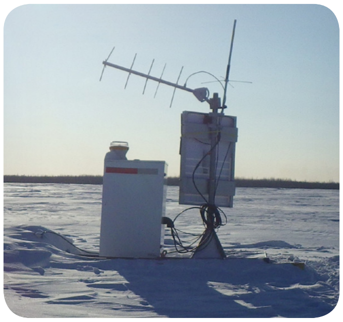
Keeyask Generation Project

Sediment Management Plan for In-stream Construction

Sediment Management Plan Report

SMP-2016-01



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KEEYASK GENERATING STATION PROJECT

SEDIMENT MANAGEMENT PLAN FOR IN-STREAM CONSTRUCTION

Report #SMP-2016-01

Annual Report April 2015 – March 2016: Year 2 Construction

By

Manitoba Hydro

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1.0 INTRODUCTION

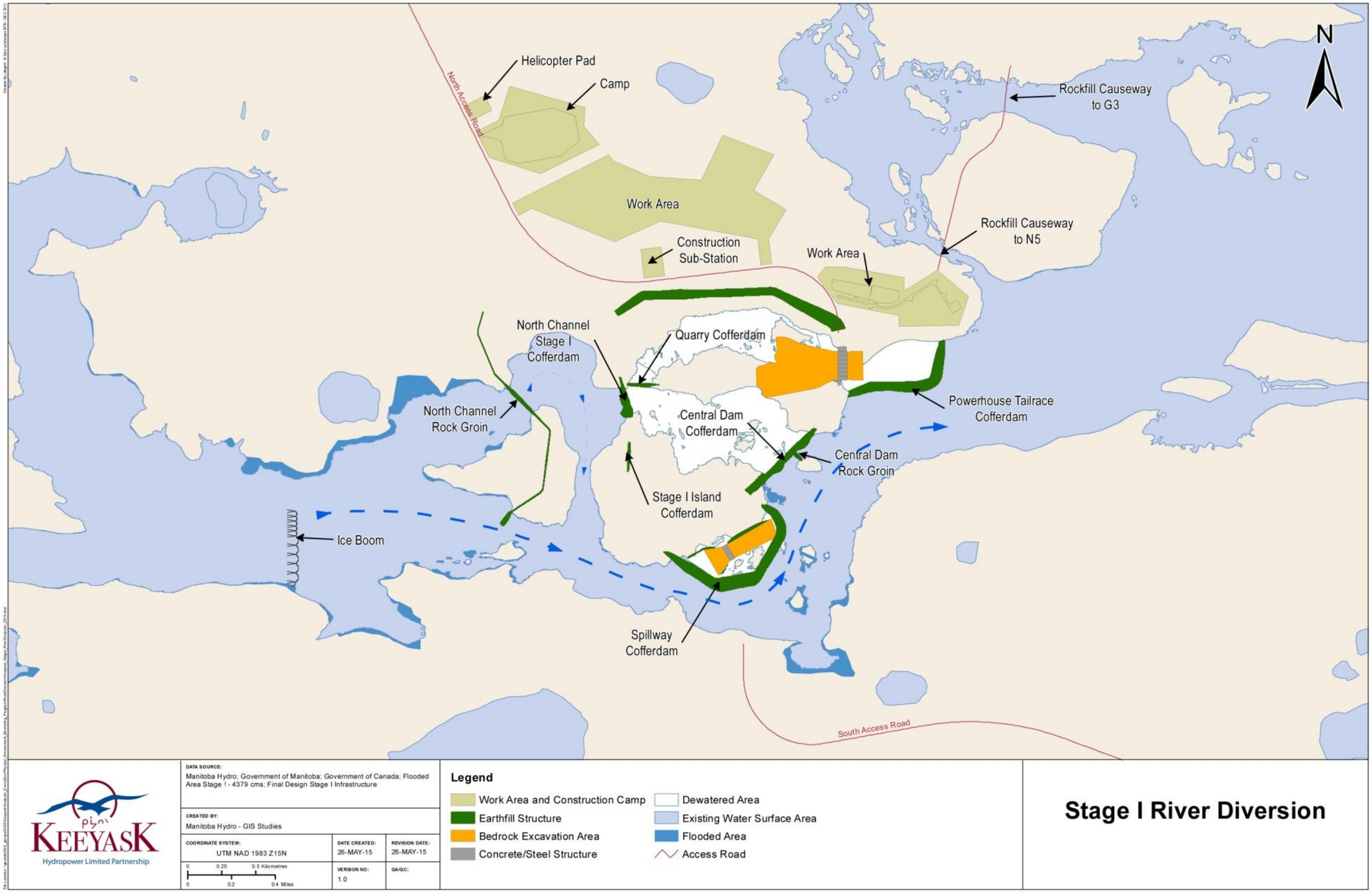
The Keeyask Generation Station Project (the Project) is a 695 megawatt hydroelectric generating station and associated facilities at Gull Rapids on the lower Nelson River in northern Manitoba immediately upstream of Stephens Lake. The Project is located within the Spilt Lake Resource Management Area and located approximately 30km 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), 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 May 2015 to April 2016. In-stream construction activities during this time period included the construction of the Central Dam Cofferdam and the completion of the Spillway Cofferdam (see Map 1).



