raising Gate 1 out of the water. This resulted in the largest effect with peak estimated TSS of about 80 mg/l and 95 mg/l (60-75 mg/l above background) at K-SWCOMM-1 and SMP-2L, respectively. Gate 2 was raised in three increments: first rising to 2 m open, then rising another meter to 3 m open 2.5 hours later, and three hours later it was raised four meters to the fully open position (i.e., 7 m opening). The first two increments produce smaller TSS peaks of about 30-40 mg/l (10-20 mg/l above background), while the large increase to fully open it produced a larger peak TSS of about 50 mg/l (30 mg/l above background). Gates 3 and 4 were opened in larger increments on the third day, but the effects were more diminished, where the TSS peaks of about 38-43 mg/l (18-23 mg/l above background). On the fourth day, gates 4, 5, and 6 were all fully opened, with gate 5 being raised from 3 m open to fully open in one movement while gate 6 was fully opened in one step, only 7 minutes later. Despite rapidly opening the gates, the estimated peak TSS at SMP-2L and K-SWCOMM-1 ranged from about 26-29 mg/l (6-9 mg/l above background). Finally, on the fifth day, Gate 7 was completely opened in one step and there was no apparent effect at the downstream sites.

Estimated TSS increases at site K-SWCOMM-2, which is about half way between SMP-2L and SMP-2R, was lower than at the other two sites. The two, largest peaks at this site were about 40 mg/l and 44 mg/l after gate 1 was raised to 2 m and 7 m respectively (Figure 34). At SMP-2R, on the south side of the channel, there were no apparent effects due to Spillway Commissioning, with no obvious peaks in estimated TSS due to Spillway gate operations. The results observed at SMP-2L, SMP-2R, K-SWCOMM-1 and K-SWCOMM-2 suggest that SMP monitoring detected the peak effects of the sediment plume at SMP-2 during Spillway Commissioning.

The detailed analysis of potential commissioning effects indicated peak increases of about 250-300 mg/l above background might occur near SMP-2L (Figure 33). Observed effects of the Spillway on sediment (Figure 34) showed peak TSS increases that were much lower than predicted, with the largest increase estimated at about 75 mg/l above background. Observed effects did indicate the expected diminishing effects on TSS as commissioning progressed and as a result, the gates could be opened more rapidly as more were opened. Because the effects observed during commissioning were smaller than had been predicted, the gates were all raised to their fully open position in fewer incremental steps than had been assumed in the commissioning model; however, in both situations, the gates were over a period of four days. The smaller effects observed during commissioning, when compared to the detailed model, suggest the model was overly conservative in its estimate of how much remnant material would be left in the approach and discharge channels, as well as from cofferdam removal.

4.2.3 SOUTH DAM COFFERDAMS

The South Dam Cofferdams (SDCD) were partially constructed as the Spillway was being commissioned. Studies for the Keeyask EIS had predicted that construction of the SDCD could result in downstream TSS increasing by about 1-14 mg/l in the full river flow under high flow conditions of about 4,850 m^3/s, and 6,350 m^3/s, which are higher than the flow of approximately 3,500 m^3/s that occurred when the SDCD was constructed. This effect was primarily due to increased upstream water levels affecting erodible shoreline materials. A range was estimated for different flow conditions and different theoretical models for entrainment of shoreline material.

TSS at SMP-2R began to increase on August 6 and gradually rose to a peak level of about 29-33 mg/l (9-13 mg/l above background) during much of the day on August 7 (Figure 35). A smaller increase also occurs on August 9-10. These effects were not observed at the other sites north of SMP-2R. The increases in TSS at SMP-2R during this time period are believed to have resulted from the advancement of the SDCD across the south channel, which raised upstream water levels along shorelines that may be susceptible to erosion, particularly the south shore. Although the river was not completely closed off until August 15, there is minimal difference between estimated TSS at SMP-1 and SMP-2R after about August 12. It was anticipated that TSS effects would peak with the SDCD some distance from the south shore and the effects would diminish as the SDCD advanced further. This is because velocities over erodible material along the south shore initially increase as the SDCD advances, but at a point they begin to decline again as more of the river flow shifts to the Spillway, on the opposite side of the channel. While the peak observed increases were similar to the predicted effect of a 1-14 mg/l increase, the observed effects did not show an increase in TSS across the entire river flow.

