Keeyask Generation Project

Sediment Management Plan for In-stream Construction

Sediment Management Plan Report

SMP-2017-01

KEEYASK

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KEEYASK GENERATION PROJECT

SEDIMENT MANAGEMENT PLAN FOR IN-STREAM CONSTRUCTION

REPORT #SMP-2017-01

Annual Report

April 2016 – March 2017: Year 3 Construction

Prepared by

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 KHLP 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. There have been no exceedences of the predetermined action levels measured since the start of construction.

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1.0 INTRODUCTION

The Keeyask Generation Station Project (the Project) is a 695-megawatt hydroelectric generating station and associated facilities at Gull Rapids on the lower Nelson River in northern Manitoba immediately upstream of Stephens Lake. The Project is located within the Split Lake Resource Management Area, approximately 30 km west of Gillam.

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.

In accordance with the Project's Environment Impact Statement (EIS) and *Sediment Management Plan for In-stream Construction* (SMP) (KHLP 2014), a real-time sediment monitoring program was implemented for all in-stream construction activities in the Nelson River.

This report summarizes the results for the sediment monitoring that took place during the in-stream construction in the Nelson River from April 2016 to March 2017. In-stream construction activities during this period included widening the central portion of the Central Dam Cofferdam (Figure 1), work on the Tailrace Summer Level Cofferdam (Figure 2) and construction and removal of the North Channel Rock Groin Extension (Figure 2).

Note: The Stage 2 Tailrace Summer Level Cofferdam and North Channel Rock Groin Extension are not shown – see Figure 2

Figure 1: Map of the Keeyask Generating Station site, September 2016

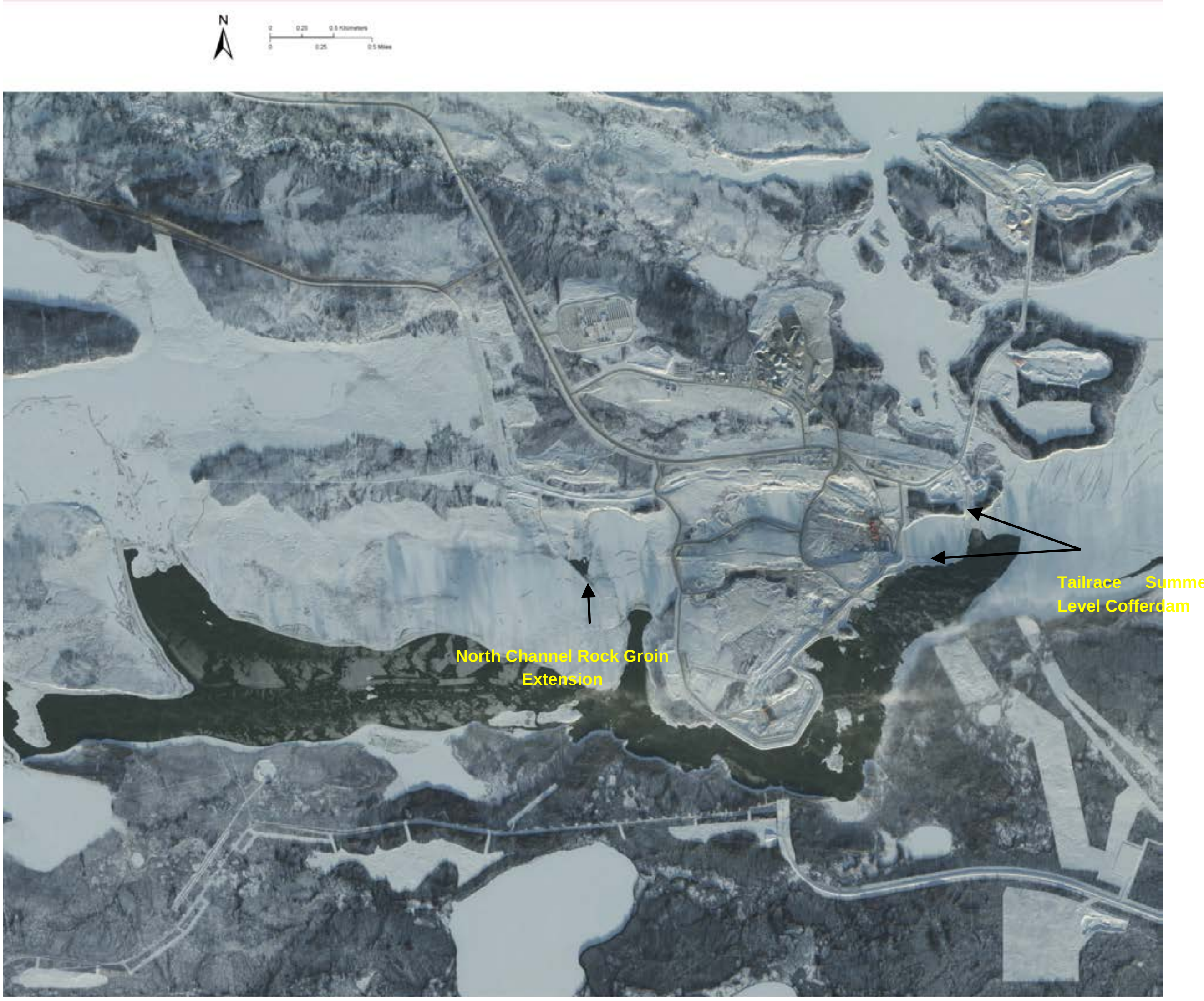


Figure 2: Map of the Keeyask Generating Station site showing the Stage 2 Tailrace Summer Level Cofferdam and North Channel Rock Groin Extension, December 2016

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* (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 the consideration of 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 2016, 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 installed 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 3 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 on-going 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 the fully mixed conditions.
- SMP-3 is located approximately 9 km downstream of 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).