Map 1. Stage 1 River Diversion Structures

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, July 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 explained in the SMP. Monitoring locations are discussed in more detail in Section 2.1, 2.2 and Section 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 May 2015 the open water monitoring stations were installed on the Nelson River. A total of 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. Sensors are installed at each station 2.0 meters below the water's surface (designated TSSS) and were located 2.0 meters above the bottom of the channel (designated TSSB). Figure 1 shows the locations for each of the SMP summer open water monitoring stations and are described in more detail below:

- SMP-1 is located upstream of all the 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 as the majority of the flow passes through this south channel and where increase in TSS will mostly occur. Data loggers are installed at both the left and right sides of the channel (SMP-3L & SMP-3R).

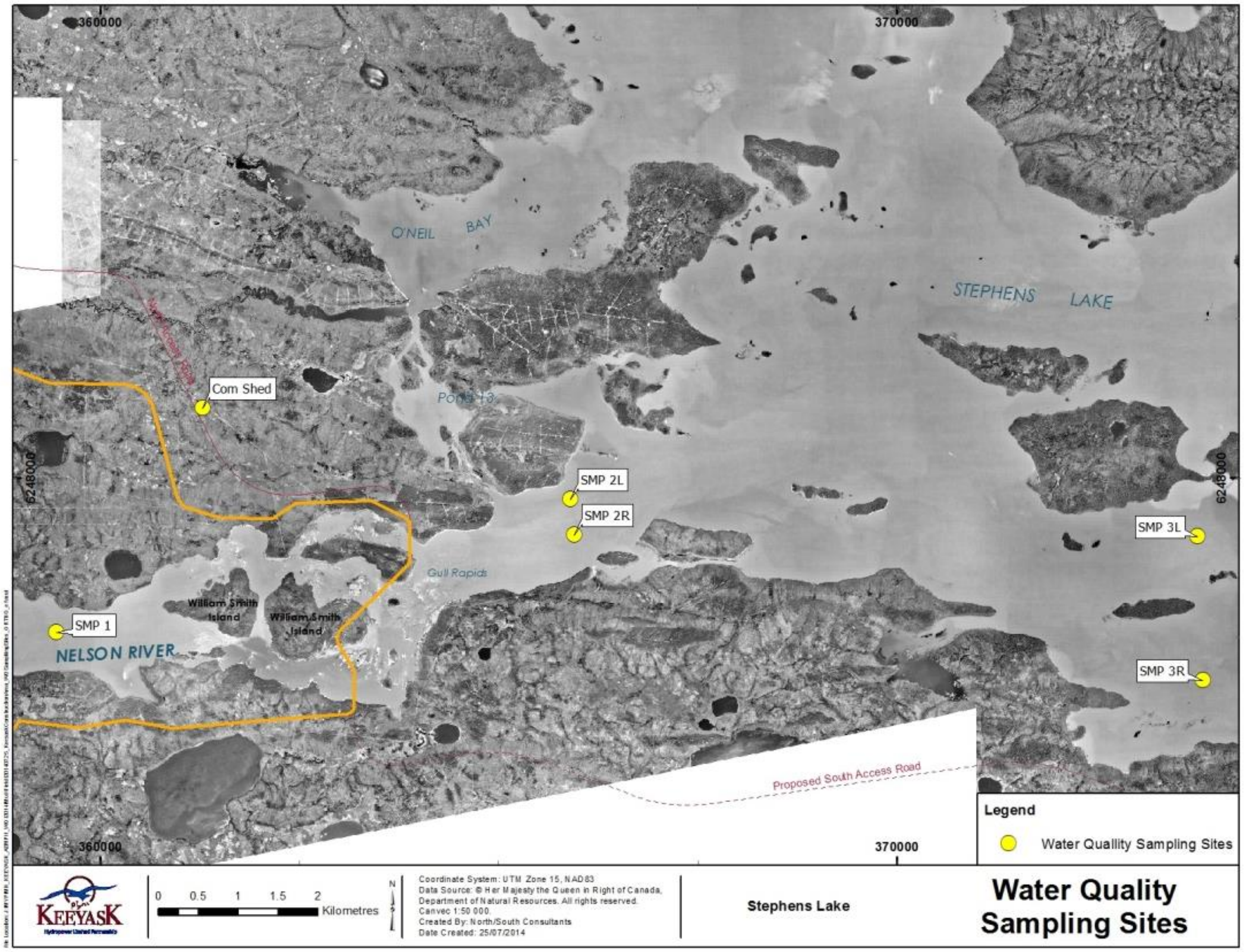


Figure 1: Open Water Monitoring Stations

2.2 SHOULDER SEASON MONITORING STATIONS

As described in Section 3.4.1 of the SMP, monitoring methodology was modified to monitor the TSS in the Nelson River during in-stream construction activities extending through the shoulder season (transition period between open-water and winter). There was no in-stream construction in the fall of 2015, so the shoulder season monitoring arrangement was not put into place.

2.3 WINTER MONITORING STATIONS

The SMP describes modifications to the open-water program required in winter with ice conditions. The Spillway cofferdam rock groins were constructed in winter 2015, so monitoring stations were installed upstream at SMP-1 and at SMP-3 downstream. The SMP-2 site could not be monitored due to unsafe ice conditions. The SMP-1 and SMP-3 loggers installed in winter 2015 remained in use until May 9, 2015.