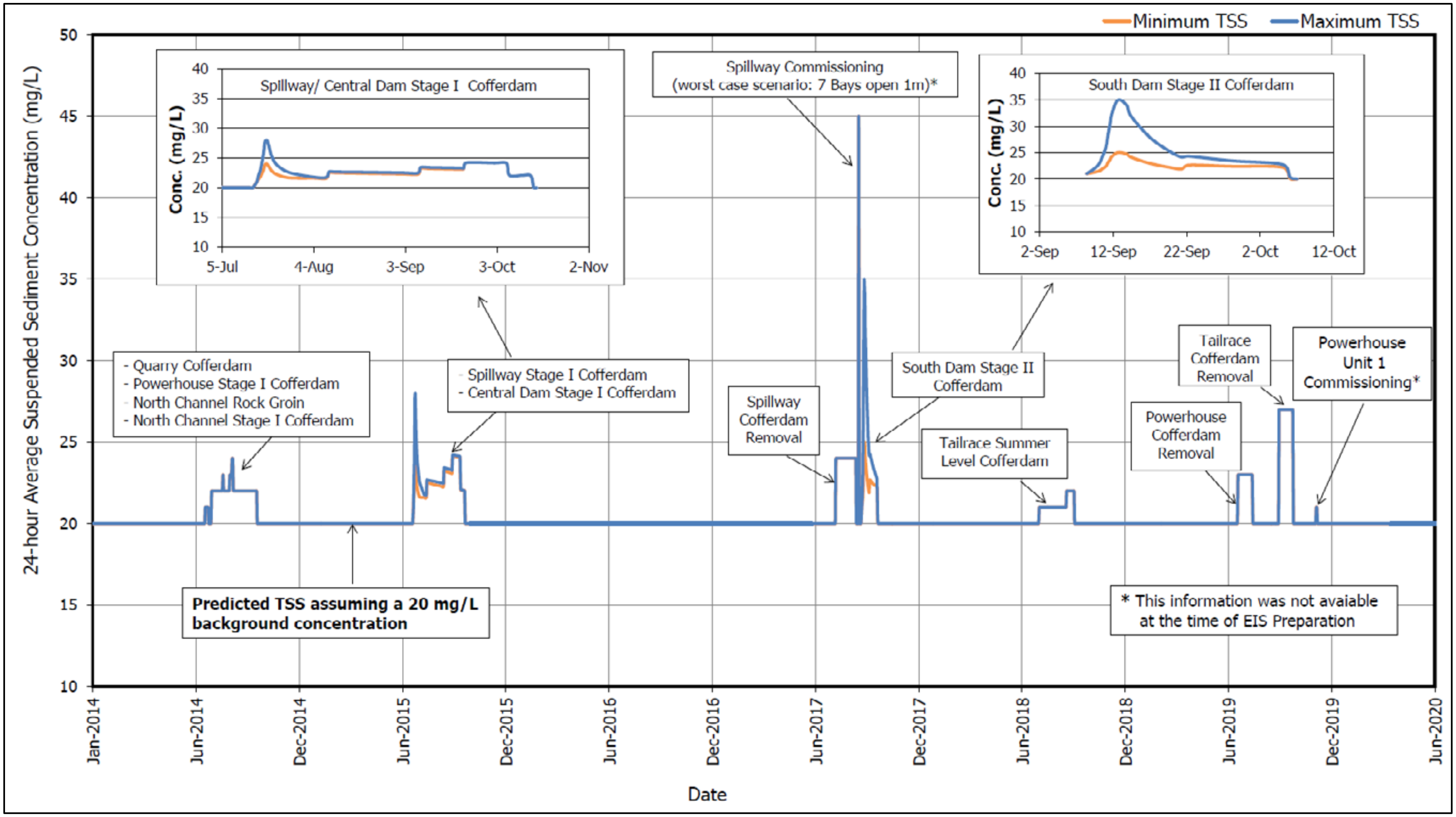

Figure 31: Fully Mixed 24-Hour Average TSS Concentration Predicted in the Proximity of Site SMP-2 (mixing zone) During Construction of the Keeyask GS (based on 2012 construction schedule)