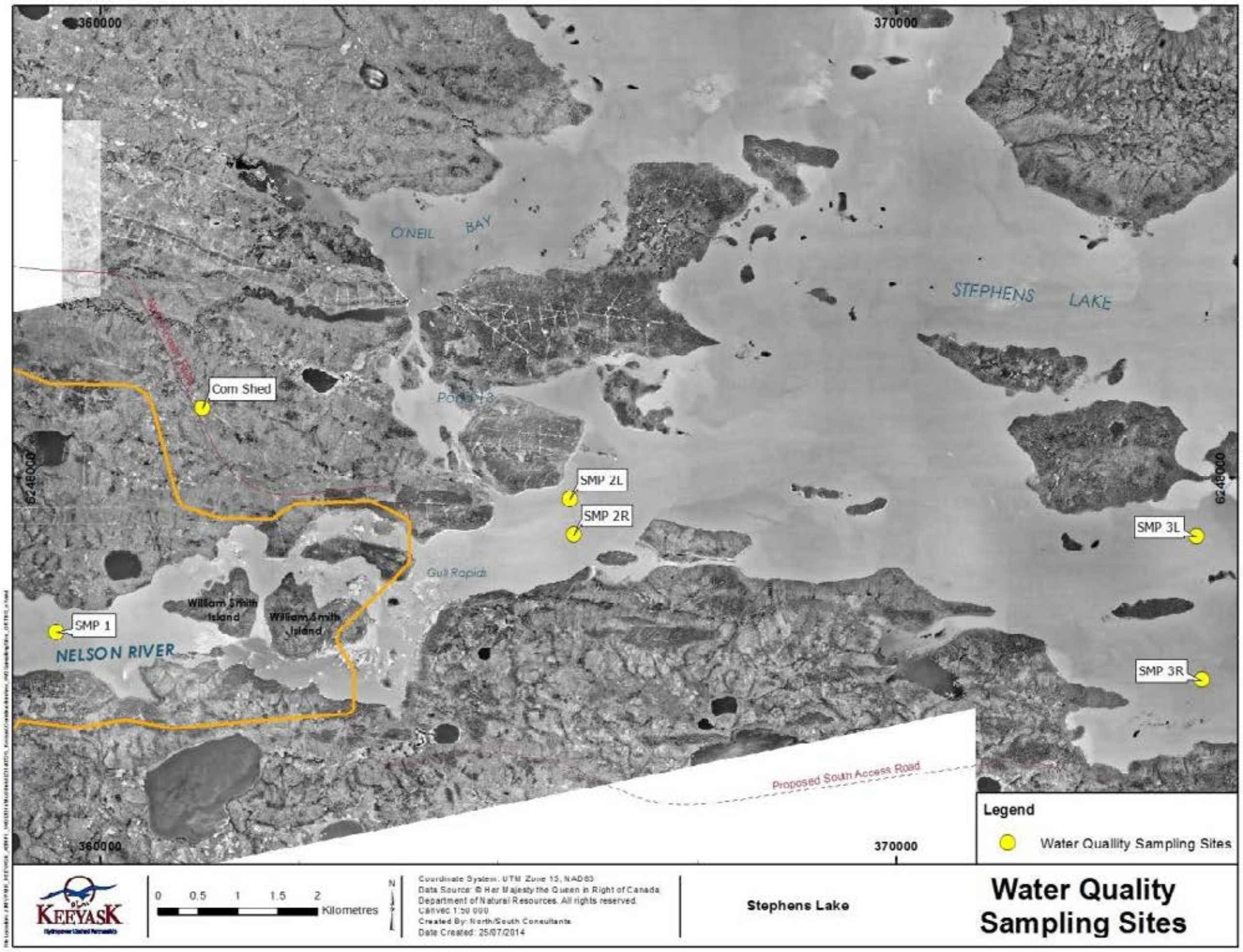


Figure 3: Open water monitoring stations for the Keeyask Sediment Management Plan

Open water monitoring equipment was removed in October 2016, near the end of the open water season, on the following days:

- SMP-1 – October 14
- SMP-2L – October 13
- SMP-2R – October 7
- SMP-3L – October 13
- SMP-3R – October 8

From June 17-22, 2016, the monitoring station at SMP-2L was out of commission, as the catamaran had broken loose during a weather event and had to be located, repaired, and reinstalled. SMP-2R was no longer operational after October 5, 2016, when the catamaran capsized in a windstorm and damaged the equipment. SMP-3R was also compromised during the same weather event when the anchor failed and the catamaran drifted approximately 1 km away. It was retrieved and removed from the river on October 8, 2016.

2.2 SHOULDER SEASON MONITORING STATIONS

Shoulder season monitoring was not implemented in 2016 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. SMP monitoring was not required in early 2016 as, at the time, no in-stream work was scheduled until June. In preparation for removal of the North Channel Rock Groin Extension, monitoring stations were installed upstream at SMP-1 and downstream at SMP-3 during the winter of 2016/2017. Monitors could not be installed at SMP-2 due to unsafe ice conditions.

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 exceedence 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 began in early August after an appropriate protocol was developed to ensure that sampling activities would comply with the Province of Manitoba's recently amended *Aquatic Invasive Species Regulation*. Turbidity measurements and TSS samples were collected near the surface and bottom of the water column in the vicinity of each SMP monitoring station. The results are provided in Table 1. The results show the relationship used to calculate real-time TSS using turbidity as a proxy is appropriate, as laboratory TSS analysis results are generally close to the calculated TSS values in Table 1.

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 capture an increase in turbidity from a passing sediment plume, if any, turbidity measurements were taken at a number of sites transecting the river near the stations to detect potential plumes. Transect data were collected from a boat using a turbidity logger that took measurements at approximately 20 locations along a cross-section of the river near the SMP-2 sites. Transect measurements were obtained once during the open water season, when in-stream work was not occurring (August 30, 2016; Table 2), and twice during in-stream work on the Tailrace Summer Level Cofferdam (October 9, 2016; Table 3, and October 16; Table 4).

Table 1: Manual sampling water quality monitoring data for the 2016 open water season

SMP Stations Reference Sonde Readings and Lab Analysis For the Reporting Year						
Date	**Station ID**	**Time (CST)**	**Sensor/Sample Depth**	**Turbidity (NTU)**	**Calculated* TSS (mg/L)**	**Lab TSS (mg/L)**
2016/08/01	SMP-1	15:18	2 m from Surface	30.7	21.4	19
		15:14	2 m from Bed	30.8	21.5	19.3
	SMP-1A	14:56	2 m from Surface	30.2	20.9	19
		14:52	2 m from Bed	29.5	20.4	20
	SMP-2L	12:12	2 m from Surface	31.2	21.8	20.3
		12:09	2 m from Bed	31.5	22	20
	SMP-2R	11:54	2 m from Surface	29.9	20.8	15.3
		11:51	2 m from Bed	29.8	20.7	16.3
	SMP-3L	11:14	2 m from Surface	28.6	19.7	13.8

SMP Stations Reference Sonde Readings and Lab Analysis For the Reporting Year						
Date	**Statio n ID**	**Time (CST)**	**Sensor/Sample Depth**	**Turbidity (NTU)**	**Calculated* TSS (mg/L)**	**Lab TSS (mg/L)**
		11:20	2 m from Bed	30.7	21.4	13
	SMP-3R	10:50	2 m from Surface	28.9	19.9	13.5
		10:43	2 m from Bed	29.2	20.2	13.5
2016/08/28	SMP-1	13:06	2 m from Surface	22.4	14.8	13.3
		13:10	2 m from Bed	22.8	15.2	14.8
	SMP-1A	13:01	2 m from Surface	22.1	14.6	14.5
		13:05	2 m from Bed	22.7	15.1	14
	SMP-2L	17:27	2 m from Surface	22.6	14.9	16.3
		17:29	2 m from Bed	23.4	15.6	17.3
	SMP-2R	17:10	2 m from Surface	23.6	15.8	13.3
		17:14	2 m from Bed	23.5	15.7	17.5
	SMP-3L	16:24	2 m from Surface	21.5	14.1	14.3
		16:28	2 m from Bed	24.1	16.2	16.5
	SMP-3R	16:46	2 m from Surface	21.3	13.9	13.8
		16:49	2 m from Bed	22.4	14.8	16
2016/09/14	SMP-1	15:22	2 m from Surface	23.5	15.7	14
		15:27	2 m from Bed	23.1	15.4	16.8
	SMP-1A	15:01	2 m from Surface	22.7	15	19
		15:05	2 m from Bed	23.2	15.4	16
	SMP-2L	12:35	2 m from Surface	23.6	15.8	16.5
		12:42	2 m from Bed	24.5	16.5	17
	SMP-2R	13:06	2 m from Surface	23.4	15.6	18.8
		13:13	2 m from Bed	23.9	16	17
	SMP-3L	11:55	2 m from Surface	23.2	15.5	17.5
		12:00	2 m from Bed	23.4	15.6	16.8
	SMP-3R	11:25	2 m from Surface	21.8	14.4	15.5
		11:29	2 m from Bed	22.4	14.8	14

*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 August 30, 2016

Site	UTM (15V)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temperature (°C)	Specific Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)
1	366145 6246883	5.0	2.0	10:14	17.2	----	23.7	100.6	9.66
1	366145 6246883	5.0	3.0	10:16	17.2	0.337	23.6	100.4	9.66
2	366118 6246957	6.5	2.2	10:25	17.2	0.337	23.5	100.8	9.68
2	366118 6246957	6.5	4.5	10:28	17.2	0.337	23.6	100.2	9.64
3	366104 6247011	5.5	2.3	10:34	17.2	0.337	23.2	100.5	9.65
3	366104 6247011	5.5	3.6	13:39	17.2	0.337	23.1	100.3	9.65
4	366086 6247050	7.7	2.1	10:45	17.2	0.337	23.7	100.5	9.66
4	366086 6247050	7.7	5.7	10:48	17.2	0.337	23.4	100.1	9.63
5	366073 6247100	9.3	2.1	10:55	17.2	0.337	23.2	100.7	9.65
5	366073 6247100	9.3	7.7	11:01	17.2	0.337	23.3	100	9.61
6	366055 6247150	10.2	1.9	11:10	17.2	0.337	23.2	100.4	9.65
6	366055 6247150	10.2	8.8	11:16	17.2	0.337	23.3	99.7	9.58
7	366036 6247192	12.5	2.2	11:21	17.2	0.337	23.3	100.9	9.69
7	366036 6247192	12.5	11.1	11:25	0.7	0.337	23.8	99.6	9.58
8	366028 6247230	13.8	2.0	11:31	17.2	0.336	23.7	100.6	9.66
8	366028 6247230	13.8	11.1	11:37	17.2	0.336	23.8	99.8	9.59
9	366008 6247295	13.7	2.0	11:42	17.2	0.335	23.2	100.7	9.70
9	366008 6247295	13.7	10.4	11:49	17.2	0.335	23.2	100	9.61
10	365997 6247342	14.0	2.2	11:59	17.2	0.335	23.3	100.5	9.67
10	365997 6247342	14.0	12.0	12:05	17.2	0.335	23.5	99.8	9.60
11	365984 6247390	13.6	2.0	12:12	17.2	0.334	23.5	100.3	9.64
11	365984 6247390	13.6	1.6	12:15	17.2	0.334	23.7	99.8	9.60
12	365969 6247439	13.0	2.0	12:22	17.2	0.333	23.6	100	9.62
12	365969 6247439	13.0	11.0	12:25	17.2	0.333	23.6	99.4	9.57
13	365950 6247475	13.5	2.0	12:31	17.2	0.330	23.7	99.8	9.59
13	365950 6247475	13.5	11.3	12:34	17.2	0.333	23.8	99.5	9.55

