Keeyask Generation Project

PRELIMINARY DRAFT

In-stream Construction Sediment Management Plan

KEEYASK
Hydropower Limited Partnership

April 2013

KEEYASK GENERATION PROJECT
SEDIMENT MANAGEMENT PLAN
FOR IN-STREAM CONSTRUCTION

DRAFT

Prepared by

Keeyask Hydropower Limited Partnership

Winnipeg, Manitoba

April 2013

Canadian Environmental Assessment

Registry Reference Number: 11-03-64144

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ABBREVIATIONS

DFO	Department of Fisheries and Oceans
EnvPP	Environmental Protection Plan
GS	Generating Station
KHLP	Keeyask Hydropower Limited Partnership
m	Meter
mg/L	milligrams per liter
NTU	Nephelometric Turbidity Units
SMP	Sediment Management Plan
TSS	Total Suspended Solids
Tu	Turbidity

1.0 INTRODUCTION

[Drafting Note: The Keeyask Hydropower Limited Partnership (KHLP) submitted a draft of the Sediment Management Plan for In-Stream Construction (SMP) to the regulators (Canadian Environmental Assessment Agency; Health Canada; Fisheries and Oceans Canada; Environment Canada; Manitoba Conservation and Water Stewardship; Manitoba Aboriginal and Northern Affairs; Natural Resources Canada) on October 30, 2012 to assist in their review of the Keeyask Generation Project EIS. The KHLP subsequently met with these regulators several times to discuss their questions about the draft SMP after their review. Based on their input the KHLP has committed to making revisions to the draft SMP. However, it is recognized that the public has an interest in also reviewing this document and so a decision was made to share the version provided to the regulators as part of the Information Request responses while these revisions are being made. This version of the document includes editorial notes explaining where and how revisions based on regulatory input will be made. . The KHLP also notes that the SMP will not be finalized until all regulatory processes for the Keeyask Generation Project have been completed.]

1.1 PURPOSE

This Sediment Management Plan (SMP) is developed for the construction phase of the Keeyask Generation Project (the Project). It has been developed to minimize the impacts of in-stream sediment from construction activities in the Nelson River. It outlines 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 introduction of excessive amounts of sediment load could change the water quality and be harmful to fish and fish habitat. The SMP is a fundamental component of the Project's overall Environmental Protection Plan (EnvPP).

This SMP describes the works that may cause increases to TSS concentration and the method that Manitoba Hydro, on behalf of the Keeyask Hydropower Limited Partnership (KHLP), will use to oversee and manage the contractors' in-stream construction activities. Appendix A provides an overview of the mitigation measures that may be used by the contractors during in-stream work. The contractors' EnvPPs will include mitigation measures to reduce sediment inputs during in-stream construction and to control erosion and runoff from land-based activities such as road construction, borrow area development, clearing, etc. Complying with the Environmental Protection Plan and meeting the targets outlined in Section 4.1 are the contractual obligation of the contractor.

Manitoba Hydro's on-site Resident Manager will be accountable for environmental protection compliance. The Resident Manager together with the Site Environmental Officer will verify that the actual work carried out complies with the regulatory requirements, approval conditions, the *Keeyask Generation Project Generating Station Construction Environmental Protection Plan*, and this document.

1.2 PROJECT DESCRIPTION

The Project will be located on the Nelson River at Gull Rapids approximately 30 km west of Gillam, 60 km northeast of Split Lake, and 180 km northeast of Thompson, Manitoba (Figure 1). The general arrangement and supporting infrastructure of the Project are shown in Figure 2.

The principal structures of the Keeyask GS 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 Project construction sequence and river management are depicted in Figure 3, and a full description of the Project and construction sequence may be found in the Keeyask Generation Project Response to Guidelines [Ref 1] and Keeyask Generating Station River Management Design Memorandum [Ref 2].

2.0 POTENTIAL SOURCES OF SEDIMENT AND MANAGEMENT STRATEGIES

2.1 GENERAL

Various alternatives have been considered in the planning, design, scheduling of work, and proposed construction methods for the Project with the objective of reducing the amount of suspended sediment added to the Nelson River. The final design and construction methods that will be used to construct the Project will consist of best management practices, and all in-stream work will be conducted to meet the requirements of this sediment management plan. The in-stream works that may increase TSS concentrations and the mitigation strategies (primary and secondary) that are associated with these works are outlined in this section.

2.2 IN-STREAM CONSTRUCTION ACTIVITIES

Construction of the Project will require management of river flows through the construction of supporting infrastructure that includes two rock groins and 10 cofferdams (Figures 2 and 3). Cofferdams are required to isolate areas so they can be dewatered, which allows construction of principal structures to occur “in-the-dry”. There are, however, several Project components that require in-stream construction activities that are expected to result in sediment increases in the Nelson River due to erosion of river shorelines or through the introduction of fine sediment from the placement and removal of construction materials in the river. In-stream work and incidental activities that could potentially increase TSS levels are summarized in Table 1, which also indicates the type of construction, required removal and type of removal (for more detail on these items refer to the Keeyask GS Project Response to Guidelines [Ref 1]). The planned sequencing of Project phases, staging and main activities during the construction of the Project are illustrated in Figure 3.

2.3 PREDICTED SEDIMENT LOAD FROM IN-STREAM CONSTRUCTION ACTIVITIES

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. Several numerical and empirical methods were used to predict increases in TSS concentration.

Figure 5 summarizes the predicted 24-hour average TSS concentrations in the proximity of site SMP-2 (Figure 4) for all in-stream activities that would release sediment into the Nelson River during the construction of the Keeyask GS. In preparation of this figure, an existing sediment background of 20 mg/L was assumed for the Nelson River during the construction. The 20 mg/L represents the existing typical conditions of TSS on the Nelson River. This existing sediment background is selected based on the field data collected in the open water months during the years 2001 to 2007. The TSS concentration in the Keeyask area generally lies within the range of 5 to 30 mg/L [Ref 4].

The following is a summary of the predictions for TSS levels (24-hour average, unless otherwise stated) in the proximity of the monitoring site SMP-2. Site SMP-2 is located within the mixing zone downstream of the construction site.

2.3.1 Cofferdam Construction and Removal

In relation to cofferdam construction and removal, the predicted maximum increases in TSS concentrations are as follows:

- TSS concentration due to the Spillway Stage I Cofferdam construction is predicted to increase by up to approximately 8 mg/L, primarily due to anticipated shoreline erosion within Gull Rapids,
- Construction of the South Dam Stage II Upstream Cofferdam is predicted to increase TSS by up to 15 mg/L, again primarily due to shoreline erosion within Gull Rapids as the south channel of the river is closed off,
- Construction of other cofferdams is predicted to increase TSS levels by less than 5 mg/L, and
- Increases due to cofferdam removals range from approximately 3 mg/L (Powerhouse Cofferdam removal) to 7 mg/L (Tailrace Cofferdam removal).

The increase in peak sediment concentration during Stage I and Stage II cofferdam construction is predicted to occur within the first few days of the construction activity and then taper off gradually over the following weeks. The increases due to cofferdam removal are expected to be uniform during the periods of removal, which last for periods of about four weeks (Figure 5).

Table 1: Supporting Infrastructure Required for River Management

Structure	Type of Construction	Required Removal	Type of Removal
Quarry Cofferdam	mostly in-the-wet	No removal required	–
North Channel Rock Groin	mostly in-the-wet	Lowered to elev. 153.0 m*	in-the-dry & in-the-wet
North Channel Stage I Cofferdam	mostly in-the-wet	Lowered to elev. 152.5 m*	in-the-dry & in-the-wet
Powerhouse Stage I Cofferdam	in-the-dry & in-the-wet	Partial removal of eastern leg; Portion of the south leg will be incorporated into the Transmission Tower Spur.	in-the-dry
Spillway Stage I Cofferdam	in-the-dry & in-the-wet	Partial removal of approach and discharge channels	in-the-dry & in-the-wet
Central Dam Stage I Cofferdam	mostly in-the-wet	No removal required – incorporated into the central dam	–
Central Dam Rock Groin	mostly in-the-wet	No removal required	–
Stage I Island Cofferdam	in-the-dry	Lowered to elev. 152.0 m*	mostly in the dry
Tailrace Summer Level Cofferdam	mostly in-the-wet	Complete removal to riverbed	in-the-dry & in-the-wet
South Dam Stage II Upstream Cofferdam	mostly in-the-wet	No removal required – incorporated into the south dam	–
South Dam Stage II Downstream Cofferdam	mostly in-the-wet	No removal required – incorporated into the south dam	–
Stage II Island Cofferdam	in-the-dry	Lowered to elev. 151.0 m*	in-the-dry

* Studies are ongoing to determine the extent to which these structures will be removed.