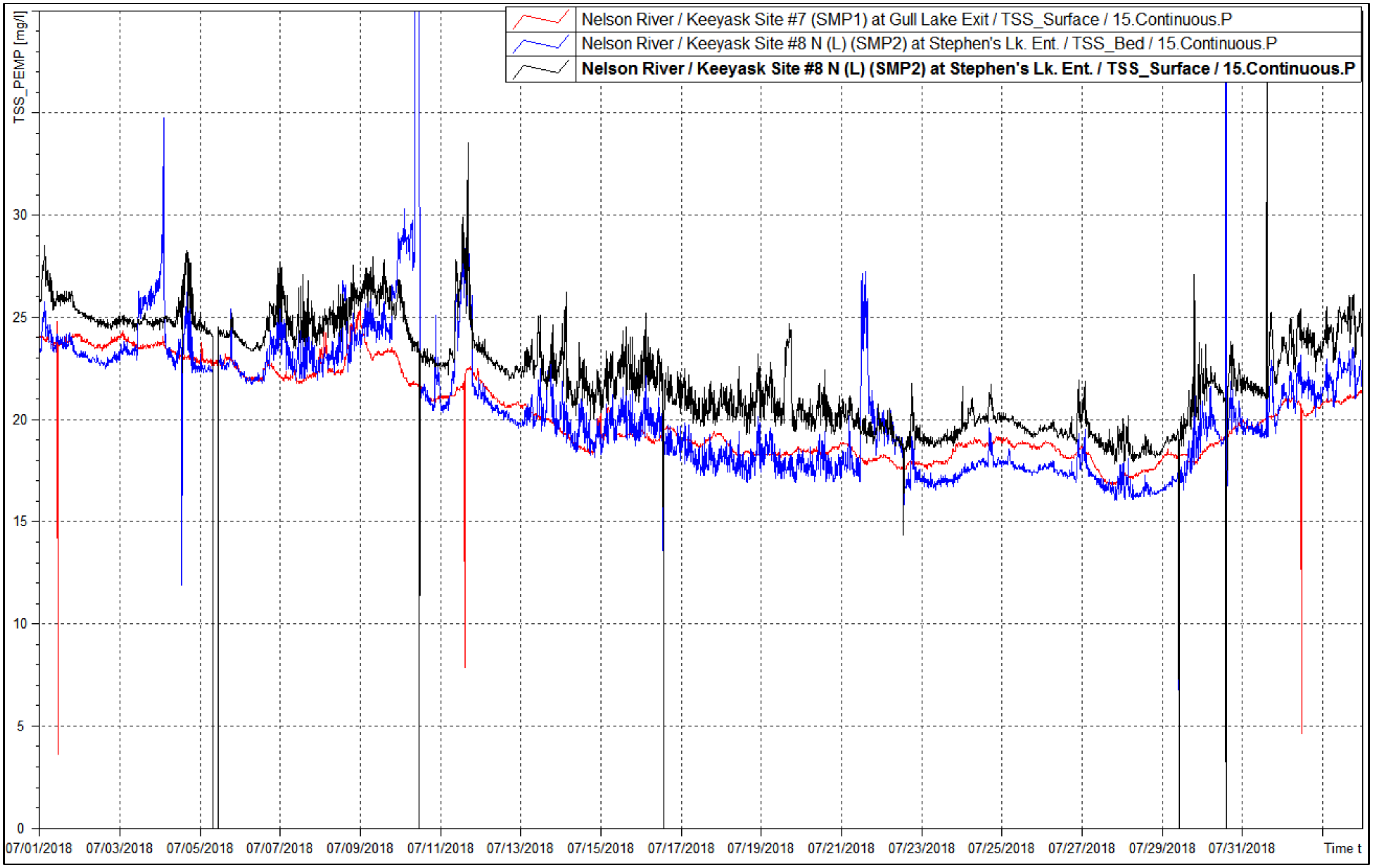

Figure 32: Estimated TSS Concentration in July 2018 (raw data)