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 the hundreds to hundreds of thousands of mg/L. The action levels at SMP-2 are set so that action is initiated to mitigate sediment inputs due to construction in order to maintain a 24-hour average increase of 25 mg/L or less at SMP-3 relative SMP-1.

Exceedence of these action levels will initiate action to identify the source of the TSS and secondary mitigation strategies for unanticipated events and/or a modification to all in-stream construction activities procedures, including commissioning of Spillway and Powerhouse, which are outlined in the SMP.

2.5 MANUAL SAMPLING

As outlined in the SMP the in-situ turbidity logger data would be supplemented through manual monitoring of turbidity using handheld loggers and collecting water samples. Turbidity measurements and samples were collected from the near surface and near-bottom from within the water column along a river cross section in the vicinity of the SMP monitoring sites during the reporting period (see Table 1).

Table 1: 2015 Open Water Manual Turbidity Monitoring Results

SMP Stations Reference Sonde Readings and Lab Analysis For the Reporting Year						
Date	Station ID	Time (cst)	Sensor/Sample Depth	Turbidity (NTU)	TSS (mg/L)	Lab TSS (mg/L)
18-Jul-2015	SMP3L	13:54	2m from Surface	19.1	12.23	
		14:01	2m from Bed	19.7	12.70	
	SMP3R	14:19	2m from Surface	19.2	12.31	
		14:24	2m from Bed	20.1	13.02	
	SMP2R	15:02	2m from Surface	21.5	14.13	
		15:09	2m from Bed	21.4	14.05	
	SMP2L	15:20	2m from Surface	21.3	13.97	
		15:26	2m from Bed	21.3	13.97	
19-Jul-2015	SMP1	14:48	2m from Surface	22	14.52	
		14:51	2m from Bed	21.9	14.44	
9-Aug-15	SMP3R	10:09	2m from Surface	25.1	16.97	10.5
		10:26	2m from Bed	24.3	16.34	9.3
	SMP3L	10:53	2m from Surface	24.4	16.42	11
		10:59	2m from Bed	26.4	18.00	11.3
	SMP2R	11:37	2m from Surface	25	16.89	16.3
		11:41	2m from Bed	25.5	17.29	15.8
	SMP2L	13:23	2m from Surface	26.2	17.84	15.5
		13:26	2m from Bed	26.2	17.84	16.8
	SMP1	15:57	2m from Surface	19.9	12.86	11.30
		16:09	2m from Bed	18.8	11.99	13
30-Aug-15	SMP2L	15:19	2m from Bed	20.5	13.335	
31-Aug-15	SMP3L	14:43	2m from Surface	25.7	17.443	
		14:47	2m from Bed	25.7	17.443	
	SMP3R	15:03	2m from Surface	18.1	11.439	
		15:07	2m from Bed	18.1	11.439	
	SMP2R	16:20	2m from Surface	18.8	11.992	
		16:25	2m from Bed	19.1	12.229	
11-Sep-15	SMP1	15:21	2m from Surface	17.2	10.728	
		15:24	2m from Bed	17.4	10.886	

3.0 IN-STREAM WORK

3.1 CENTRAL DAM COFFERDAM OUTER ROCK GROIN

The Central Dam Cofferdam across the centre channel consists of inner and outer rock groins between which impervious Class A & B fill is placed. The inner rock groin was constructed in 2014. The cofferdam was completed 2015 by extending the outer rock groin across the centre channel, parallel to the inner groin, and then filling between the groins with impervious fill. The original plan for the Central Dam Cofferdam involved constructing a single groin with impervious material placed on the slope facing the river. The actual construction using two rock groins is a modification to the original plan and the work in 2015 was not proposed during the planning phase prior to the start of construction in 2014. The in-stream construction of the Central Dam Cofferdam outer rock groin (see Figures 2 and 3) commenced on July 16, 2015 and was completed on August 6, 2015. The impervious Class A & B material was placed between August 25 and September 13, 2015: however, this was not considered an in-stream work activity as it did not involve material placement within the flow of the river.

Figure 4 shows the daily TSS values averaged over the previous 24 hours compared with the action levels, which are shown in red and light blue. Increases in TSS above the SMP actions levels occurred between July 16 to August 6, 2015 at SMP-2L. Staff inspected monitoring equipment when TSS exceeded action levels and determined that the increases were a result of floating debris, biofouling of the sensors, and on two occasions, the sensors hit the bottom after a mooring cable broke. On July 16, 2016 the SMP-2L catamaran was moved, from its location in an eddy, towards the centre of channel into more linear main flow in and effort to ensure more accurate water quality measurements. Because of differences in water regime conditions (flow, level), the eddy condition present in 2015 was not present in 2014 even though the same location was originally selected for monitoring in 2015.

Figure 5 shows the daily TSS values averaged over the previous 24 hours compared with the action levels, which are shown in red and light blue. Increases in TSS levels above the SMP actions levels occurred July 16 to August 6, 2015. The increases in TSS levels were a result of the SMP-3L catamaran breaking away from its anchoring system on August 1, 2016. This allowed for the catamaran to drift into a shallower area where the bottom sensor and sensor weight dragged on the lake bed. The resulting displaced sediment caused high TSS readings.