2.3.2 First Flows Through Spillway and Powerhouse

Based on the TSS assessments and Manitoba Hydro's recent experience during the construction of the Wuskwatim GS, the maximum increases in TSS are expected to occur when water is first passed through the Spillway and the Powerhouse, which activities do not occur at the same time. The maximum increases in TSS are predicted to occur when water is first passed through the Spillway. For a scenario with all seven Spillway bays each open 1 m (worst case scenario), the downstream instantaneous TSS in the proximity of site SMP-2 is predicted to increase sharply to a maximum peak of up to 250 mg/L and then drop rapidly, with elevated TSS persisting for about 25 minutes. Subsequent increases in flow through the Spillway bays (with gates open more than 1 m) would result in sharp peaks that rapidly attenuate. It is predicted that each subsequent peak will be progressively lower in magnitude. The increase in daily average TSS is predicted to range between 1 and 25 mg/L (Figure 5) for scenarios with one Spillway bay open 1 m and seven Spillway bays each open 1 m, respectively [Ref 3]. It should be noted that the opening seven Spillway bays was modeled to gain an understanding of the potential sediment load for the worst case scenario, but it does not represent how the Spillway will be commissioned. During the first flow through the Spillway, the Spillway gates will be actively managed to control and maintain the TSS level within the limits described in Section 4.

During the testing of the Powerhouse units, the TSS level is predicted to increase by 41 mg/L at the initial start-up of Unit 1 (5-minute average TSS level). The TSS concentrations are predicted to decrease with each subsequent incremental increase of flow through this unit. Less effect on TSS level is expected when testing the subsequent Powerhouse's units. The predicted increase in daily average TSS is predicted to be less than 1 mg/L (Figure 5) during the testing of the Powerhouse units [Ref 3].

2.4 PRIMARY MITIGATION STRATEGIES

Primary mitigation strategies were reviewed and incorporated into the preliminary design, and these will be utilized to reduce potential sediment releases during in-stream construction. They have been determined based on Project site characteristics and the construction activities taking place and include the following:

- managing the river to direct flows away from in-stream construction works, where possible;
- constructing the cofferdams with cross-sections that have the least potential for erosion;
- incorporating measures, such as deflector groins, to reduce flow velocities across the face of cofferdams where and when required;
- carefully controlling in-stream work to minimize riverbank and bed disturbance;
- working in-the-dry, where possible; and
- developing construction sequences that will provide tranquil water areas, where possible, for placement of granular and impervious fill for the cofferdams.

A summary of the preliminary primary mitigation strategies for the in-stream construction activities associated with the Project components are presented in Appendix A.

2.5 SECONDARY MITIGATION STRATEGIES

Sedimentation estimates are based on engineering judgment, numerical and empirical modeling results, and best construction practices and are considered as worst case scenarios. Uncertainties exist in prediction of shoreline sediment that may be eroded and the amount of fine material that may be washed away from the impervious fill, granular transition fill, and rockfill during cofferdam placement/removal in-the-wet. Due to these uncertainties, secondary mitigation strategies have been developed for in-stream construction activities to further mitigate sediment releases into the watercourse, should the need arise.

The secondary mitigation strategies developed for the Keeyask GS that could be implemented if required consist of slowing down or temporarily stopping the construction activities to reduce the rate of sediment entrainment in the water, which would reduce TSS concentrations. In addition, stockpiles of rockfill materials may be placed strategically around the site for use as secondary mitigation measures. These materials could be used as riprap for shoreline armoring or constructing deflector groins, if required. The selection of the most practical secondary mitigation strategy will depend on the type of site characteristics, construction activity, when and where erosion is occurring, and the local water conditions in the area of the activity.

3.0 SEDIMENT REAL-TIME MONITORING PROGRAM

A detailed in-stream real-time TSS monitoring program will be implemented by the Manitoba Hydro construction management team throughout the course of construction to monitor the magnitude, spatial, and temporal changes in TSS increases in the Nelson River during in-stream construction activities. The monitoring program design is based on the modeling of construction effects on the sedimentation regime in the river, and recent experience by Manitoba Hydro on other hydroelectric construction projects. Overall, the design is based on an upstream and downstream approach to capture effects in the initial mixing zone as well as the effects downstream in the fully mixed area.

The construction management team will include a Site Environmental Officer position whose role includes facilitating environmental compliance, as well as overseeing the sediment monitoring program. The Site Environmental Officer will also be integral in implementing the *Adaptive Action Plan* and the *Spillway and Powerhouse Commissioning Management Plan,* described later in this document, should TSS concentration increases exceed the water quality target levels identified in Section 4.1 of this document.

3.1 OBJECTIVES

The sediment monitoring program is intended to document the spatial and temporal characteristics of TSS and the magnitude of the increases in the Nelson River during in-stream construction activities. In addition, the program has been designed to facilitate responses to pre-determined action levels described in Section 4.1.

3.2 MONITORING PARAMETERS

The main parameter being monitored is TSS; however, TSS cannot be measured in real time but must be determined in a laboratory using a sample of the river water. Turbidity (Tu) will be measured as a surrogate using automated turbidity loggers that can measure and report turbidity on a real time basis. The following relationship between TSS and Tu has been developed by Manitoba Hydro to facilitate the use of turbidity as a surrogate of TSS (Figure 6).

$$\text{TSS (mg/L)} = 0.79 * \text{Tu (NTU)} - 2.86$$

This relationship was develop utilizing turbidity data (collected by YSI sensors) and water samples collected at a depth of 2 m in the Nelson River during both open water and ice-covered seasons between 2007 and 2009 at various monitoring sites located from the exit of Clark Lake to upstream of the Kettle GS [Ref 5].

Using real time, in-situ turbidity measurements, the real time TSS concentrations at monitoring sites will be estimated during construction. The Site Environmental Officer can then determine if in-stream construction activities are causing TSS increases that exceed specific action thresholds so that corrective actions can be implemented in a timely manner.

During in-stream work, samples of water at the monitoring stations will be periodically collected and analyzed for TSS to confirm or adjust the Tu-TSS relationship, as required.

3.3 MONITORING LOCATIONS

Project activities that may affect TSS are located in the vicinity of Gull Rapids. TSS and turbidity will be monitored through deployment of *in-situ* turbidity loggers at three transect locations as shown in Figure 4 and described as follows:

- SMP-1 will be located upstream of all construction activities in the centre of the river channel to monitor ongoing background conditions.
- SMP-2 will be located approximately 1.5 km downstream of all in-stream sediment sources from the Project and is a near-field location within the mixing zone prior to fully mixed conditions. [Drafting Note: SMP-2 will be located approximately 1.5 km downstream of the future powerhouse, or approximately 0.7 km to 3 km downstream of sediment sources from the Project due to in-stream construction depending on which structure is being constructed. This is a near-field location within the mixing zone prior to fully mixed conditions. Loggers will be installed at two sites (SMP-2L and SMP-2R) located evenly across the channel width to monitor for sediment plumes that may be located closer to one shoreline]
- SMP-3 will be located approximately 9 km downstream of the construction site in the fully mixed zone of the primary flow channel along the thalweg (deepest part) of the river. This location was chosen because the majority of the flow will pass through this south channel and it will be where any increases in TSS are most likely to be observed within the fully mixed zone. Loggers will be installed at two sites (SMP-3L and SMP-3R) located across the width of the south channel of the river to monitor for sediment plumes that may travel along the thalweg of the channel.

The loggers will be installed approximately 2 m above the riverbed and 2 m below the water surface. Loggers have been considered at multiple depths in case TSS concentrations vary through the water column.

The monitoring locations are consistent with the baseline monitoring sites that were used in the Keeyask GS 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 consideration of factors such as safety of personnel and equipment, accessibility, and ambient conditions (e.g., high river flow or water velocity, unsafe ice).

3.4 MONITORING METHODOLOGY

Real-time turbidity data from the in-situ YSI turbidity loggers installed at monitoring sites will be remotely transmitted to a central computer at the construction site at a pre-determined interval (every 15 minutes) so monitoring results can be evaluated as soon as possible.