Site	UTM (15V)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temperature (°C)	Specific Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)
14	365935 6247519	13.3	2.0	12:39	17.2	0.331	23.0	100.3	9.66
14	365935 6247519	13.3	10.0	12:42	17.2	0.332	23.3	99.4	9.61
15	365915 6247574	14.0	2.0	12:49	17.2	0.330	22.5	100	9.61
15	365915 6247574	14.0	12.0	12:53	17.2	0.332	23.8	99.4	9.59
16	365906 6247617	14.1	2.0	12:59	17.2	0.330	22.3	99.9	9.58
16	365906 6247617	14.1	12.0	13:05	17.2	0.331	23.1	99.1	9.57
17	365885 6247661	14.3	2.0	13:10	17.3	0.330	22.2	99.5	9.57
17	365885 6247661	14.3	12.0	13:13	17.2	0.332	23.2	99.5	9.58
18	365867 6247717	14.1	2.0	13:20	17.3	0.330	22.5	99.7	9.57
18	365867 6247717	14.1	12.2	13:24	17.2	0.331	22.9	98.8	9.49
19	366156 6246800	12.7	2.0	13:30	17.3	0.330	22.4	99.5	9.54
19	366156 6246800	12.7	10.8	13:33	17.3	0.330	22.4	98.5	9.46
20	365852 6247766	13.1	2.0	13:38	17.3	0.330	22.5	99.7	9.57
20	365852 6247766	13.1	10.7	13:41	17.3	0.330	22.7	98.4	9.45
21	365837 6247813	11.7	2.0	13:46	17.3	0.330	22.4	99.5	9.55
21	365837 6247813	11.7	9.0	13:49	17.3	0.330	22.5	99	9.50

Table 3: Manual sampling water quality monitoring data for a monitoring transect near SMP-2, collected on October 9, 2016

Site	UTM (15V)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temperature (°C)	Specific Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)
2	366118 6246957	6.5	2.2	13:15	6.4	0.331	26.7	99.0	12.19
2	366118 6246957	6.5	4.6	13:30	6.4	0.331	26.8	98.8	12.16
3	366104 6247011	7.2	1.9	13:34	6.4	0.331	27.2	98.9	12.18
3	366104 6247011	7.2	4.8	13:37	6.4	0.331	27.4	98.9	12.14
4	366086 6247050	8.1	2.1	13:41	6.4	0.330	27.1	98.8	12.16
4	366086 6247050	8.1	6.0	13:44	6.4	0.330	27.5	98.7	12.13
5	366073 6247100	9.3	2.1	13:50	6.4	0.330	27.1	98.7	12.14
5	366073 6247100	9.3	6.6	13:53	6.4	0.330	27.2	98.4	12.12
6	366055 6247150	12.0	2.3	14:00	6.4	0.330	26.9	98.6	12.12
6	366055 6247150	12.0	9.2	14:03	6.4	0.330	27.3	98.1	12.07
7	366036 6247192	11.8	1.9	14:08	6.4	0.329	26.9	98.8	12.15
7	366036 6247192	11.8	10.2	14:11	6.4	0.329	26.9	98.0	12.06
8	366028 6247230	14.3	2.0	14:15	6.4	0.329	27.1	98.0	12.14
8	366028 6247230	14.3	11.7	14:21	6.4	0.329	27.3	98.2	12.08
9	366008 6247295	14.4	2.2	14:26	6.4	0.329	27.3	98.8	12.16
9	366008 6247295	14.4	11.3	14:29	6.4	0.329	27.6	98.1	12.08
10	365997 6247342	13.6	2.0	14:34	6.4	0.328	27.3	98.5	12.13
10	365997 6247342	13.6	12.3	14:37	6.4	0.328	27.4	97.9	12.04
11	365984 6247390	14.5	2.0	14:43	6.4	0.327	27.1	98.4	12.10
11	365984 6247390	14.5	12.5	14:46	6.4	0.327	27.6	97.7	12.02
12	365969 6247439	13.4	2.1	14:51	6.4	0.327	27.2	98.0	12.07
12	365969 6247439	13.4	10.8	14:54	6.4	0.327	27.8	97.4	11.90
13	365950 6247475	13.5	1.8	14:59	6.4	0.327	26.9	98.5	12.13
13	365950 6247475	13.5	10.6	15:02	6.4	0.327	27.6	97.5	12.01
14	365935 6247519	14.4	1.9	15:07	6.4	0.326	27.2	98.8	12.17
14	365935 6247519	14.4	12.6	15:09	6.4	0.327	27.4	97.9	12.06

Site	UTM (15V)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temperature (°C)	Specific Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)
15	365915 6247574	14.3	2.3	15:14	6.3	0.326	29.2	95.5	12.15
15	365915 6247574	14.3	12.4	15:17	6.4	0.327	27.9	98.0	12.08
16	365906 6247617	14.2	2.2	15:26	6.4	0.327	28.2	98.8	12.18
16	365906 6247617	14.2	11.8	15:30	6.3	0.327	29.6	98.4	12.13
17	365885 6247661	14.7	2.3	15:38	6.4	0.326	28.0	98.7	12.17
17	365885 6247661	14.7	11.2	15:40	6.3	0.326	27.9	97.9	12.08
18	365867 6247717	14.3	2.0	15:47	6.3	0.326	27.8	98.4	12.14
18	365867 6247717	14.3	12.3	15:50	6.3	0.326	28.8	97.2	12.00
19	366156 6246800	13.1	2.0	15:58	6.3	0.326	27.3	98.5	12.16
19	366156 6246800	13.1	10.9	16:01	6.3	0.326	29.1	97.8	12.07
20	365852 6247766	13.7	2.2	16:08	6.3	0.326	28.1	98.7	12.15
20	365852 6247766	13.7	10.2	16:11	6.3	0.326	27.8	98.5	12.15

Table 4: Manual sampling water quality monitoring data for a monitoring transect between Gull Rapids and SMP-2, collected on October 16, 2016

Site	UTM (15V)	Site Depth (m)	Sensor Depth (m)	Time (CST)	Water Temperature (°C)	Specific Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (% Sat.)	Dissolved Oxygen (mg/L)
1	365052 6246755	10.8	2.0	13:36	3.6	0.324	32.4	98.7	13.07
2	365031 6246866	9.1	2.0	13:40	3.6	0.323	32.0	98.9	13.09
3	365011 6246995	9.1	2.0	13:45	3.6	0.323	32.4	99.3	13.13
4	364999 6247106	7.8	2.0	13:53	3.6	0.322	32.4	99.0	13.09
5	364974 6247213	3.8	2.0	13:58	3.6	0.322	33.8	99.1	13.12

3.0 IN-STREAM WORK

3.1 CENTRAL DAM COFFERDAM EXTENSION

The Central Dam Cofferdam (CDCD) Extension consists of two additional short cofferdams (which are comprised of upstream and downstream rock groins (Figure 4), between which impervious, sandy-silt material is placed) to connect the existing CDCD to the island shown in Figure 1. The extension was constructed during the spring of 2016 to reduce the volume of seepage through the Central Dam Cofferdam (Figure 1). The blanket is a modification to the original design of the Central Dam Cofferdam and the work in 2016 was not proposed during the planning phase prior to the start of construction in 2014. (An alteration to *Environment Act* Licence 3107 was issued to expand the CDCD beyond the footprint limits.)