Figure 2: Central Dam Cofferdam outer rock groin construction

Figure 3: Central Dam Cofferdam outer rock groin in progress

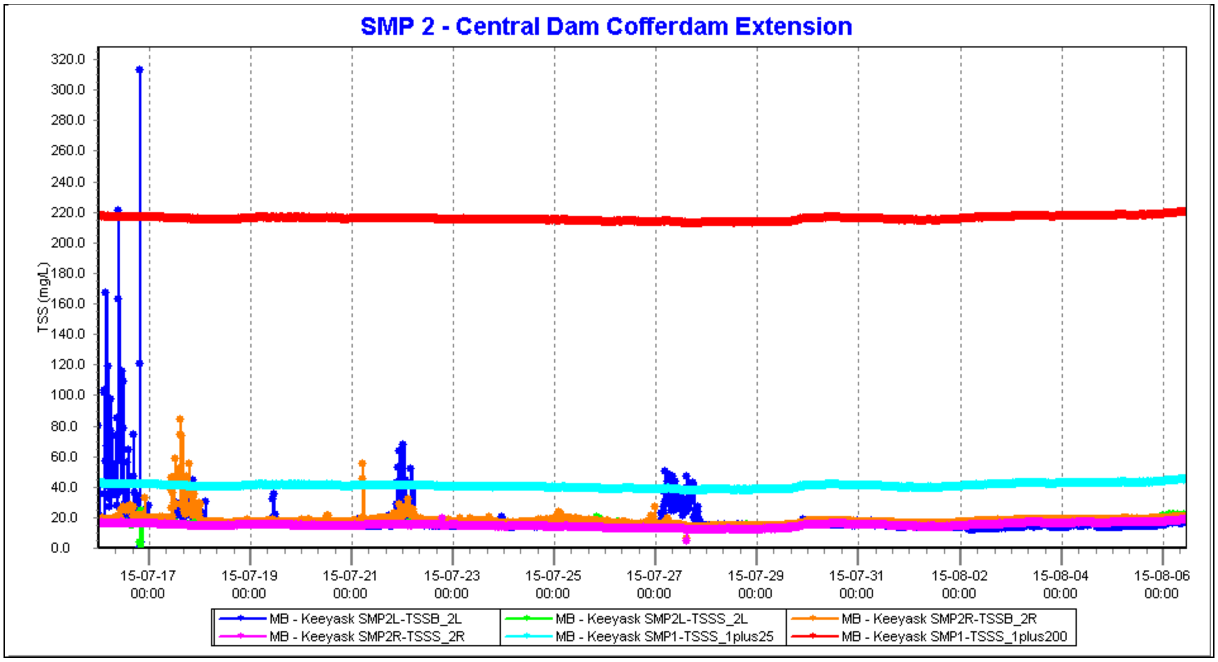


Figure 4: Central Dam Cofferdam TSS values at SMP-2L & SMP-2R (15 minute average).

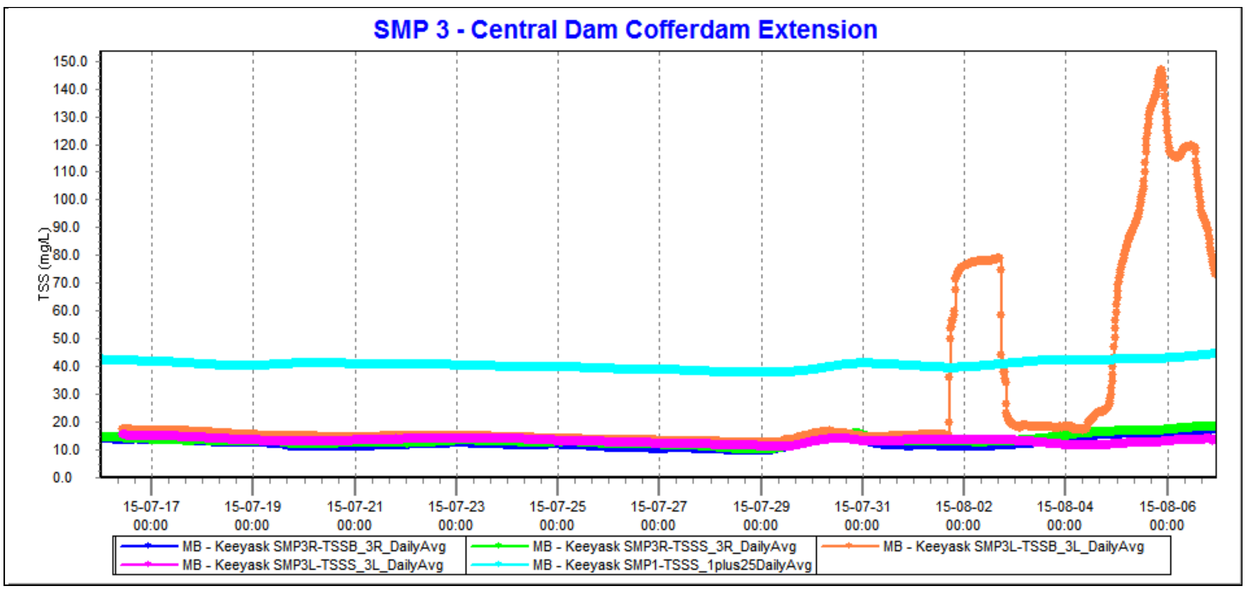


Figure 5: Central Dam Cofferdam outer rock groin – TSS values at SMP-3L & SMP-3R (rolling 24 hour moving average)

3.2 SPILLWAY COFFERDAM

In-stream work for the construction of the Spillway Cofferdam rock groins (see Figures 6 and 7) commenced on February 27, 2015 and was completed May 6, 2015. The Spillway Cofferdam was completed later by placing impervious Class A & B material between the two rock groins in summer 2015, between June 9 and August 24. Placement of the impervious fill was not considered an in-stream work activity as it did not involve material placement within the river flow.