The computer program will automatically convert the turbidity reading into a TSS reading using the Tu-TSS relationship presented in Section 3.2. The TSS change between SMP-1 and SMP-2 will be determined by comparing the baseline TSS calculated at SMP-1 with the calculated TSS at SMP-2. The increases in TSS concentration at SMP-3 will be calculated the same way, except it will be converted into a 24-hour rolling average. The information will be displayed graphically so it can be easily seen of measurements meet or exceed the target levels at SMP-2 and SMP-3.

The schedule for checking measurements from the SMP sites to assess construction effects will depend on the specific construction activities occurring at a particular time. When in-stream work is occurring, the data from the SMP sites will be monitored continuously so that corrective actions can be taken as soon as possible should the TSS target levels be exceeded. Depending on the activity taking place and the presence or absence of an effect, the need for continuous monitoring of incoming data can be evaluated and potentially reduced to regular verification of monitoring data (e.g., hourly). To confirm that high TSS conditions are recorded and assessed, the monitoring system will include an automated messaging system that will notify the Site Environment Officer of high TSS conditions that may require a corrective action.

[Drafting Note: Methods are being developed to confirm that site SMP-2 (left and right) is able to detect changes in TSS concentrations due to in-stream construction activities. A potential method being explored is to augment the in-situ data loggers with additional manual readings.]

In-situ turbidity logger data will be supplemented through manual monitoring of turbidity using handheld loggers and collecting water samples. At each location, water samples will also be collected for analysis of TSS to confirm or improve the Tu-TSS relationship. Manual sampling will consist of the collection of turbidity measurements and water sampling at near surface, mid-depth, and near-bottom depths in the water column along a river cross section in the vicinity of the turbidity loggers (SMP sites). It should be noted that manual samples will be collected only if it is safe to do.

Visual inspections will be conducted in the immediate vicinity of the construction activities during major construction events to document activities that may cause large, obvious increases in TSS in order to supplement real-time monitoring.

3.4.1 Winter Monitoring

[Drafting Note: Methods for fall, winter and spring monitoring are currently under development and are being discussed with regulators. Details will be added to a future draft of this SMP.]

3.4.2 Biofouling Effect and Loggers Maintenance

The YSI turbidity loggers that will be used for the Project are equipped with self-cleaning optical sensors with integrated wipers to remove biofouling and maintain high data accuracy. However, the loggers will be visited every two weeks to maintain and clean the monitoring system (and free them of algae and vegetation debris) to avoid erratic spikes in data.

[Drafting Note: At the request of the regulators, this section will be revised to include additional maintenance and manual sampling to determine if there are problems with loggers such as biofouling and reporting of the data and outcomes to the regulators.]

4.0 ADAPTIVE ACTION PLANS

4.1 TARGET LEVELS

Management of TSS levels during construction will incorporate two action levels measured in the mixing zone at SMP-2:

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

Both proposed action levels (i.e., 25 mg/L and 200 mg/L above background) are below acutely lethal thresholds of suspended sediment for freshwater fish, which range from the hundreds to hundreds of thousands mg/L [Ref 6]. Exceedence of these action levels will initiate an action plan to identify the source of the TSS and secondary mitigation strategies for unanticipated events and/or a modification to the Spillway and Powerhouse commissioning procedures.

4.2 ADAPTIVE ACTION PLAN FOR UNANTICIPATED EVENTS

The *Adaptive Action Plan* for responding to TSS levels will be implemented as soon as possible in response to these results as follows:

When the displayed TSS output is less than 25 mg/L above background at SMP-2 and SMP-3 results will continue to be monitored and no action will be taken.

When the TSS at SMP-2 is equal to or greater than 25 mg/L above background for four consecutive, 15-minute averaged readings, but less than 200 mg/L, the Resident Manager and Site Environmental Officer will:

a. Confirm the results are accurate (i.e. rule out logger malfunction);

b. If possible, take a handheld turbidity reading to confirm the result;

c. Take Action, which includes investigating to try and identify the activity resulting in the recorded TSS increase and if it is still underway, implement mitigation, if possible. Mitigation may include advising the contractor of the need to modify work activities, such as (but not limited to):

    - Temporary suspension of work activity,
    - Modifying the rate of material placement or removal,
    - Modifying the sequence of material placement or removal,
    - Installing additional erosion and sediment control measures,

- Verifying the quality of the material being used is appropriate, and
- Temporarily moving to a new work area,

d. Record the event in the daily report.

When the TSS at SMP-2 is equal to or greater than 200 mg/L above background (one 15-minute average reading) the Resident Engineer and Site Environmental Officer will:

a. Ensure the results are accurate (i.e. rule out logger malfunction);

b. If possible, take a handheld turbidity reading to confirm the result;

c. Discuss the exceedence with the Resident Manager;

d. Take Action, which in this case should be carried out by the Resident Manager after he/she evaluates whether the construction activity that resulted in high TSS is still underway. If so, the following measures may be required of the contractor;

- Temporary work stoppage,
- Installation of sediment containment, and
- Other modifications to construction practices.

e. Notify Fisheries and Oceans Canada (DFO); and

f. Record the event in the daily report.

When the TSS at SMP-3 is equal to or greater than 25 mg/L above background (measured as a 24-hour rolling average) the Resident Manager and Site Environmental Officer will:

a. Ensure the results are accurate (i.e. rule out logger malfunction);

b. Discuss the exceedence with the Resident Manager ;

c. Take Action, which includes investigating to try and identify the activity resulting in the recorded TSS increase and if it is still underway, mitigation may need to be implemented. This may include advising the contractor of the need to modify work activities, such as (but not limited to);

- Temporary suspension of work activity,
- Modifying the rate of material placement or removal,
- Modifying the sequence of material placement or removal,
- Installing additional erosion and sediment control measures,
- Verifying the quality of the material being used is appropriate, and
- Temporarily moving to a new work area, and

d. Record the event in the daily report;

If the exceedance at SMP-3 continues for 3 days in a row, the Resident Manager and Site Environmental Officer will:

a. Take further action, which in this case should be carried out by the Resident Manager . The following measures may be required of the contractor;

- Temporary work stoppage,
- Installation of sediment containment

b. Notify DFO.

4.3 SPILLWAY AND POWERHOUSE COMMISSIONING MANAGEMENT PLAN

Once the principle structures area complete, commissioning of the Spillways and the Powerhouse are activities that have the potential to cause excess sediment to be transported downstream. When water first passes through the powerhouse, intake channel, tailrace channel, spillway, spillway approach channel and spillway discharge channel, it will flow over residual materials that will have been left behind on the river bottom after the cofferdams are removed. Although every effort will be taken to remove residual material, inevitably some will be left behind and some will get flushed downstream when water first passes through these structures. To allow a gradual flush of this material, the following steps will be taken for commissioning of these structures.

4.3.1 Spillway

- When the spillway gates are first used near the end of Stage I Diversion, the gates will be opened slowly, one at a time, in small increments to prevent a large concentration of sediment from being washed downstream;
- Gate opening activities will be closely monitored using the real-time sediment monitoring information to prevent exceedences of target levels;
- Systematic opening and closing of the gates will be undertaken to prevent exceedence of target levels; and
- The staged approach to gate opening will continue until real-time output clearly illustrates there is no excess sediment being generated.

4.3.2 Powerhouse

- Powerhouse units will be tested one at a time. Each turbine will be operated at speed-no-load for around 4 to 6 hours with the flow through the unit estimated to be approximately 233 m^3/s.
- Following the completion of initial testing, the units will be stepped up to the rated flow capacity for each unit (approximately 571 m^3/s) over a period of 1 or 2 days, with the flow through the unit being increased by approximately 15 m^3/s per hour.

- Monitoring of the TSS generated from the testing of the units will continue until the real-time output clearly illustrates there is no excess sediment being generated.

This procedure is a technical requirement for testing of the Powerhouse units, which also prevents large concentrations of sediment from being washed downstream.

5.0 REPORTING

For each day there is in-stream construction activity, a report on the monitoring results will be prepared and submitted daily to DFO one to two days after the Sediment Monitoring Program results are collected and analyzed. The report will contain the following types of information:

- A brief statement of major construction activities taking place that day;
- Any construction issues that arose that may have impacted TSS in the river;
- Any exceedence of target levels;
- A brief description of the incident that led to the exceedence (if known);
- Adaptive management carried out to correct the exceedence; and
- Data for the 24-hour result period and time stamped photographs of the day of construction activities, any incidents, and corrective action taken.

Annual summary reports of the SMP activities will also be prepared for submission to both DFO and Manitoba Conservation and Water Stewardship.