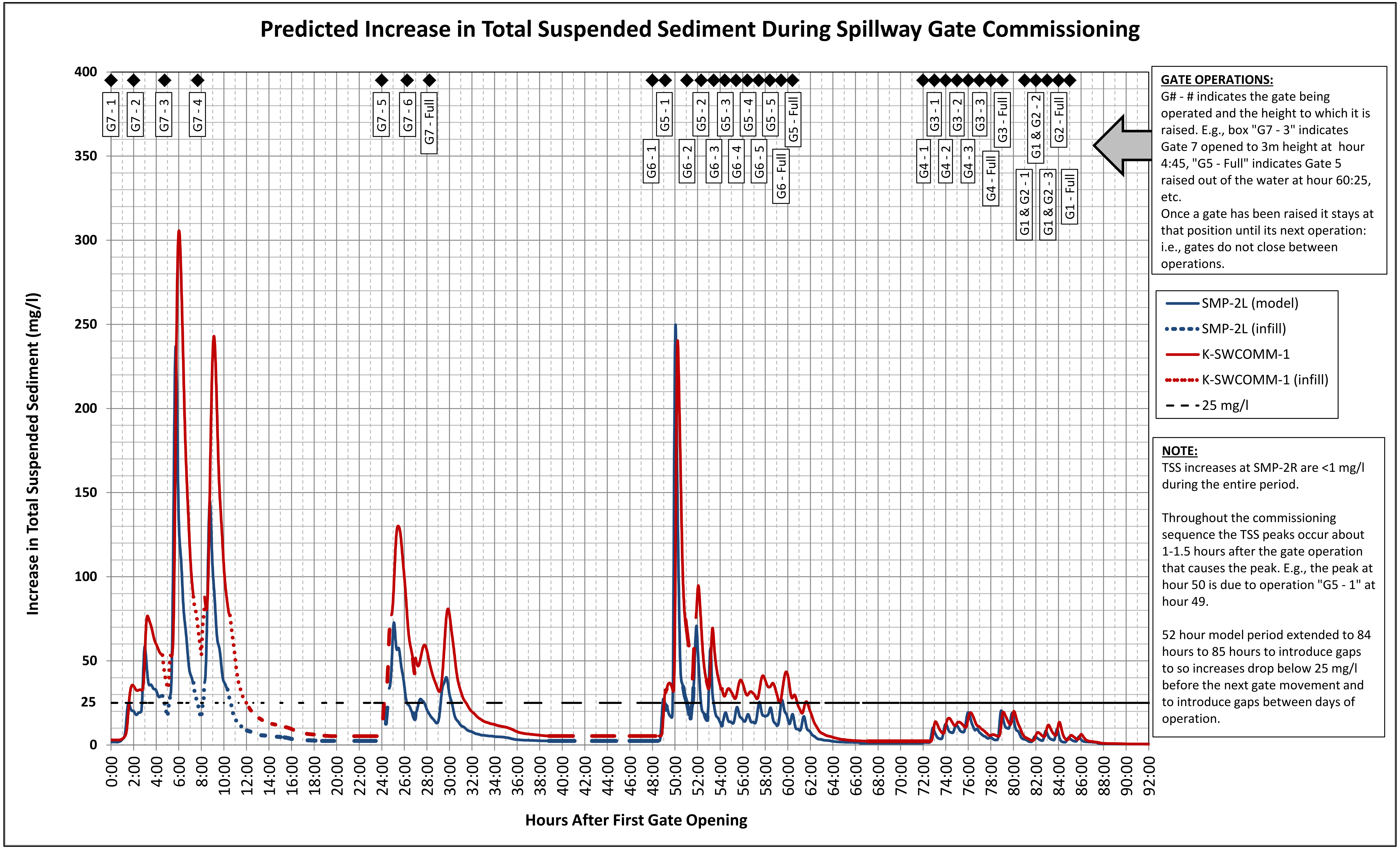

Figure 33: Predicted Increases in Total Suspended Sediment during Spillway Commissioning