Figure 8 shows the daily TSS values averaged over the previous 24 hours compared with the action levels, which are shown in red. The results show increases in TSS levels at SMP-3L that are above the SMP actions levels from May 1 to May 6, 2015. Staff investigated the cause of the elevated TSS and determined it was due to slush and ice interference with the sensors, causing high TSS readings.

Figure 6: Aerial photo - Spillway Cofferdam

Figure 7: Aerial photo - Spillway Cofferdam

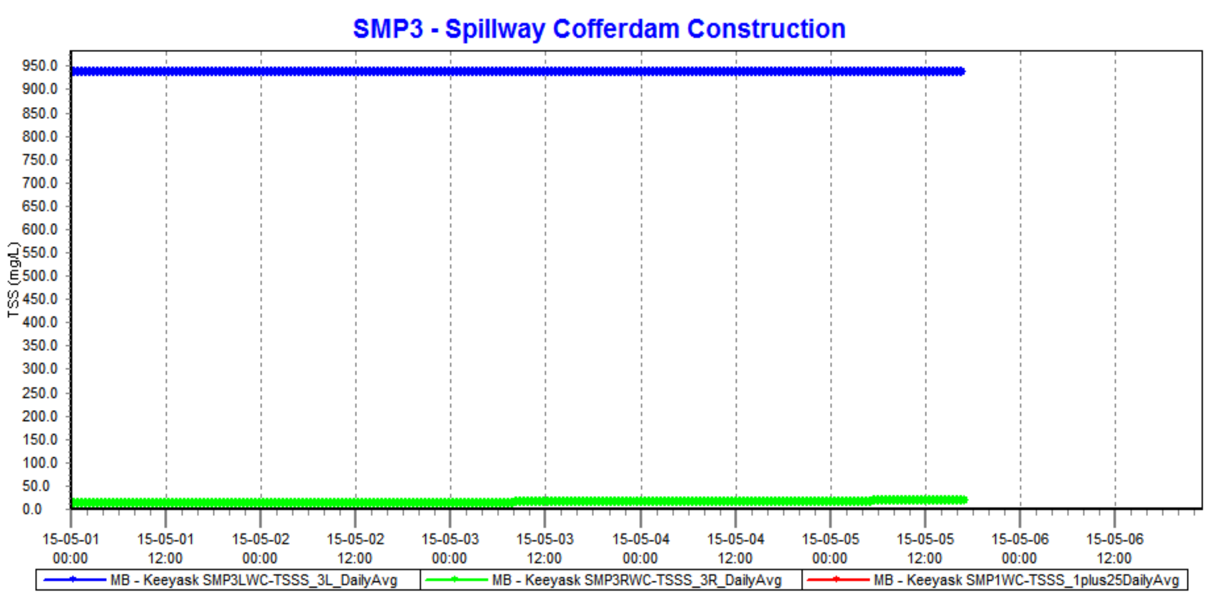


Figure 8: 24 hour moving average of TSS Values

3.3 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 9) were based on the proposed construction timeline at the time that the analyses were performed. The proposed schedule showed the stage 1 spillway and central dam cofferdams being constructed from mid-July to mid-October in the second summer of construction.

The inner and outer rock groins for the Spillway Cofferdam were actually constructed in winter, from February 27 to May 6, 2015. The Spillway Cofferdam was completed in summer by placement of finer Class A & B material between the two rock groins from June 9 to August 24, 2015: however, this was not classified as in stream work. The predictions of construction effects on TSS did not consider rock groin construction in the winter.

The Central Dam Cofferdam was partially constructed 2014 when the inner rock groin was put in place. In 2015, the cofferdam was completed by placing the outer rock groin across the centre channel (July 16 to August 6, 2015) and then placing impervious Class A & B material between the inner and outer rock groins (August 25 to September 13, 2015). Placement of the impervious material was not considered an in stream work activity.

3.3.1 PREDICTED CONSTRUCTION EFFECTS

Several numerical and empirical modeling methods were used to predict increases in downstream TSS concentrations during construction. Due to the analytical methods employed, the analyses assumed that sediment entering the river was fully mixed within the river flow and did not predict the larger local increases that would occur immediately adjacent to the work and within the mixing zone. Effects would be greatest near the source and diminish downstream as mixing occurs. For the in-stream work completed in 2015/16 the effects of construction on downstream TSS were predicted to be:

- Short duration increase of about 8 mg/L during Spillway Cofferdam construction but increases generally varying from about 2-4 mg/L during spillway and central dam cofferdam construction.

The actual construction does not match the conditions assumed in the pre-construction analyses performed to estimate the potential effects of construction. The assessment assumed the spillway cofferdams would be constructed in summer when there would be no influences on sediment in the river due to ice effects, which would occur even without the Project. Additionally, the analysis assumed the Central Dam Cofferdam would be a single rock groin with an impervious cover on the side facing the river, which would be expose the fine material to flowing water during placement. Actual construction involved the use of double rock groins so the impervious fill placed between two was never directly exposed to the flow of the river. This is an improvement as it avoided the placement of fine material within flowing water, effectively eliminating the potential entrainment of fine sediment in the river.