6.0 REFERENCES

Keeyask Hydropower Limited Partnership. 2012. Keeyask Generation Project Environmental Impact Statement: Response to EIS Guidelines, Winnipeg, Manitoba. June 2012..

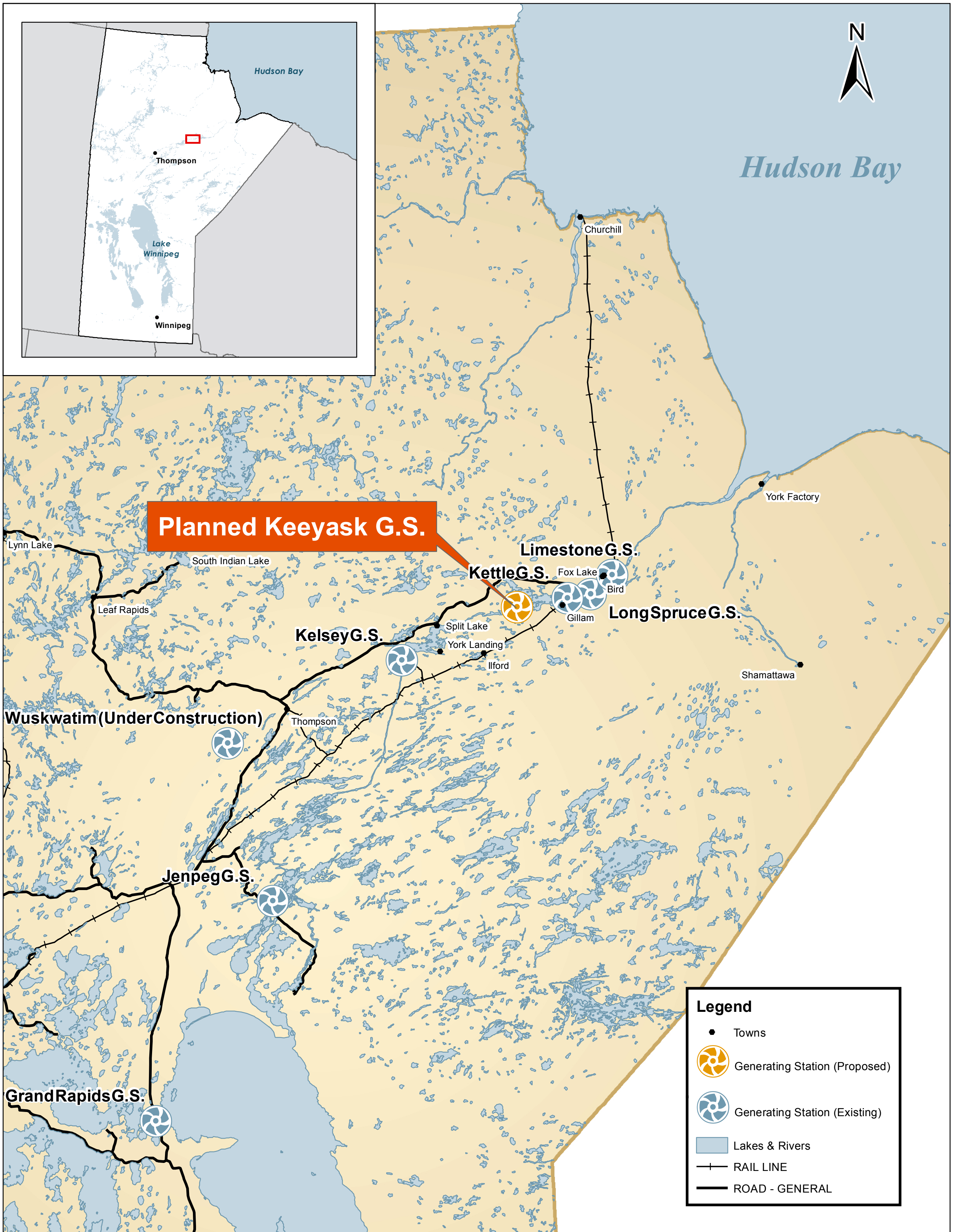
KGS Acres Ltd., Memorandum GN-2.8 Revision 1 “Keeyask Generating Station – Stage IV Studies, River Management during Construction”, Manitoba Hydro File 00195-10420-0002_04, March 2012.

KGS Acres Ltd., Memorandum GN-2.17 Revision 1 “Keeyask Generating Station – Stage IV Studies, Cofferdam Erosion during Construction”, Manitoba Hydro File 00195-11100-0191_02, April 2012.

KGS Acres Ltd., Memorandum GN 9.2.3 Revision 0 “Keeyask Generating Station – Stage IV Studies, Existing Environment Sedimentation” Manitoba Hydro File 00195-11100-0154_03, June 2011.

KGS Acres Ltd., Memorandum GN-9.2.16 “Keeyask Generating Station – Stage IV Studies, Relationship of Total Suspended Solids and Turbidity in a Laboratory in the Lower Nelson River Near the Proposed Keeyask Generating Station”, Manitoba Hydro File 00195-11100-0207_01, March 2012.

Department of Fisheries and Oceans Canada. Effects of Sediment on Fish and Their Habitat. DFO Pacific Region Habitat Status Report 2000/01.

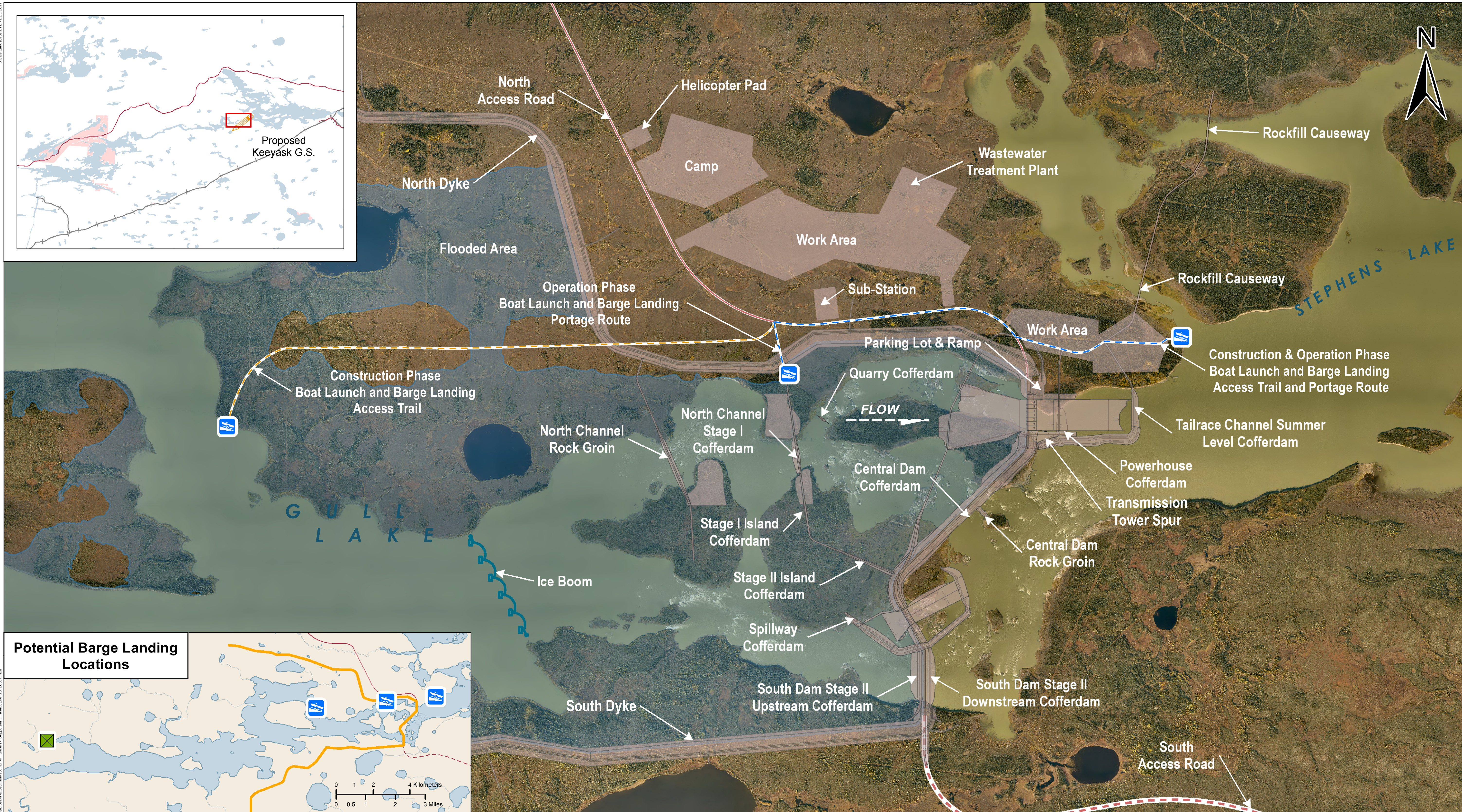


KEEYASK Hydropower Limited Partnership

DATA SOURCE: Manitoba Hydro; Government of Manitoba; Government of Canada			
CREATED BY: Manitoba Hydro - Hydro Power Planning - GIS & Special Studies			
COORDINATE SYSTEM: UTM NAD 1983 Z15N		DATE CREATED: 31 MAY 12	REVISION DATE: 05-SEP-12
0 25 50 Kilometers 0 10 20 Miles		VERSION NO: 1.0	QA/QC: XXX/YYY/ZZZ