Figure 4: Constructing a rock groin for the Central Dam Cofferdam Extension on May 10, 2016.

In-stream construction of the Central Dam Cofferdam Extension commenced on April 27, 2016 and was completed on May 11, 2016. In-stream SMP monitoring equipment was not in place during the construction of the Central Dam Cofferdam Extension because monitoring during the shoulder season was not implemented in 2016 for reasons explained in Section 2.2. However, visual monitoring for sediment plumes was conducted daily during this period.

On May 6, 2016, a sediment plume was observed during the placement of impervious material adjacent to the outer rock groin (Figure 5). This plume quickly dissipated once it reached higher flows within Gull Rapids; however, upon its discovery, the placement of impervious material was halted. In order to mitigate the loss of the impervious material to the river, the following day, a groin was constructed using coarse rockfill material with the intention that it would act as a barrier to reduce the amount of impervious material entering the river (Figure 6). Once this was complete, placement of impervious material resumed during the night shift on May 7, 2016. The construction of this additional, coarse rockfill, center groin was successful in minimizing sediment entering the Nelson River due to placement of impervious material and no additional plumes were observed.

Figure 5: On May 6, 2016, a sediment plume developed while placing impervious material at the Central Dam Cofferdam Extension, which is shown in the background.

Figure 6: Dozer placing coarse rockfill to create a barrier to prevent impervious material from entering the river (May 7, 2016)

3.2 DOWNSTREAM BOAT LAUNCH

The 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 every spring. Attempts to repair the Downstream Boat Launch on May 2, 2016 were hampered by the presence of ice, but it was eventually repaired on July 16, 2016. This included the placement of C1 rockfill (Figure 7), and the shaping and rebuilding of the boat launch ramp using an excavator (Figure 8).

Figure 7: Cat 740 haul truck placing rock for the repair of the Downstream Boat Launch on July 16, 2016

Figure 8: Excavator placing and shaping rockfill during the repair of the Downstream Boat Launch ramp on July 16, 2016

There was no SMP monitoring equipment in place during material placement on May 2, 2016 because shoulder season monitoring was not implemented in 2016, as explained in Section 2.2. However, equipment at the SMP-2 and SMP-3 sites was in place in July and there were no exceedences of the action levels observed at any time on July 16, 2016 (Figure 9 & Figure 10).

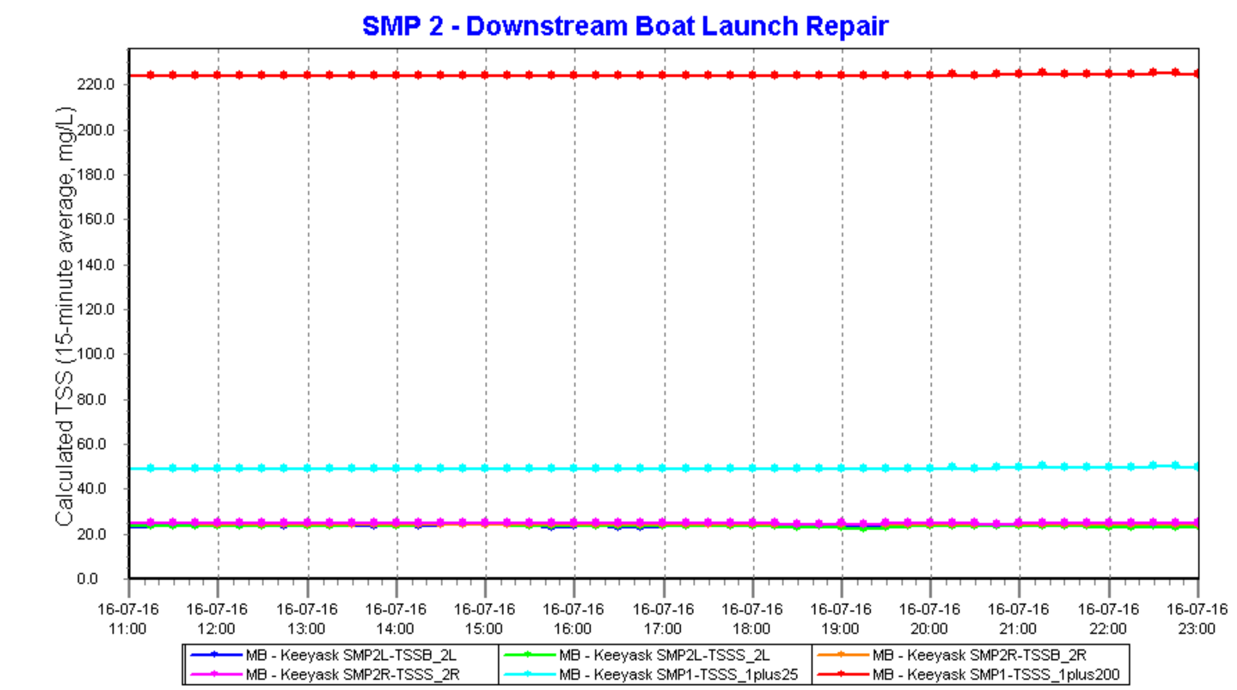


Figure 9: **Calculated total suspended solids (TSS) values (15 minute average, mg/L) for a duration of 12 hours at monitoring stations SMP-2R and SMP-2L compared with the action levels, which are shown in red and light blue**

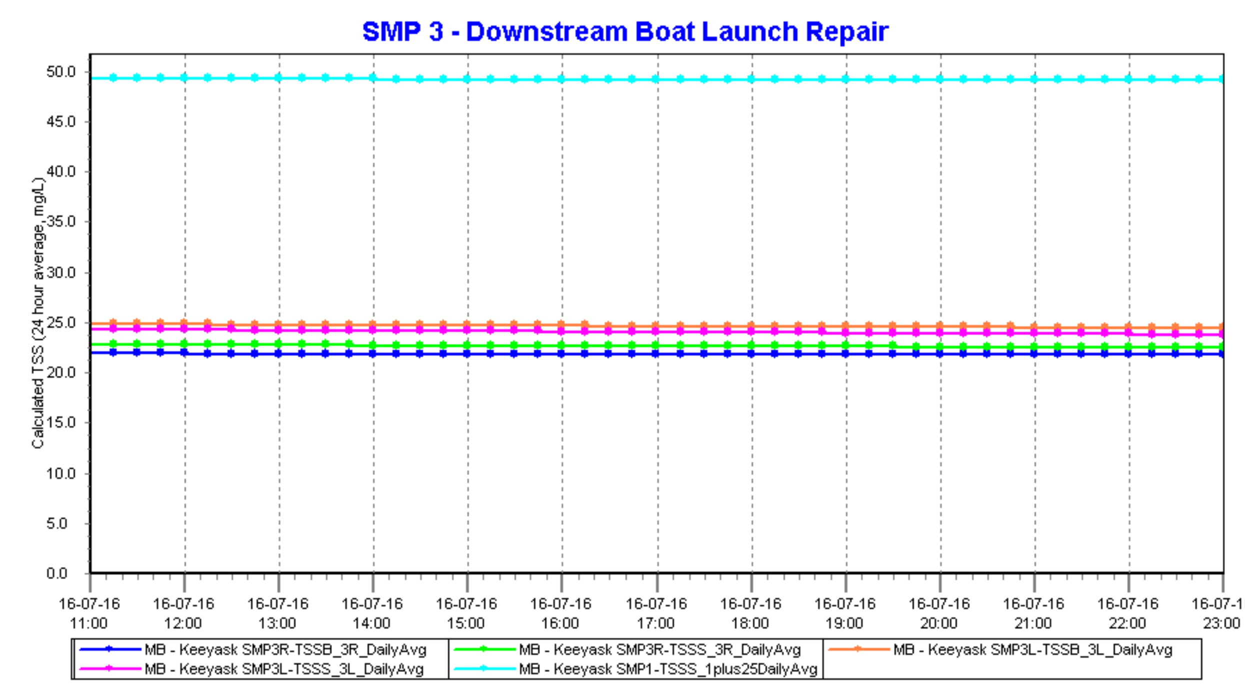


Figure 10: **Calculated total suspended solids (TSS) values (24 hour rolling average, mg/L) for a duration of 12 hours at monitoring stations SMP-3R and SMP-3L compared with the action level, which is shown in light blue**

3.3 TAILRACE SUMMER LEVEL COFFERDAM

In-stream work to construct the Tailrace Summer Level Cofferdam rock groins (Figure 11 & Figure 12) commenced on August 4, 2016 using Class C1 rockfill and Class C2 riprap. After August 5, changes to the design and schedule delayed further work on the cofferdam until October 2016. In-stream work resumed on October 7, 2016 and included placing C1 and C2 rock to construct a boat launch off the inner groin of the cofferdam to allow water access for emergencies and spill response. Construction ceased for the winter after December 2 and an opening was left in the cofferdam to allow fish to move freely out of the area throughout the winter months (visible in Figure 13).