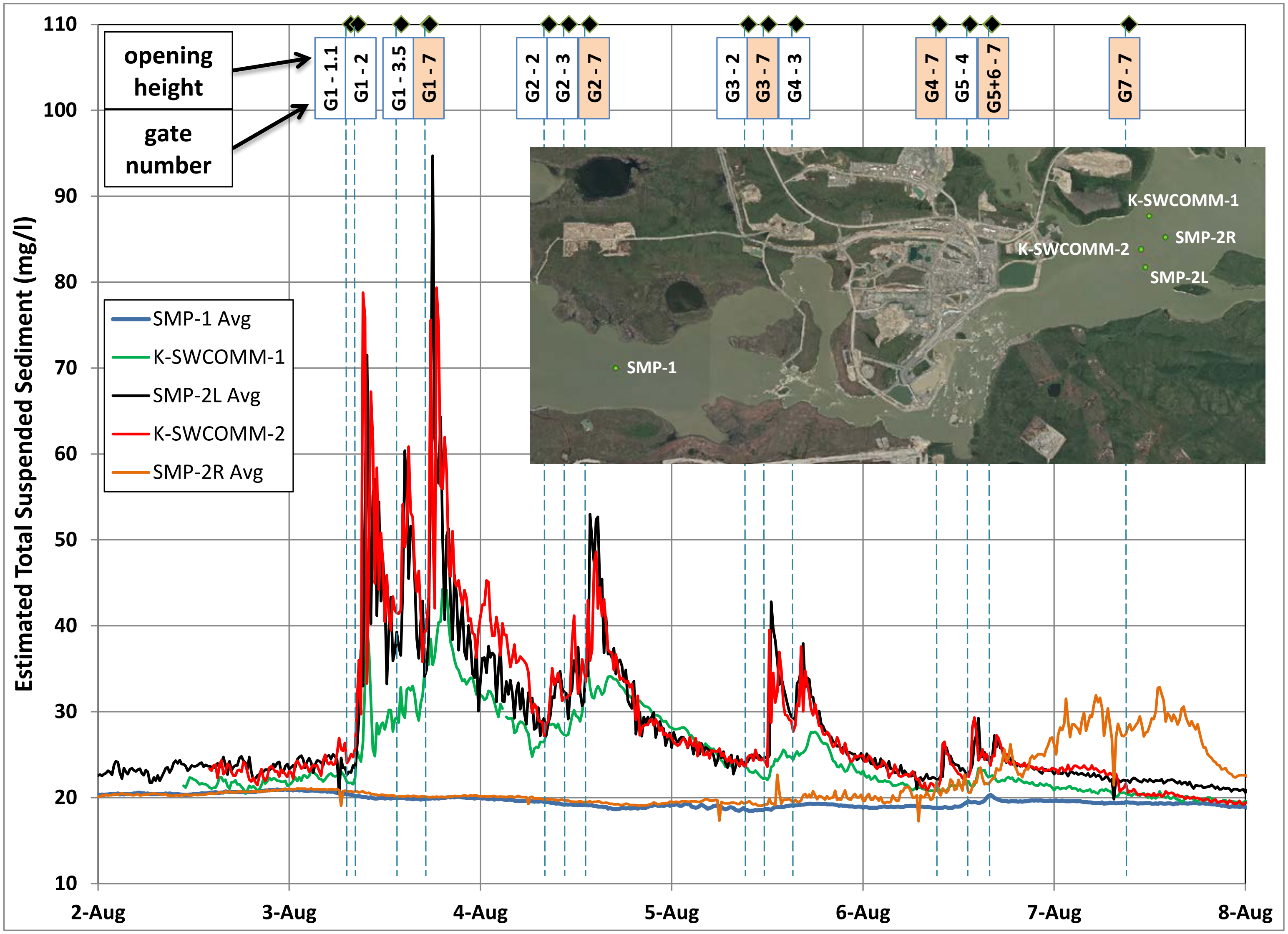

Figure 34: Estimated TSS Concentration during Spillway Commissioning

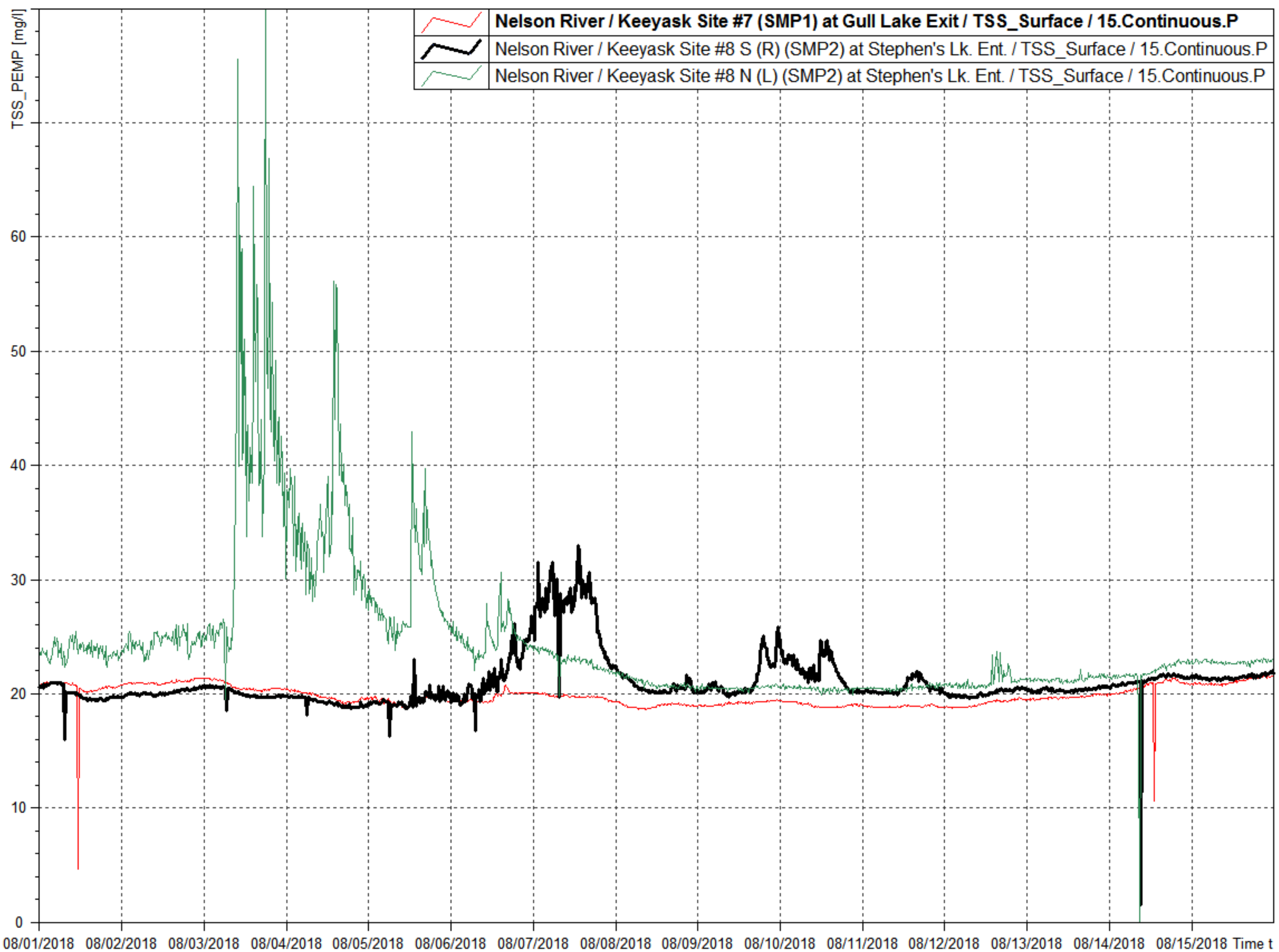

Figure 35: Estimated TSS Concentration in Aug 1-15, 2018 (raw data)