Site Location

Figure 1



KEEYASK
Hydropower Limited Partnership

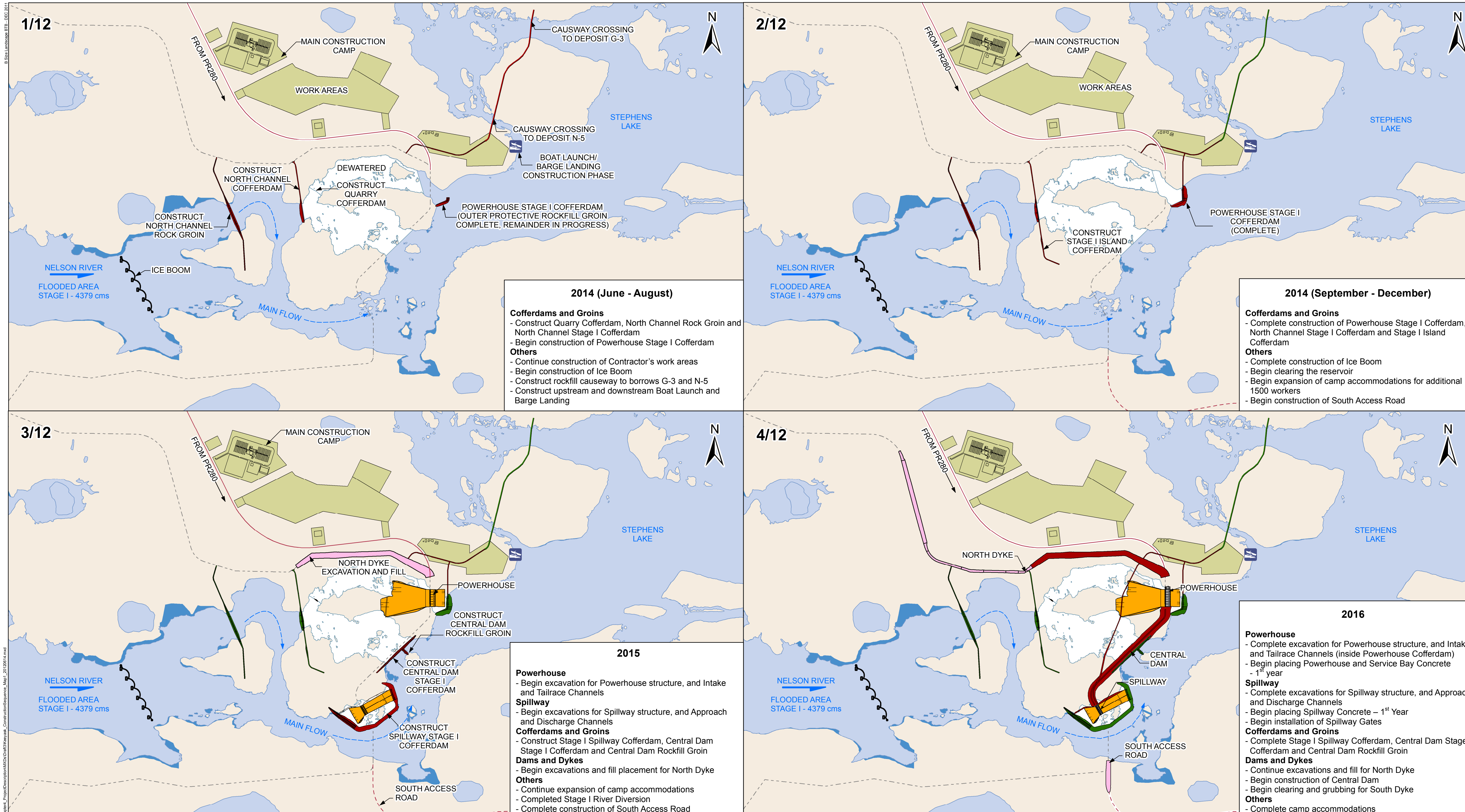
DATA SOURCE: Manitoba Hydro; Government of Manitoba; Government of Canada; KGSA; Manitoba Hydro 2010 10cm Color DOI	
CREATED BY: Manitoba Hydro - Hydro Power Planning - GIS & Special Studies	
COORDINATE SYSTEM: UTM NAD 1983 Z15N	**DATE CREATED:** 03-AUG-11 / **REVISION DATE:** 05-SEP-12
0 0.25 0.5 Kilometres / 0 0.2 0.4 Miles	**VERSION NO:** 2.0 / **QA/QC:** JCL/MES/MWZ

Legend

- Initial Flooded Area (Forebay Level = 159 m)
- Infrastructure
- Proposed Access Road
- Access Road
- Boat Launch (Barge Landing)
- Portage Route
- Boat Launch Access Trail
- Potential Barge Landing Location