3.3.2 OBSERVED CONSTRUCTION EFFECTS

Using the 15 minute averaged data collected at the three SMP monitoring sites, comparisons were made between the calculated TSS levels upstream and downstream of the project site. For each sensor, the 24-hour moving average TSS was calculated based on the 15-minute data. The average TSS at each SMP location was then calculated by averaging the TSS values from the sensors at each site. Calculations were largely done using the raw turbidity data, however some data that were obviously erroneous such as very high readings due to vegetation or ice interference were excluded as they would unreasonably influence the results.

During construction of the spillway rock groins in the winter, the in stream suspended sediment concentrations were monitored at the upstream SMP-1 site and at the left and right SMP-3 locations downstream in Stephens Lake. The SMP-2 site could not be monitored due to unsafe ice conditions. The recorded data from the SMP-3L sensor (SMP-3 left sensor) was not considered as the entire record shows undue influence from ice interference. Although SMP-3 is well downstream of Gull Rapids, it is still influenced by frazil and slush ice originating upstream and transported by the flow under the lake's surface ice cover. The SMP-1 record starts prior to the beginning of in stream work but ends about 3 weeks before the end of construction. The SMP-3R data record covers the entire period of in stream work.

The winter monitoring results show a TSS variation from about 4-8 mg/L at SMP-1 while SMP-3R varied over a much larger range of about 4-22 mg/L (Figure 10). Values at SMP-3R were generally 5-10 mg/L higher than at SMP-1 and may have been up to 15-18 mg/L higher. The results however show that concentrations at SMP-3R were consistently about 5 mg/L higher than SMP-1 even before in stream work began. This could be due to high flows combined with water level staging on erodible shorelines just below Gull Rapids caused by a large ice dam at the entrance to Stephens Lake. It is likely that erosion of shorelines was occurring due to the flow and ice conditions in 2015 because downstream shoreline erosion during winter was observed prior to construction (KHLP 2012). Additionally, given the influence of ice on the SMP-3L sensor, the SMP-3R sensor is very likely to have been affected by ice at times as well. Due to confounding factors of ice interference and shore erosion unrelated to the project, it is not reasonably possible to determine if or how much the project may have affected TSS between SMP-1 and SMP-3R, though it seems likely that any effect was not more than an 8 mg/L increase.

The summer monitoring results show an overall TSS variation between about 10-20 mg/L, with higher TSS of about 15-20 mg/L occurring in July to mid August and lower levels of about 10-15 mg/L from mid August to mid October. During periods with and without construction, primarily in July, the SMP-2 data show a number of short duration increases of several milligrams per liter. These are likely due to the fouling of the bottom turbidity sensors, which causes elevated readings and increases the average TSS from the four sensors at this location. Aside from some of these peaks, the calculated average TSS concentrations at both SMP-2 and SMP-3 are typically within about +/-1.5 mg/L of the concentration at SMP-1. This is a negligible difference between the upstream and downstream sites and suggests there is essentially no change in TSS between them. Additionally, the patterns of TSS deviation between the three sites during the period of in stream construction is not discernibly different in the period with and without in stream work, suggesting no clear effects due to construction.