5.0 CONCLUSION

During the SMP monitoring period (April 2018 to March 2019), there were no unexpected exceedances of the SMP action levels attributed to in-stream construction activities that took place. As anticipated, Spillway Commissioning generated an increase in the TSS at SMP-2 that exceeded one of the action levels outlined in the SMP (more than one hour above 25 mg/L over the background TSS). Mitigation was implemented to halt spillway gate opening as soon as the real-time results indicated the action level threshold was surpassed, which allowed the TSS to disperse before commissioning continued. By following this process, the SMP action level was exceeded three times over the course of two days, but the peak of the exceedance and its duration were below those predicted in the Project EIS and well below levels that would cause an effect on aquatic life.

There were other occasions when the real-time TSS results showed the action levels were exceeded, but further investigation proved these occurred as a result of malfunctioning wipers, interference during maintenance, vegetation on a sensor and the anchor of the sensor stirring up the sediment.

Construction of the Tailrace Cofferdam, upstream and downstream groins of the Spillway Cofferdam, construction of the South Dam Cofferdam and construction of the temporary and permanent, downstream boat launches/wave break did not cause exceedances of the SMP action levels in 2018/19.

6.0 LITERATURE CITED

Keeyask Hydropower Limited Partnership (KHLP), 2012. Keeyask Generation Project: Physical Environment Supporting Volume. June 2012. Winnipeg, Manitoba

Keeyask Hydropower Limited Partnership. 2014. Keeyask Generation Project Sediment Management Plan for In-stream Construction. Winnipeg, Manitoba. June 2014.

TABLES

Table 1: Manual sampling water quality monitoring data for the 2018 open water season

Station ID	Date (D/M/Y)	Time (CST)	Site Depth (m)	Sensor/Sample Depth (m)	Turbidity (NTU)	Calculated TSS* (mg/L)	Lab TSS (mg/L)
SMP-1	6/24/2018	14:52	11.5	2.0	26.3	17.92	10.3
	6/24/2018	14:54	11.5	5.8	27.3	18.71	11.8
	6/24/2018	14:56	11.5	9.5	27.2	18.63	11.8
	7/13/2018	15:46	10.9	1.9	26.8	18.31	11.0
	7/13/2018	15:42	10.9	5.5	27	18.47	11.5
	7/13/2018	15:40	10.9	9.1	27	18.47	11.0
	8/14/2018	13:50	10.4	2.0	30.1	20.92	10.0
	8/14/2018	13:49	10.4	5.6	30.1	20.92	11.0
	8/14/2018	13:46	10.4	8.0	30.6	21.31	10.0
	8/29/2018	13:35	9.5	1.8	28.9	19.97	7.0
	8/29/2018	13:40	9.5	4.7	28.8	19.89	8.0
	8/29/2018	13:38	9.5	7.4	28.9	19.97	6.0
	9/15/2018	23:41	8	2.0	24	16.10	6.0
	9/15/2018	23:38	8	3.9	24	16.10	5.0
	9/15/2018	23:36	8	6.3	24.2	16.26	6.0
SMP-2L	6/25/2018	13:23	13.5	2.1	28.2	19.42	11.3
	6/25/2018	13:25	13.5	6.7	28.6	19.73	11.0
	6/25/2018	13:27	13.5	11.5	29.2	20.21	11.8
	7/16/2018	13:25	13.5	2.1	26.5	18.08	12.8
	7/16/2018	13:23	13.5	6.9	26	17.68	11.8
	7/16/2018	13:21	13.5	11.4	26.6	18.15	12.8
	8/13/2018	22:57	14	2.1	29.7	20.60	11.0
	8/13/2018	22:53	14	7.1	30.6	21.31	12.0
	8/13/2018	22:49	14	12.2	31.9	22.34	13.0
	8/27/2018	22:39	14.2	2.1	31.8	22.26	9.0
	8/27/2018	22:36	14.2	7.1	31.6	22.10	9.0
	8/27/2018	22:32	14.2	12.2	31	21.63	9.0
	9/16/2018	15:34	13.6	2.1	25.1	16.97	7.0
	9/16/2018	15:32	13.6	6.9	24.2	16.26	6.0
	9/16/2018	15:30	13.6	11.4	24.6	16.57	5.0
SMP-2R	6/25/2018	13:08	15	2.1	28.5	19.66	12.0
	6/25/2018	13:10	15	7.4	29.1	20.13	12.5
	6/25/2018	13:12	15	13.1	29.1	20.13	14.8
	7/16/2018	13:01	15.1	2.0	25.8	17.52	11.3
	7/16/2018	0:58	15.1	7.5	25.8	17.52	11.8
	7/16/2018	0:55	15.1	13.1	25.2	17.05	12.5
	8/14/2018	22:08	14.5	2.1	30.4	21.16	7.0