Supporting Infrastructure

Figure 2



Construction Sequence
Years 2014 to 2016

KEEYASK Hydropower Limited Partnership

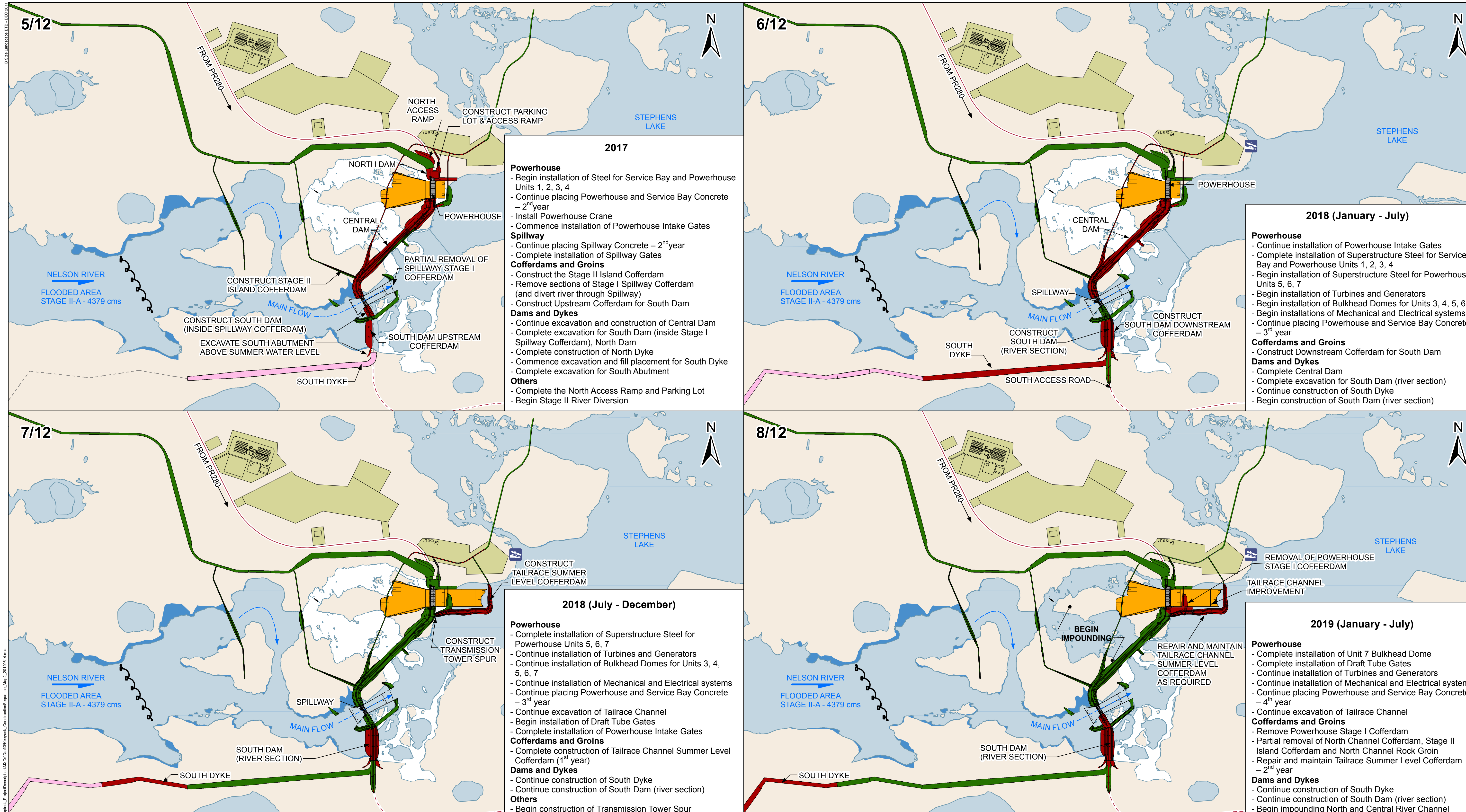
Legend

- Planned/Removed Feature
- Proposed Access Road
- Access Road
- Work Area and Construction Camp
- Structure in Progress
- Earthfill Structure (Complete)
- Excavation Area
- Bedrock Excavation Area
- Concrete/Steel Structure
- Boat Launch & Barge Landing
- Existing Water Surface Area
- Stage I Flooded Area
- Potential Dewatered Area

DATA SOURCE:
Manitoba Hydro, KGS Acres, Government of Manitoba

CREATED BY:
Manitoba Hydro - Hydro Power Planning Department

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	14-FEB-12	14-JUN-12
0 0.5 1 Kilometres / 0 0.4 0.8 Miles	VERSION NO: 3.0	QA/QC: JCL/MES/ZZZ



KEEYASK Hydropower Limited Partnership

DATA SOURCE:
Manitoba Hydro, KGS Acres, Government of Manitoba

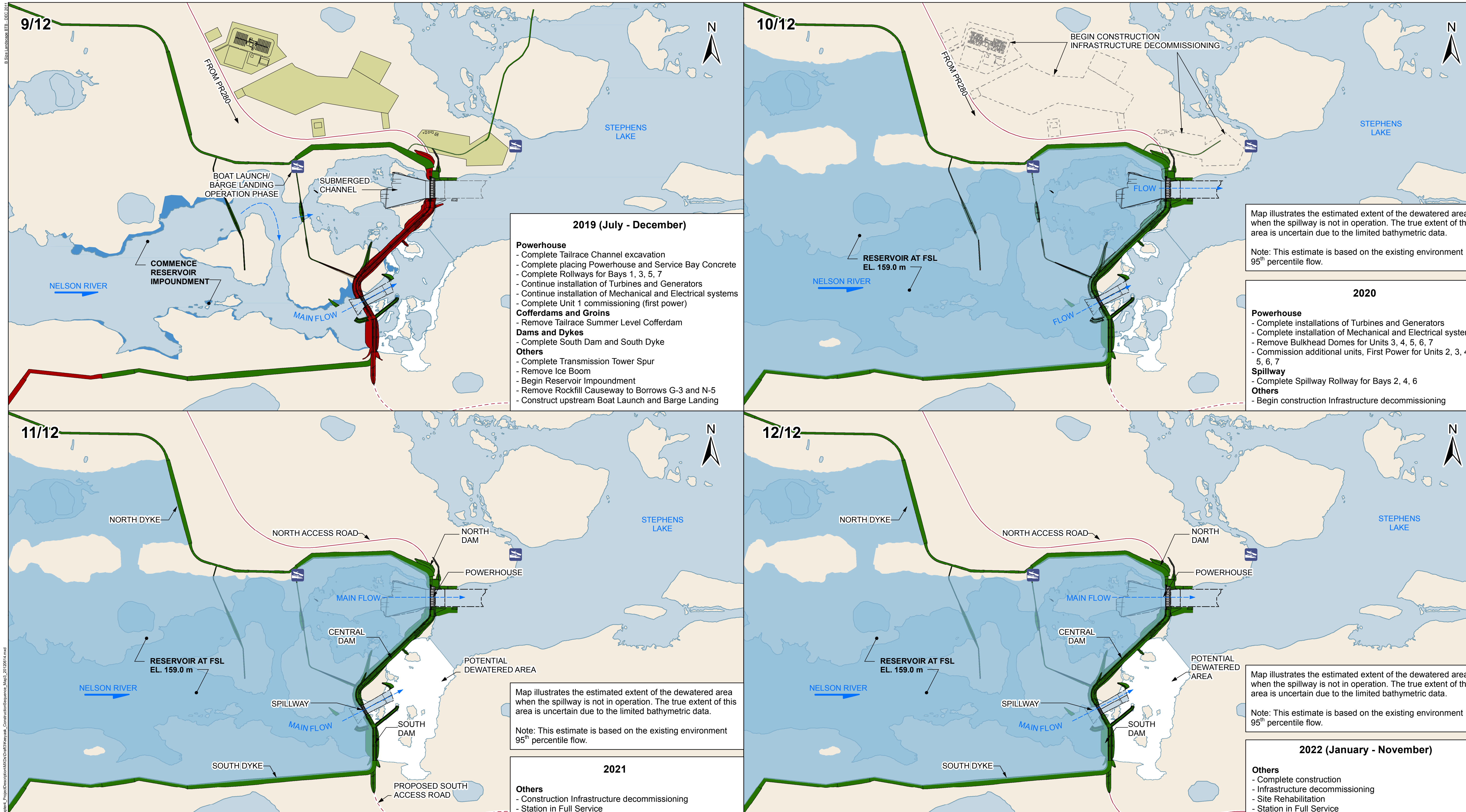
CREATED BY:
Manitoba Hydro - Hydro Power Planning Department

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	14-FEB-12	14-JUN-12
0 0.45 0.9 Kilometres / 0 0.4 0.8 Miles	VERSION NO: 3.0	QA/QC: JCL/MES/ZZZ

Legend

- Planned/Removed Feature
- Proposed Access Road
- Access Road
- Work Area and Construction Camp
- Structure in Progress
- Earthfill Structure (Complete)
- Excavation Area
- Bedrock Excavation Area
- Concrete/Steel Structure
- Boat Launch & Barge Landing
- Existing Water Surface Area
- Stage II Flooded Area
- Potential Dewatered Area