Figure 11: Placement of Class C1/C2 rockfill and riprap on the outer groin of the Tailrace Summer Level Cofferdam on November 4, 2016

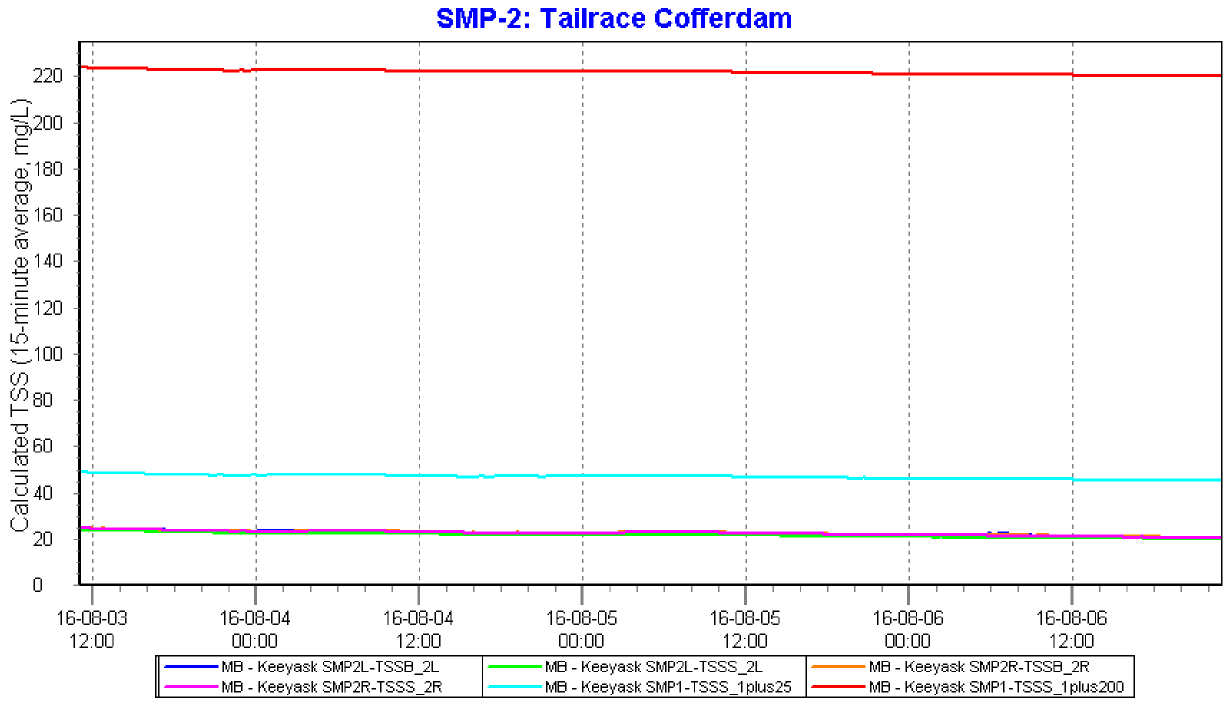
Figure 12: Aerial view of the incomplete Tailrace Summer Level Cofferdam, showing the outer rock groin (extending from the left) and a spur of the inner rock groin (extending from the right) on November 7, 2016

Figure 13: Aerial view of the Tailrace Summer Level Cofferdam in the winter, showing the inner and outer rock groins (red lines) and gap left for fish movement.

During construction of the Tailrace Summer Level Cofferdam, in-stream SMP monitoring took place until the equipment was removed in early to mid-October in preparation for ice-on. Only data for SMP-2L are shown on Figure 16 for reasons described in Section 2.1.

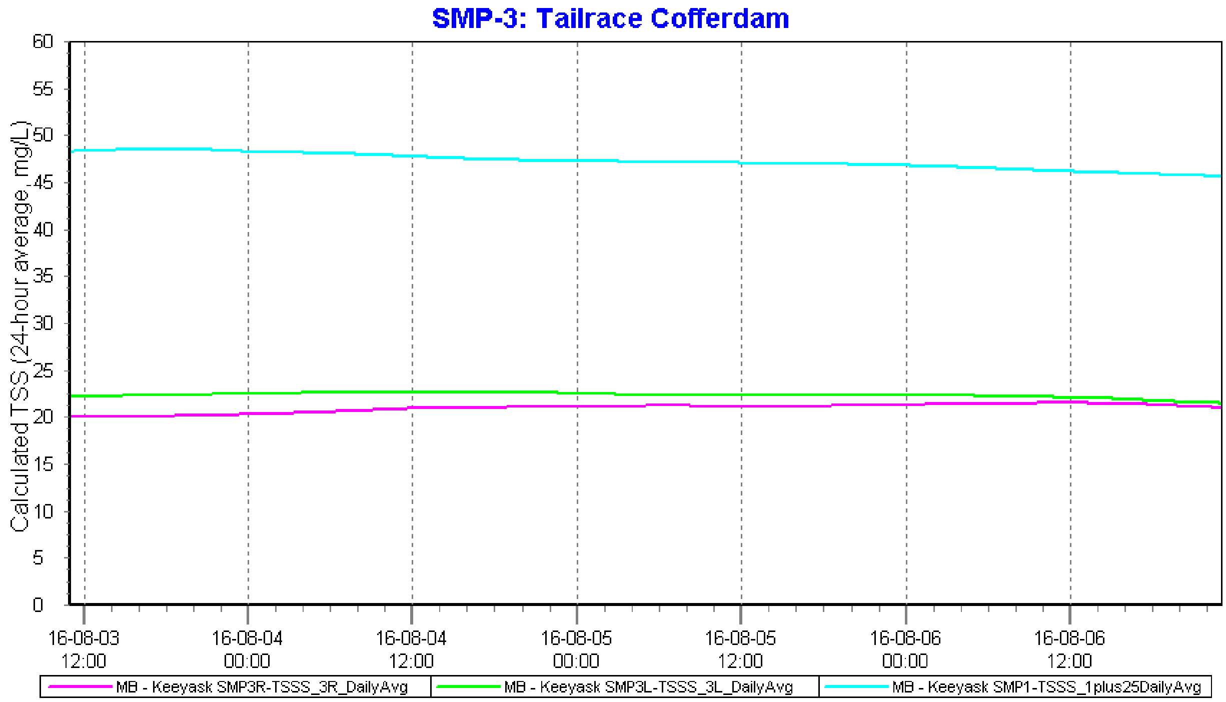
There were no exceedences of the action levels observed during construction of the Tailrace Summer Level Cofferdam during the period that in-stream SMP monitoring equipment was installed (Figure 14 to Figure 17).

The increases in the 24 hour daily rolling average TSS values observed at all of the SMP-3 monitoring stations, as shown in Figure 17, were not associated with in-stream construction, as the increase was also observed upstream from the site (at SMP-1).