Station ID	Date (D/M/Y)	Time (CST)	Site Depth (m)	Sensor/Sample Depth (m)	Turbidity (NTU)	Calculated TSS* (mg/L)	Lab TSS (mg/L)
SMP-2R	8/14/2018	22:06	14.5	7.2	30.3	21.08	10.0
	8/14/2018	22:03	14.5	12.7	31.4	21.95	11.0
	8/27/2018	23:20	15.3	2.0	30.2	21.00	7.0
	8/27/2018	23:17	15.3	7.7	30.6	21.31	8.0
	8/27/2018	23:13	15.3	13.3	30.8	21.47	7.0
	9/16/2018	14:40	14.6	2.1	23.9	16.02	7.0
	9/16/2018	14:38	14.6	7.7	23.6	15.78	7.0
	9/16/2018	14:35	14.6	12.6	24.1	16.18	6.0
SMP-3L	6/25/2018	23:54	19	2.0	26.4	18.00	9.0
	6/25/2018	23:59	19	9.6	25.1	16.97	8.5
	6/25/2018	23:57	19	17.0	24.9	16.81	8.0
	7/16/2018	0:20	18.7	2.0	23.7	15.86	9.0
	7/16/2018	0:17	18.7	9.4	25.8	17.52	11.3
	7/16/2018	0:14	18.7	16.7	27	18.47	11.8
	8/14/2018	22:52	18.2	2.2	27.4	18.79	8.0
	8/14/2018	22:49	18.2	9.2	28.8	19.89	7.0
	8/14/2018	22:42	18.2	16.1	28.7	19.81	10.0
	8/27/2018	14:24	19.1	2.0	30.7	21.39	7.0
	8/27/2018	14:20	19.1	9.6	32.9	23.13	8.0
	8/27/2018	14:18	19.1	17.2	32.9	23.13	9.0
	9/16/2018	13:26	18.6	2.1	23.8	15.94	6.0
	9/16/2018	13:24	18.6	9.2	23.7	15.86	6.0
	9/16/2018	13:21	18.6	16.5	24	16.10	7.0
SMP-3R	6/25/2018	0:35	9.8	1.9	23.4	15.63	7.3
	6/25/2018	0:37	9.8	4.9	24.1	16.18	8.0
	6/25/2018	0:39	9.8	7.8	24.7	16.65	7.5
	7/16/2018	23:44	11.9	2.0	24.7	16.65	8.5
	7/16/2018	23:42	11.9	5.9	24.5	16.50	9.0
	7/16/2018	23:39	11.9	9.8	24	16.10	10.3
	8/14/2018	23:21	9.9	1.8	28.1	19.34	7.0
	8/14/2018	23:19	9.9	4.4	26.6	18.15	8.0
	8/14/2018	23:16	9.9	7.9	27.8	19.10	9.0
	8/27/2018	13:42	12.3	2.1	30.9	21.55	7.0
	8/27/2018	13:39	12.3	6.2	30.8	21.47	5.0
	8/27/2018	13:37	12.3	10.2	31.5	22.03	7.0
	9/16/2018	13:59	12.5	2.0	24	16.10	6.0
	9/16/2018	13:57	12.5	6.1	23.4	15.63	4.0
	9/16/2018	13:55	12.5	10.4	23.8	15.94	6.0

*Turbidity/TSS Relationship where TSS = [0.79 x Turbidity] – 2.86

Table 2: Manual sampling water quality monitoring data for a monitoring transect near SMP-2, collected on July 4, 2018