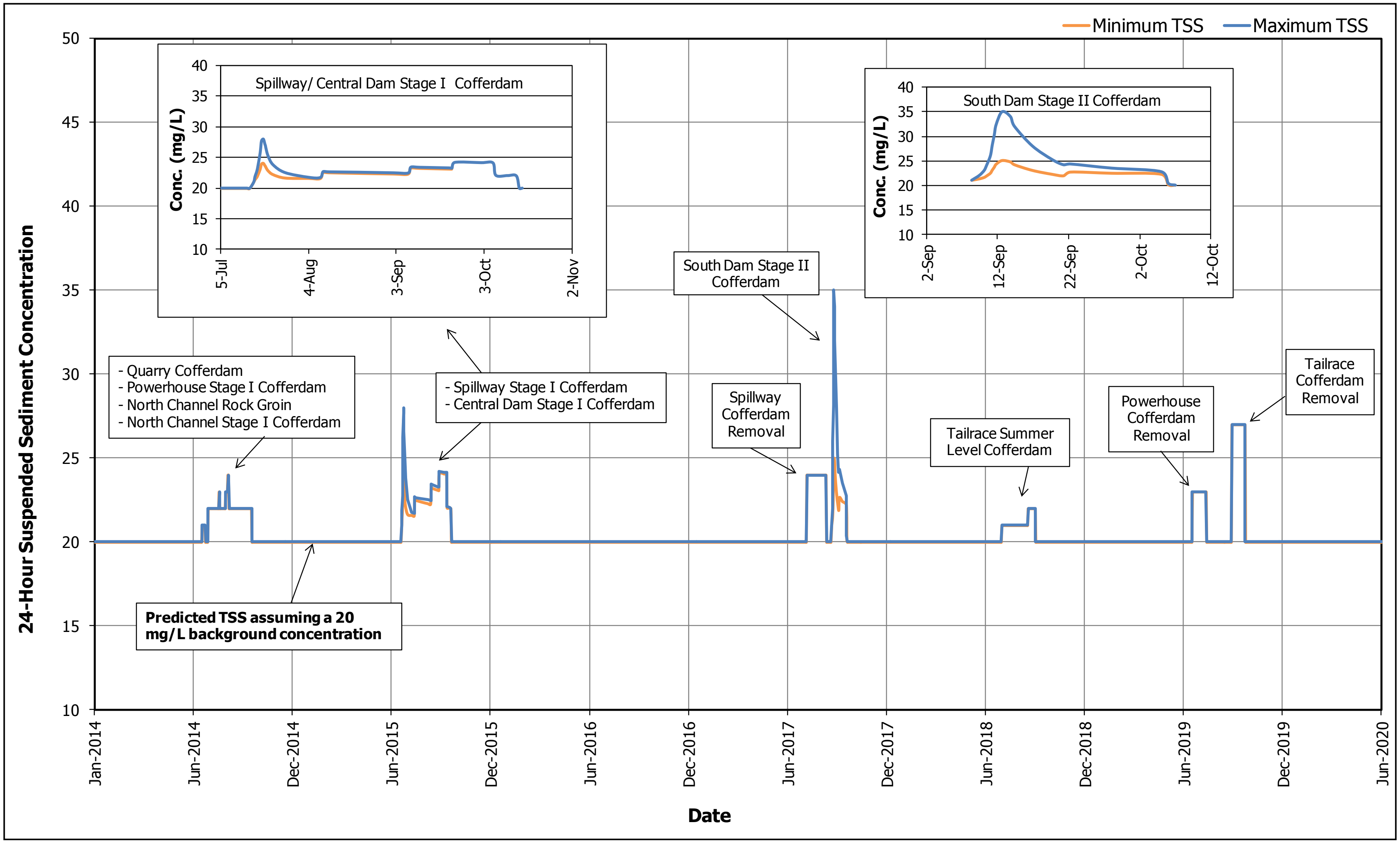


Figure 9: Fully Mixed 24-Hour Average TSS Concentration Predicted in the Proximity of Site SMP2 (mixing zone) During Construction of the Keeyask GS

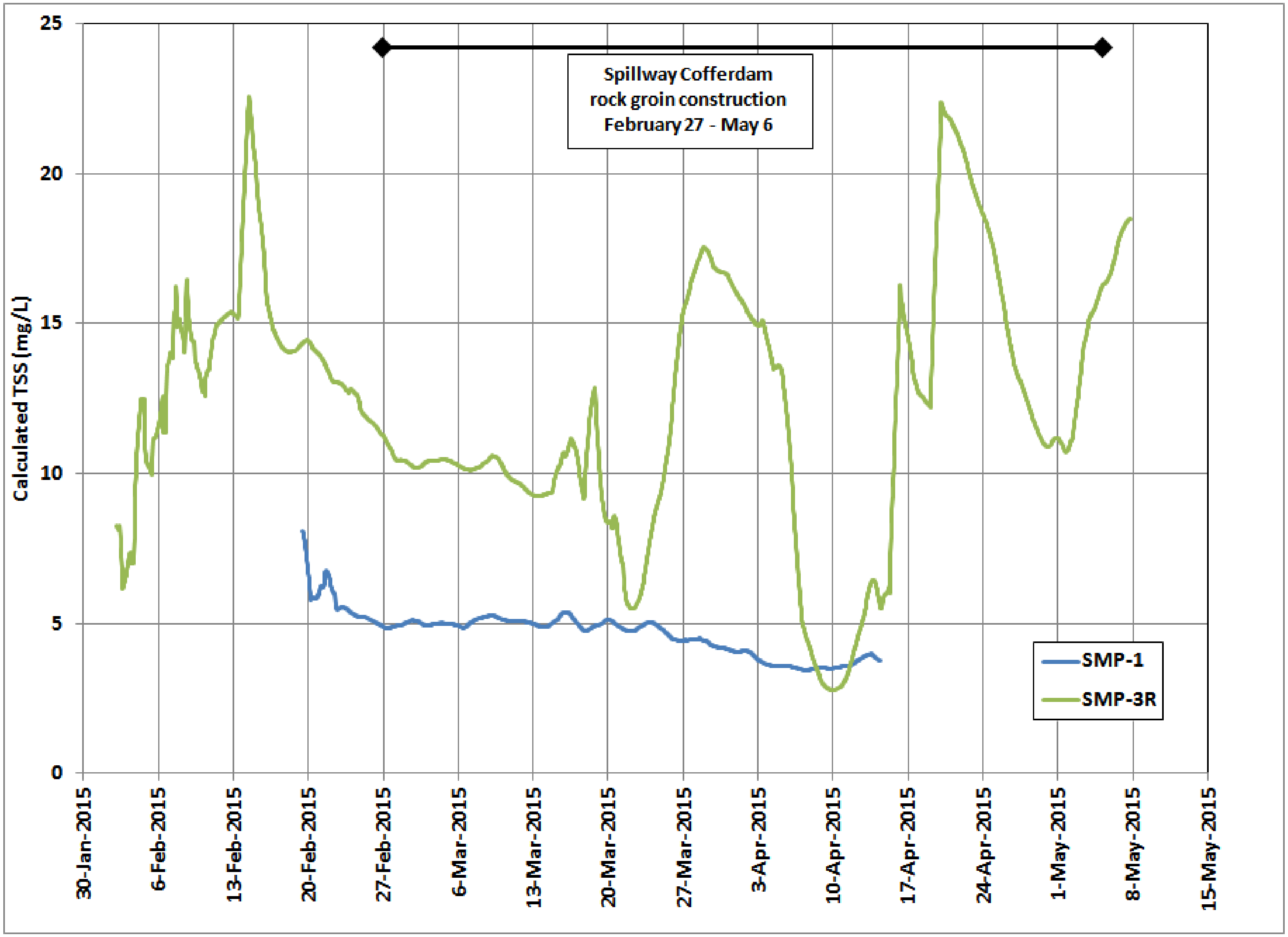


Figure 10: Figure 19: 24-Hour Moving Average TSS Concentration during Spillway Rock Groin Construction