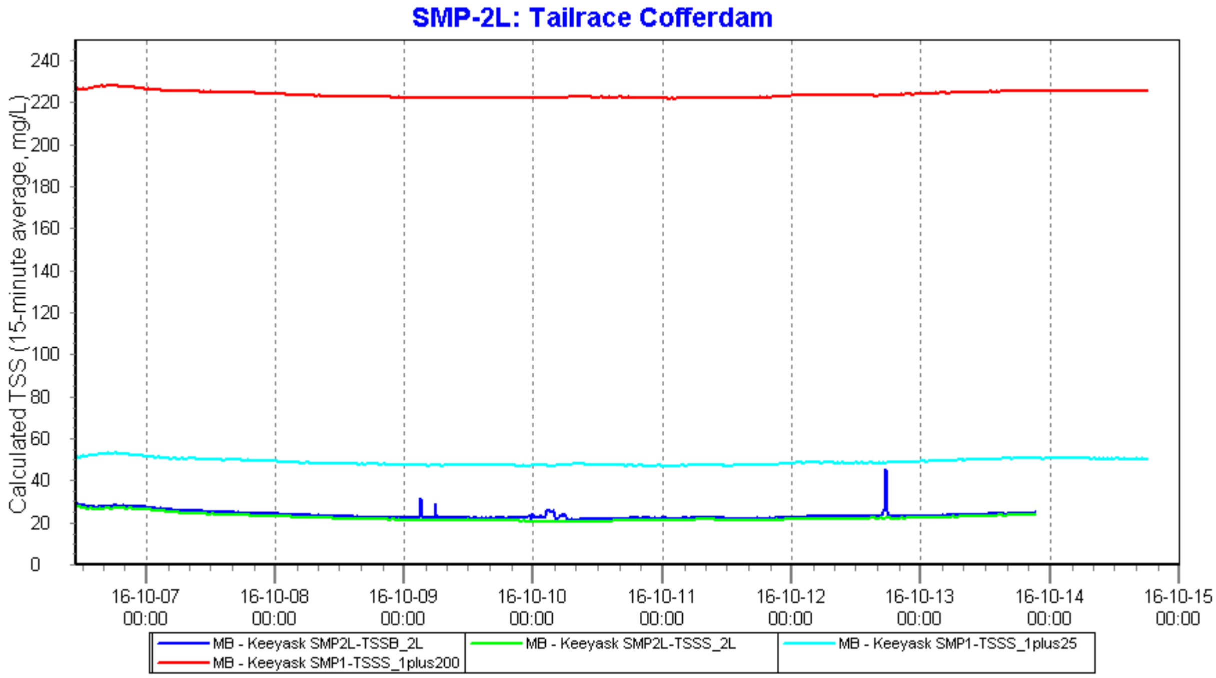
Note that the time is plotted in Greenwich Mean Time (GMT), which is five hours ahead of local time (Central Daylight Time).

Figure 14: Calculated total suspended solids (TSS) values (15 minute average, mg/L) at monitoring stations SMP-2R and SMP-2L compared with the action levels, which are shown in red and light blue, from August 3-6, 2016



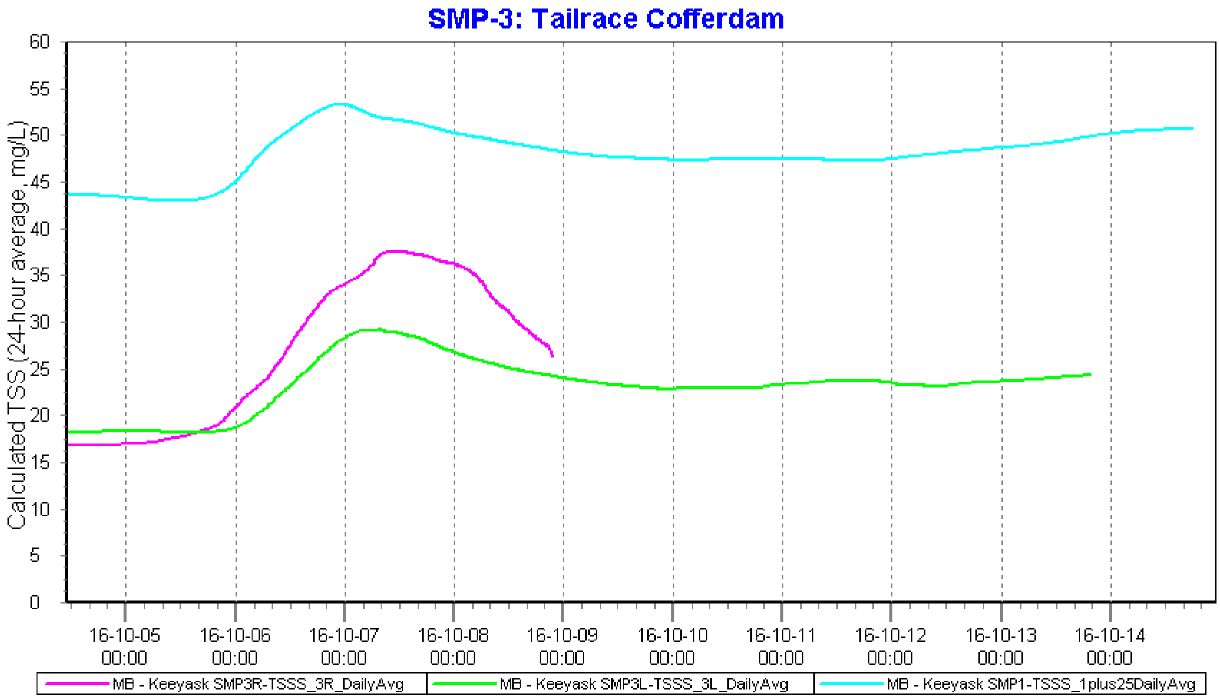
Note that the time is plotted in Greenwich Mean Time (GMT), which is five hours ahead of local time (Central Daylight Time).

Figure 15: Calculated total suspended solids (TSS) values (24-hour rolling average, mg/L) at monitoring stations SMP-3R and SMP-3L compared with the action level, which are shown in light blue, from August 3-6, 2016



Note that the time is plotted in Greenwich Mean Time (GMT), which is five hours ahead of local time (Central Daylight Time).

Figure 16: Calculated total suspended solids (TSS) values (24-hour average, mg/L) at monitoring stations SMP-2R and SMP-2L compared with the action level, which is shown in light blue, from October 7-14, 2016



Note that the time is plotted in Greenwich Mean Time (GMT), which is five hours ahead of local time (Central Daylight Time).

Figure 17: Calculated total suspended solids (TSS) values (24-hour rolling average, mg/L) at monitoring stations SMP-3R and SMP-3L compared with the action level, which are shown in light blue, from October 5-14, 2016

On October 9, 2016, turbidity measurements were taken along a transect near SMP-2 (Table 3), as described in Section 2.5. The turbidity results were similar to turbidity values measured upstream of the Keeyask site, at SMP-1, during transect monitoring at that location (Table 1).

Once the SMP in-stream monitoring stations were removed from the river in preparation for winter, the remainder of in-stream sediment monitoring was completed visually by looking for plumes and taking in-situ measurements for turbidity using a portable sensor. During this period, no sediment plumes or high turbidity measurements (Table 4) were observed in the Nelson River in the vicinity or downstream from the Tailrace Summer Level Cofferdam.

3.4 NORTH CHANNEL ROCK GROIN EXTENSION

The North Channel Rock Groin Extension was constructed in order to promote the formation of a solid ice sheet on Gull Lake during the winter of 2016/2017. This work consisted of placing and shaping rockfill material (Classes C1/C2, C3) using a Cat 390D excavator (Figure 18). In-stream work commenced on November 12, 2016 and was completed on November 19, 2016.

As explained in Section 2.2, SMP in-stream monitoring equipment was not in place during construction of the North Channel Rock Groin Extension. At this time, SMP monitoring was performed by conducting visual inspections for sediment plumes in the Nelson River in close proximity to and downstream from the in-stream work (Figure 19). No sediment plumes were observed during the course of the work.