Site	UTM (15U)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temp (°C)	Turbidity (NTU)	Calculated TSS* (mg/L)	Dissolved Oxygen (mg/L)
1	366145 6246883	5	2.154	14:37	16.22	30.8	21.472	9.52
			2.643	14:36	16.23	29.9	20.761	9.51
			3.2	14:36	16.24	29.2	20.208	9.42
2	366118 6246957	6.5	2.063	14:42	16.21	30.3	21.077	9.53
			3.635	14:41	16.21	30.4	21.156	9.54
			4.948	14:40	16.21	30.1	20.919	9.55
3	366104 6247011	4.8	2.087	14:45	16.21	31.1	21.709	9.53
			2.557	14:45	16.21	30.6	21.314	9.58
			2.907	14:44	16.21	31.3	21.867	9.65
4	366086 6247050	7.5	2.137	14:49	16.21	30.7	21.393	9.51
			3.954	14:48	16.2	32	22.42	9.52
			5.573	14:47	16.2	31.4	21.946	9.6
5	366073 6247100	8.9	2.232	14:53	16.21	30.4	21.156	9.51
			4.601	14:52	16.21	30.6	21.314	9.48
			7.006	14:51	16.2	33.5	23.605	9.05
6	366055 6247150	9.6	2.097	14:56	16.2	30.7	21.393	9.5
			4.126	14:56	16.2	30.4	21.156	9.54
			7.712	14:55	16.2	30.7	21.393	9.59
7	366036 6247192	11.9	1.813	15:02	16.2	30.4	21.156	9.51
			5.876	15:01	16.2	30.9	21.551	9.54
			10.141	15:00	16.19	31.1	21.709	9.78
8	366028 6247230	13.4	2.154	15:08	16.2	31.1	21.709	9.51
			6.65	15:07	16.2	30.4	21.156	9.47
			11.241	15:05	16.2	30.5	21.235	9.52
9	366008 6247295	13.5	2.124	15:13	16.2	31.3	21.867	9.54
			6.683	15:12	16.2	31.2	21.788	9.51
			11.099	15:11	16.19	29.9	20.761	9.56
10	365997 6247342	13.5	1.929	15:18	16.19	30.8	21.472	9.54

Site	UTM (15U)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temp (°C)	Turbidity (NTU)	Calculated TSS* (mg/L)	Dissolved Oxygen (mg/L)
			6.66	15:17	16.19	30.8	21.472	9.51
			11.274	15:16	16.19	32.9	23.131	9.75
11	365984 6247390	13.2	1.905	15:22	16.17	32.9	23.131	9.49
			6.796	15:21	16.18	32.4	22.736	9.5
			11.375	15:20	16.18	32.8	23.052	9.57
12	365969 6247439	13	2.165	15:29	16.16	34.6	24.474	9.5
			6.033	15:26	16.13	34.7	24.553	9.59
			10.843	15:25	16.14	35.1	24.869	9.65
13	365950 6247475	13.6	2.019	15:32	16.13	33.9	23.921	9.51
			6.797	15:31	16.08	32.4	22.736	9.54
			12.099	15:31	16.08	32.3	22.657	9.54
14	365935 6247519	13.9	2.173	15:37	16.15	35.5	25.185	9.51
			6.871	15:36	16.1	32.8	23.052	9.49
			12.012	15:35	16.08	30.8	21.472	9.54
15	365915 6247574	13.8	2.086	15:40	16.14	35.1	24.869	9.51
			6.546	15:39	16.12	34.7	24.553	9.48
			11.977	15:39	15.98	2.8	-0.648	9.24
16	365906 6247617	13.3	1.823	15:43	16.12	34.4	24.316	9.52
			6.232	15:42	16.12	34.7	24.553	9.5
			11.512	15:41	16.08	32.5	22.815	9.56
17	365885 6247661	14.1	2.14	15:58	16.14	36.1	25.659	9.52
			7.112	15:58	16.13	35	24.79	9.5
			12.235	15:57	16.13	34.5	24.395	9.54
18	365867 6247717	13.2	2.025	16:03	16.1	30.7	21.393	9.48
			6.859	16:02	16.1	30.9	21.551	9.47
			10.958	16:01	16.08	31.9	22.341	9.5
20	365852 6247766	12.4	2.047	16:06	16.08	31	21.63	9.49
			6.879	16:05	16.08	31.3	21.867	9.48
			10.789	16:05	16.08	31.1	21.709	9.56
21	365837 6247813	13.4	2.286	16:09	16.08	30.2	20.998	9.53

Site	UTM (15U)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temp (°C)	Turbidity (NTU)	Calculated TSS* (mg/L)	Dissolved Oxygen (mg/L)
			7.078	16:08	16.08	30.7	21.393	9.49
			11.571	16:08	16.08	22.3	14.757	9.62

*Turbidity/TSS Relationship where TSS = [0.79 x Turbidity] – 2.86

Table 3: Sequence of Gate Commissioning

Date (D/M/Y)	Time (CST)	Gate Number	Gate Opening Height[1] (m)
8/3/2018	7:45	1	1.1 m
8/3/2018	8:38	1	2 m
8/3/2018	14:04	1	3.5 m
8/3/2018	17:30	1	4.5 m
8/3/2018	17:40	1	7 m
8/4/2018	8:37	2	2 m
8/4/2018	11:07	2	3 m
8/4/2018	13:42	2	7 m
8/5/2018	9:39	3	2 m
8/5/2018	12:10	3	7 m
8/5/2018	15:40	4	3 m
8/6/2018	9:37	4	7 m
8/6/2018	13:26	5	4 m
8/6/2018	16:07	5	7 m
8/6/2018	16:14	6	7 m
8/7/2018	9:25	7	7 m

1. Gates completely out of the water at 7 m opening height