Construction Sequence
Years 2017 to 2019



KEEYASK Hydropower Limited Partnership

DATA SOURCE: Manitoba Hydro, KGS Acres, Government of Manitoba

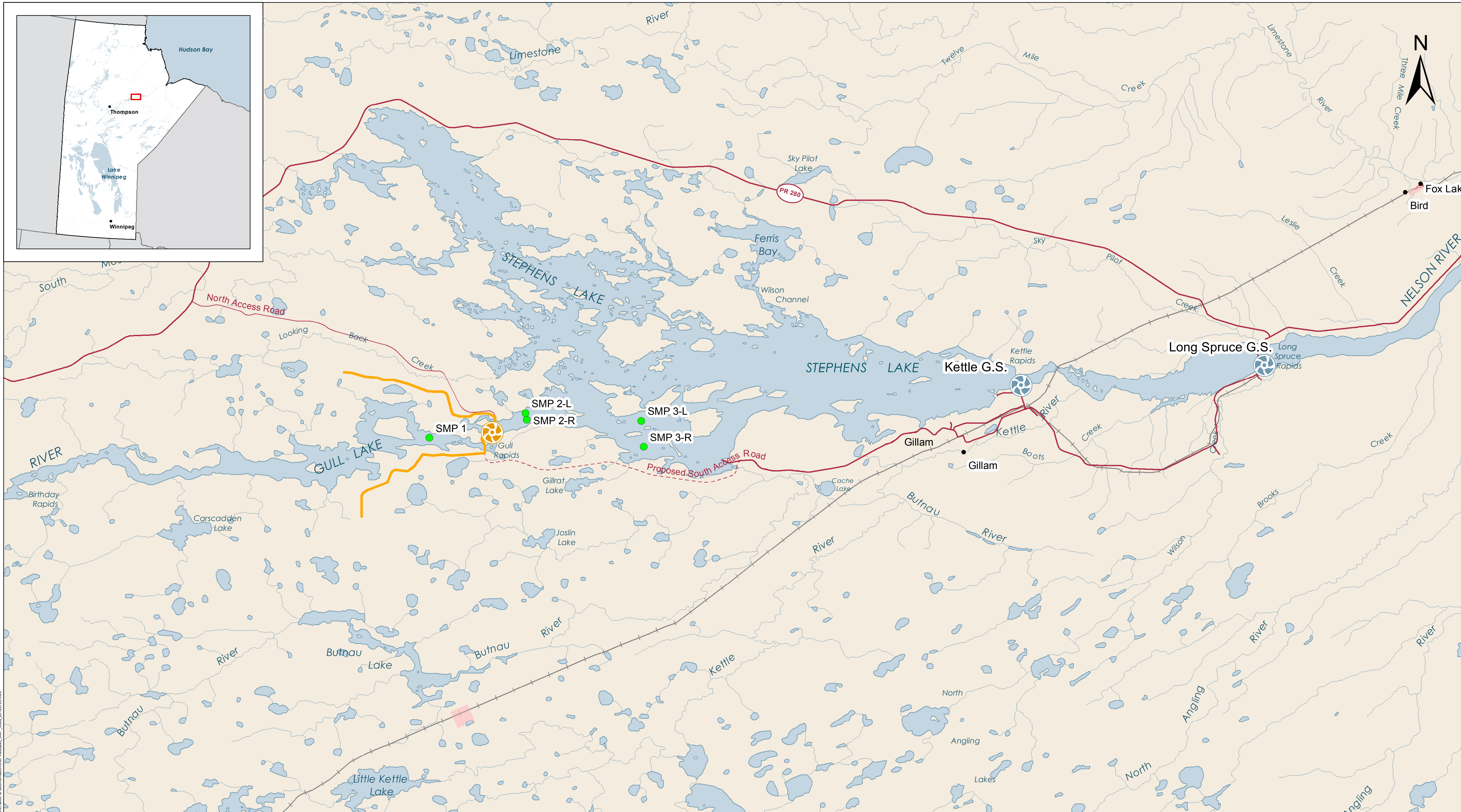
CREATED BY: Manitoba Hydro - Hydro Power Planning Department

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	14-FEB-12	14-JUN-12
0 0.45 0.9 Kilometres / 0 0.4 0.8 Miles	VERSION NO: 2.0	QA/QC: JCL/MES/ZZZ

Legend

- Planned/Removed Feature
- Proposed Access Road
- Access Road
- Work Area and Construction Camp
- Structure in Progress
- Earthfill Structure (Complete)
- Excavation Area
- Bedrock Excavation Area
- Concrete/Steel Structure
- Boat Launch & Barge Landing
- Existing Water Surface Area
- Stage II Flooded Area
- Initial Reservoir Area (159 m)
- Potential Dewatered Area

Construction Sequence
Years 2019 to 2022



DATA SOURCE:
Manitoba Hydro, KGS Acres, Government of Manitoba

CREATED BY:
Manitoba Hydro - Water Resources Engineering Department

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	05-JUL-12	05-SEP-12
	VERSION NO: 2.0	QA/QC: JCL/MES/ZZZ

KEEYASK
Hydropower Limited Partnership

Legend

- Proposed_Generating_Stations
- Existing Generating Stations
- Towns
- Sediment Monitoring Locations

0 3.5 7 14 Kilometers
0 1.75 3.5 7 Miles

Keeyask Sediment Monitoring Locations

Figure 4

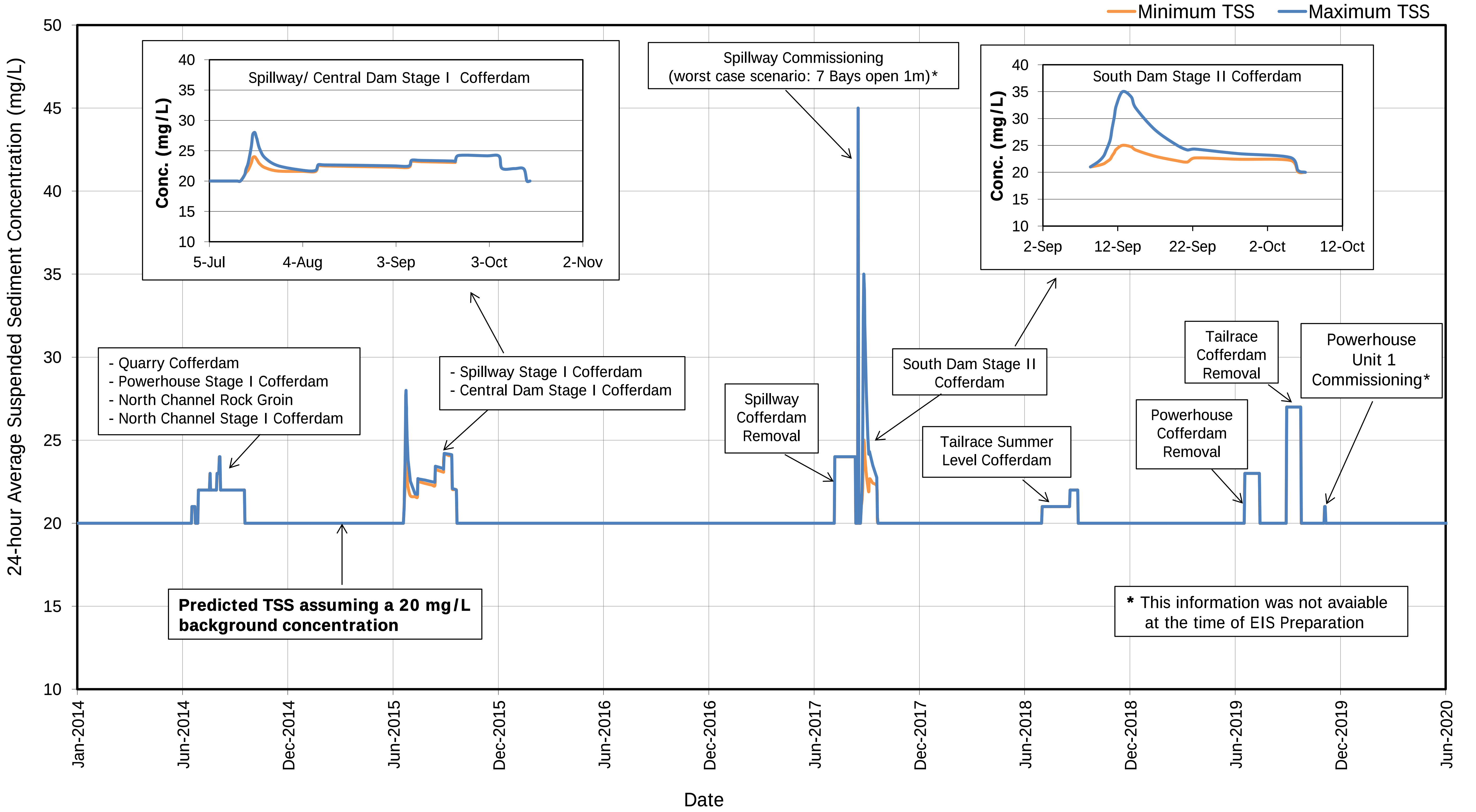


Figure 5 24-hour average TSS concentration predicted in the proximity of site SMP-2 (mixing zone) during construction of Keeyask GS