Figure 18: Excavator placing C3 material at the North Channel Rock Groin Extension on November 14, 2016

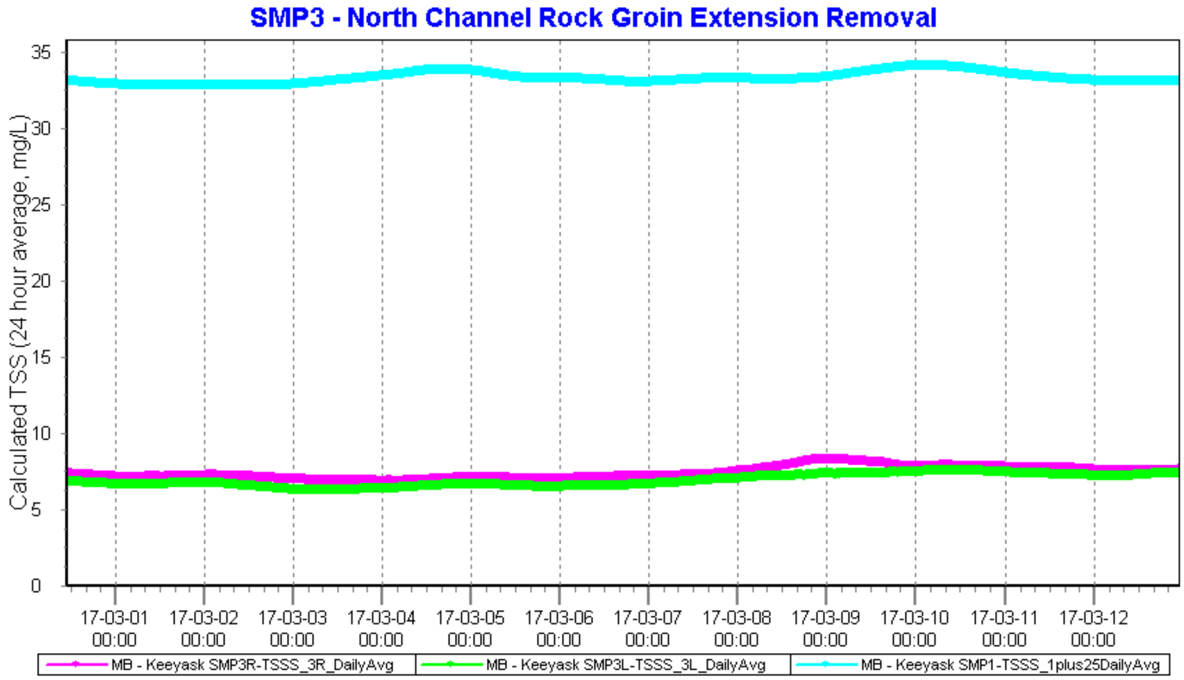
Figure 19: Aerial view of a Cat 390D excavator placing C3 material at the North Channel Rock Groin Extension on November 19, 2016

3.5 NORTH CHANNEL ROCK GROIN EXTENSION REMOVAL

The North Channel Rock Groin Extension was removed in late winter 2017 to minimize spring flooding on Gull Lake and to reduce pressure on the NCRG in anticipation of increased flows on the Nelson River due to the spring melt. In-stream work to remove it (Figure 20) commenced on February 25, 2017 and was completed by March 12, 2017.

Figure 20: Excavator placing material removed from the North Channel Rock Groin Extension into a haul truck on March 11, 2017

As explained in Section 2.3, winter in-stream monitoring equipment was installed at SMP-1 and SMP-3 sites during removal of the North Channel Rock Groin Extension. There were no exceedences of the action values at SMP-3 observed during the time that the NCRG Extension was being removed (Figure 21).



Note that the time is plotted in Greenwich Mean Time (GMT), which is six hours ahead of local time (Central Standard Time).

Figure 21: Calculated total suspended solids (TSS) values (24-hour average, mg/L) at monitoring stations SMP-3R and SMP-3L compared with the action level, which are shown in light blue, from February 25, 2016 to March 12, 2016.

3.6 PREDICTED TSS LEVELS VS. MONITORING RESULTS

As described in the SMP, construction activities during river management 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 22) were based on the proposed construction timeline at the time that the analyses were performed. It represents fully mixed conditions at the first monitoring site downstream (SMP-2) assuming fully mixed conditions. While the Tailrace Summer Level Cofferdam was included in the analysis, the Central Dam Cofferdam Extension and the North Channel Rock Groin Extension are structures that were not previously planned and were not considered in the analyses.

The Central Dam Cofferdam Extension consisted of two rock groins between the Central Dam Cofferdam and a small island about 75m offshore with impervious material placed between the groins. Plans prior to construction had called for a single rock groin across this gap to reduce velocities along the face of the Central Dam Cofferdam to reduce sediment entrainment when fines were placed on the Central Dam Cofferdam. Analyses indicated construction of the cofferdam and the single rock groin would cause downstream TSS to change less than 1 mg/L. Although a small plume of sediment was noted locally, adjacent to the rock blanket, the plume was noted to dissipate rapidly in the main flow, as would be expected. The relatively small amount of sediment that would have been present is not likely to have been measurably discernible downstream had the sediment monitoring equipment been in place.

Work at the boat launch occurred in a low velocity flow area off the main channel. Although this work was not simulated in the pre-construction analyses, the nature of the work and the location where it took place would preclude the likelihood of having any measureable effect at SMP monitoring site SMP-2.

Unlike the boat launch, the North Channel Rock Groin Extension into the south channel did involve the placement of material directly into the main river flow. The large rock used to construct the extension has limited fines content and some of the material used in 2016 had been used to construct the extension in 2015. Prior placement into and removal from the flow would have removed much of the fines from this material. While this structure was not previously assessed in pre-construction studies, it is similar to the Spillway Cofferdam rock groins, which were modeled. Increases of less than 1 mg/L were predicted for just the rock groin portion of the Spillway Cofferdam. Downstream effects due to the construction of the North Channel Rock Groin Extension would have been less than 1 mg/L and, had monitoring equipment been in place, it is not likely that any discernible effect would have been observed at the monitoring site downstream. Similarly, removal of the material would not be expected to produce any discernible effect at the monitoring site downstream.

The proposed pre-construction schedule showed the Tailrace Summer Level Cofferdam being constructed from mid-July to mid-September in the fifth summer of construction. Although construction took place later in the season, the predicted in-stream effects on TSS would not change substantively. During 2016, work began on August 4 but due to changes in the design and schedule, the bulk of construction took place from October 7-December 2. The method of construction is slightly different from what was considered in the estimate of Project effects on TSS. Over its entire length, the cofferdam will use inner and outer rock groins (Figure 13) whereas the original plan called for only an inner groin along the downstream, north-south leg of the cofferdam. The original analysis predicted a downstream TSS increase of 0-1 mg/L due to construction of the inner and outer groins (Figure 22). Plots of 15 minute average TSS for SMP-1 and SMP-2 (surface and bottom) from October 1 until the sensors were removed show the TSS at the SMP-2 locations were generally about 1-2 mg/L higher than at SMP-1 from October 7 onward (Figure 23). However, the differences are similar to those observed before construction began on the groins. These results suggest that, to the extent construction caused upstream to downstream increases, the effect was small and likely less than 1 mg/L as expected. Note that this minor potential effect was observed despite the fact that, among all in-stream works, the Tailrace Summer Level Cofferdam is the closest structure to the SMP-2 monitoring site.