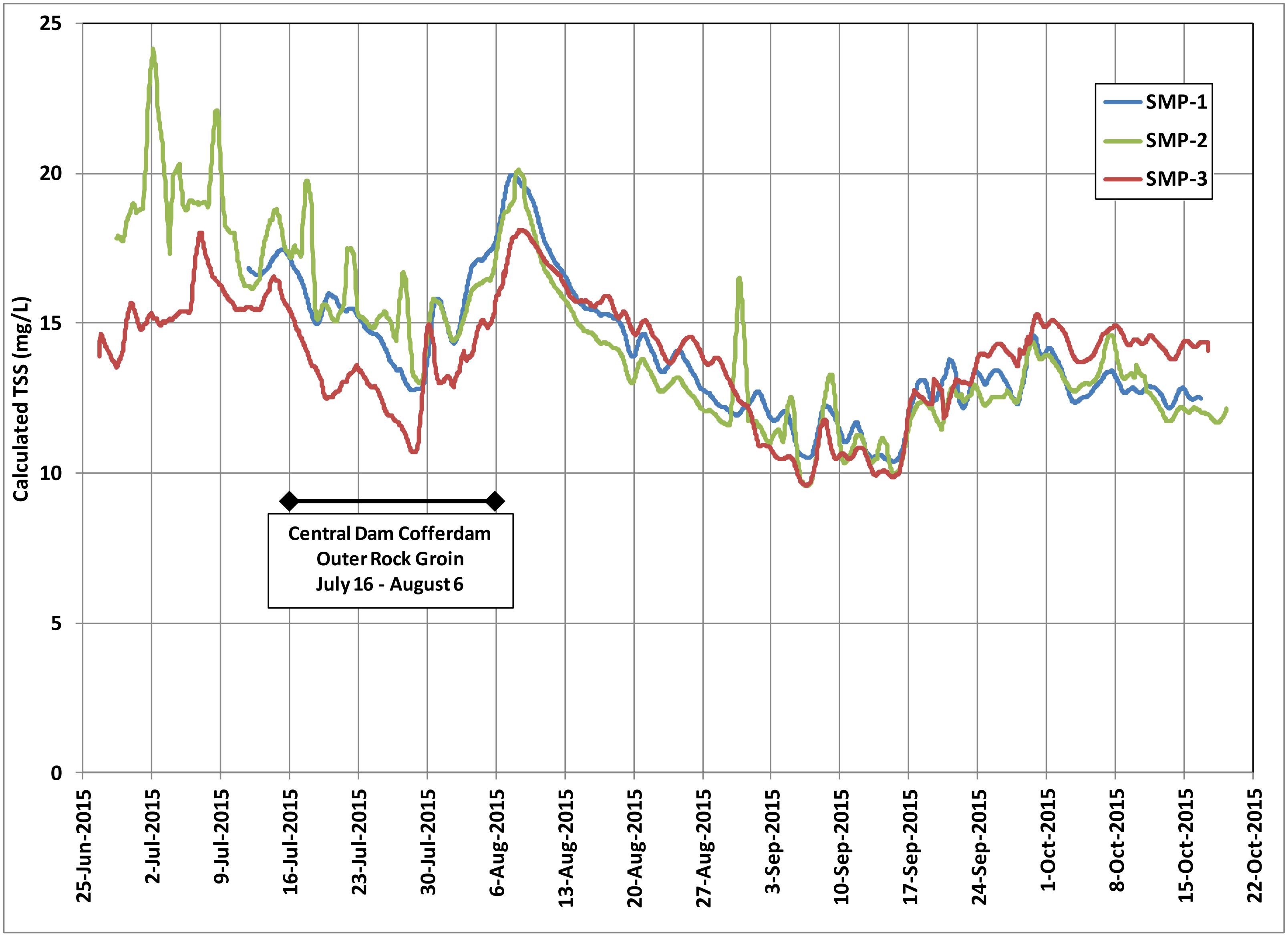


Figure 11: 24-Hour Moving Average TSS Concentration in Summer 2015

4.0 CONCLUSION

During the SMP monitoring period (May 2015 to April 2016) 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, slush ice interference on the sensors or from maintenance activities that took place during the monitoring period.

Less construction actually occurred in summer 2015 than was anticipated when effects predictions were made for the Keeyask EIS (Keeyask 2012) because some work took place sooner. Also, construction methods were different than previously assumed, and the methods employed (i.e., placing fines between two rock groins) substantially reduced the potential for sediment entrainment in the river. Overall, the 2015 summer monitoring results do not indicate any apparent impact of construction on downstream TSS concentrations.

5.0 LITERATURE CITED

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