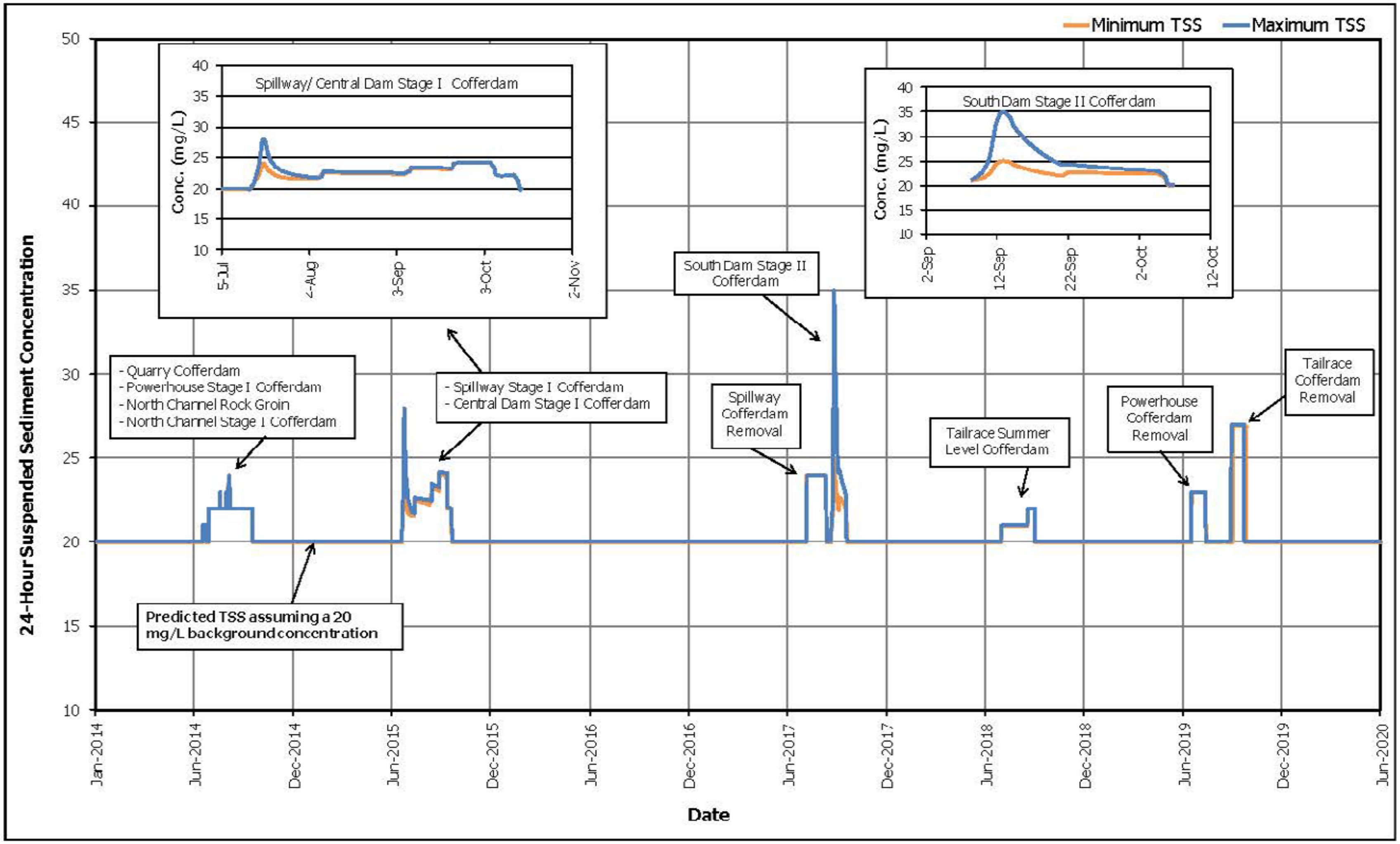


Figure 22: Fully Mixed 24-Hour Average TSS Concentration Predicted in the Proximity of Site SMP-2 (mixing zone) During Construction of the Keeyask Generating Station

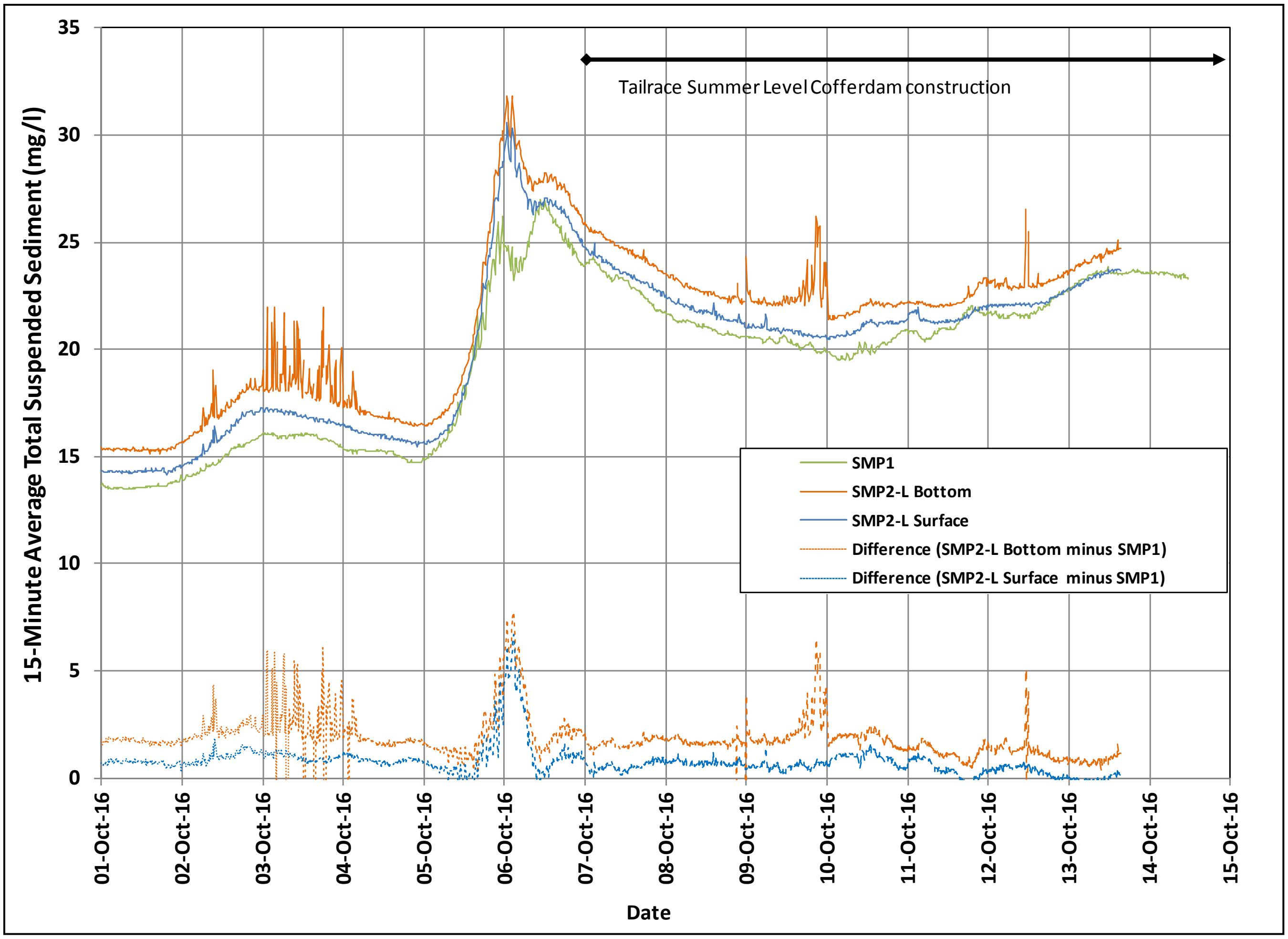


Figure 23: Continuous TSS at sites SMP-1 and SMP-2 during Tailrace Summer Level Cofferdam

4.0 CONCLUSION

During the SMP monitoring period (April 2016 to March 2017) there were no exceedences of the SMP action levels attributed to the in-stream construction activities that took place. The increases in TSS levels that were noted above the action levels were identified as resulting from equipment malfunction, vegetation interference on the sensors, or from maintenance activities that took place during the monitoring period.

The preliminary construction schedule considered in the assessment of Project effects for the Keeyask EIS (KHLP 2012) showed no in-stream construction in the 2016/17 period. The actual schedule is different, and construction of the Tailrace Summer Level Cofferdam was advanced from summer 2018 to summer 2016. Construction of the Central Dam Cofferdam Extension and the North Channel Cofferdam Extension were not planned in the pre-construction period and therefore were not assessed in pre-construction studies. However, potential effects can be inferred from other similar works. Construction of the downstream boat launch was a known activity; however, discernible effects at SMP-2 would not have been expected since the boat launch is in a low velocity area off the main flow. Construction of the Tailrace Summer Level Cofferdam did not result in any substantive effects at SMP-2 and other in-stream works similarly had little potential for discernible downstream effects.

5.0 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 Instream Construction. Winnipeg, Manitoba. June 2014.