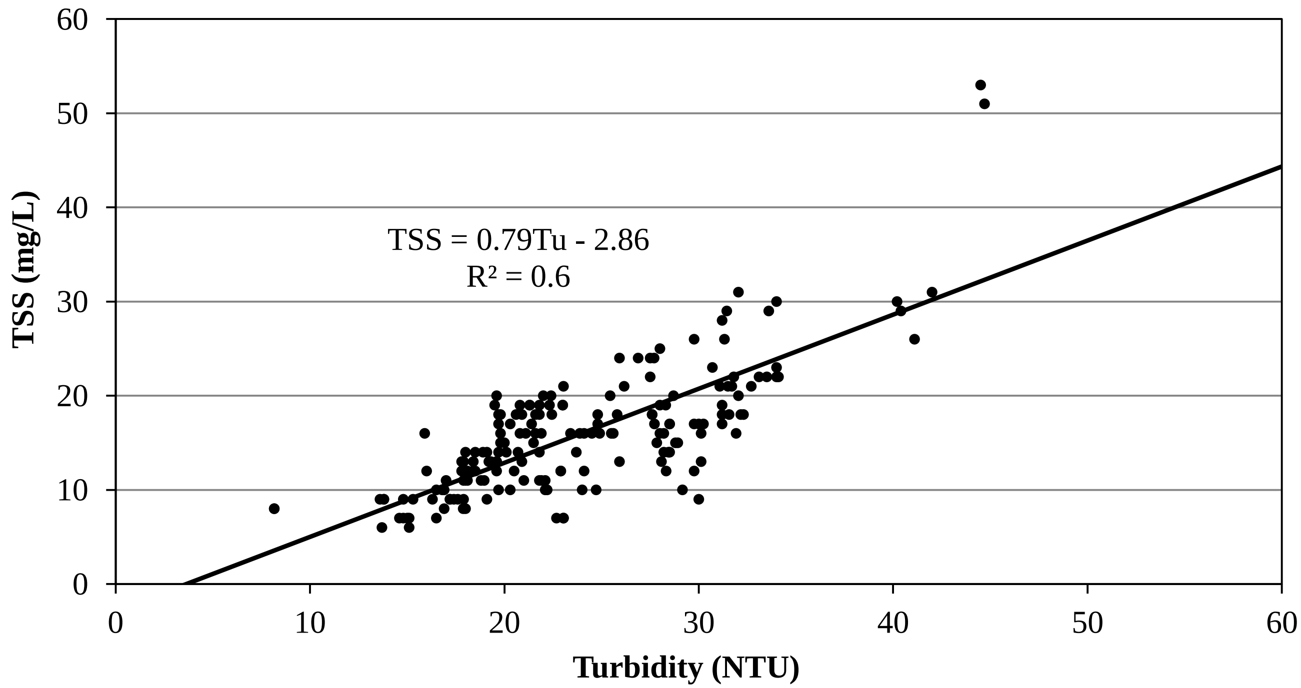


Figure 6 TSS-Turbidity Relationship for the Nelson River at Keeyask

APPENDIX A

SUMMARY OF IN-STREAM CONSTRUCTION ACTIVITIES, THEIR POTENTIAL EFFECTS AND ASSOCIATED MITIGATION

7.0 APPENDIX A

Potential Sediment Problem	Mitigation Techniques
Placement of rockfill and riprap	
Potential source of sediment that may enter the river is the washing of fine grain size material due to flow through and along the face of the rockfill used for: · quarry cofferdam, · north channel rock groin, · north channel stage I cofferdam, · powerhouse stage I cofferdam (inner & outer), · spillway stage I cofferdam (inner & outer), · central dam stage I cofferdam and rock groin, · tailrace summer level cofferdam (inner & outer), · south dam stage II upstream cofferdam, · south dam stage II downstream cofferdam.	The rockfill materials will consist of clean blast rock or boulders having a low fines content obtained from a quarry excavation. The Class C fill will consist of rock fragments of sufficient size to resist being carried downstream by the current. If monitoring identifies a sediment concern the following mitigation could be applied: · rock will be screened to reduce the content of fines. · larger Class D fill will be placed on the flow side and advanced ahead of the Class C fill to provide protection from the flow. · installation of a turbidity curtain where flow conditions permit, to isolate the construction area and control the release of sediment.
Placement of transition fill	
Potential source of sediment that may enter the river is the washing of the finer grain size material from the transition fill required for: · north channel rock groin, · north channel stage I cofferdam, · powerhouse stage I cofferdam (inner & outer), · spillway stage I cofferdam (inner & outer), · central dam stage I cofferdam , · tailrace summer level cofferdam (inner & outer), · south dam stage II upstream cofferdam, · south dam stage II downstream cofferdam Initially, a small portion of the coarse grained material may be washed through the rockfill, with the size of the particles being washed gradually reducing until essentially no washing occurs.	The granular transition fill (Class B) will consist of low silt content gravelly sand or gravel. Placement of granular fill will be sheltered with flow impeded due to the prior cofferdam rockfill advancement minimizing mobilization of sediments. If monitoring identifies a sediment concern then the following additional mitigation could be applied: · transition fill will be placed on top of the transition fill that has already been placed and pushed into the water so that it will enter the water as a sliding mass. · the transition fill zone will be constructed to a level that is slightly above the water level as it is advanced and subsequently be raised to final elevations in the dry.

Potential Sediment Problem	Mitigation Techniques
Placement of impervious fill	
otential source of sediment that may enter the river is the washing of fine grain size material by water seeping through the cofferdam and from velocities along the surface of impervious fill used for: · quarry cofferdam, · north channel stage I cofferdam, · powerhouse stage I cofferdam (inner & outer), · spillway stage I cofferdam (inner & outer) · central dam stage I cofferdam, · tailrace summer level cofferdam (inner & outer), · south dam stage II upstream cofferdam, · south dam stage II downstream cofferdam. The only potential source of sediment that may enter the river is: · washing of silt size material contained in the impervious material of single groins that is exposed to the water as the mass of fill slides into the water, · the impervious fill of inner & outer groins that may be exposed to minor flow resulting from seepage through the outer rock groin.	The impervious fill (Class A) will consist of well-graded, silty sand/sandy till that will form a homogeneous impervious mass. Placement of impervious fill will be sheltered with flow impeded due to the prior advancement of the rockfill and transition zones of the cofferdam minimizing mobilization of sediments. If monitoring identifies a sediment concern then the following additional mitigation could be applied: · impervious fill will be placed on top of the impervious fill that has already been placed and pushed into the water so that it will enter the water as a sliding mass. · the impervious fill zone will be constructed to a level that is slightly above the water level as it is advanced and subsequently be raised to final elevations in the dry.
Dewatering cofferdams	
Water trapped within the cofferdam (rainfall, snowmelt, seepage) may contain suspended sediment due to sediments trapped in the area when the cofferdam is closed or due to fine sediment from the fill materials.	Water trapped within cofferdams during construction will be discharged to the Nelson River if it meets regulatory requirements (<25 mg/L). If sediment levels exceed the regulatory requirements, it will be allowed to settle in-situ if possible until it meets the requirement and can then be pumped to the river. If settling in-situ is not feasible, the water may be pumped to the river through a filter to remove excess sediment, or it would need to be moved to a settling pond prior to being discharged to the surface water system.
Rock excavation and removal of rockfill	

Potential Sediment Problem	Mitigation Techniques
A potential source of sediment that may enter the river is the washing of the finer grain size material during excavation and removal of the blasted spillway approach and discharge channel rock and removal of rockfill used for cofferdams. The finer grain material in the rock will consist of material that was washed from the granular or impervious fill into the rockfill during construction.	Where inner and outer groins are used, the inner rockfill groin of cofferdams will be removed as much as possible using the outer groin for protection from the bulk of the flow minimizing mobilization of sediments. Installation of a turbidity curtain, where flow conditions permit, to isolate the construction area and control the release of sediment.
Removal of transition and impervious fill	
A potential source of sediment that may enter the river is the washing of the finer grain size material being removed during removal of the granular and impervious fill used for the cofferdams.	Where inner and outer groins are used, the granular and/or impervious fill used in cofferdams will be removed as much as possible using the outer groin for protection from the bulk of the flow minimizing mobilization of sediments. Installation of a turbidity curtain, where flow conditions permit, to isolate the construction area and control the release of sediment.
First flow through Spillway	
Sediment generated within the Spillway's approach and discharge channels during construction will be mobilized and transported downstream during commissioning of the Spillway. Erosion of cofferdam remnants left behind after cofferdam removal will be mobilized and transported downstream.	Construction areas with work completed in the dry will be cleaned as much as practical prior to commissioning. Sequenced commissioning of the Spillway's gates to control the timing and volume of flow released to minimize TSS increases.
First flow through Powerhouse	
Sediment generated within the Powerhouse's intake and tailrace channels during construction will be mobilized and transported downstream during testing the Powerhouse units. Erosion of cofferdam remnants left behind after cofferdam removal will be mobilized and transported downstream.	Construction areas with work completed in the dry will be cleaned as much as practical prior to commissioning. Sequence testing of the Powerhouse units to control the timing and volume of flow released to minimize TSS increases.

Potential Sediment Problem	Mitigation Techniques
Shoreline upstream of cofferdams	
Construction of the north channel rock groin, quarry cofferdam, north channel stage I cofferdam, and south dam stage II upstream cofferdam will require advancement of Class C material across an actively flowing channel. As the Class C material is advanced across the channel, the flow becomes constricted, upstream water levels rise and flow velocities between the advancing face and the closing shore increase. Increased water levels and velocities along the upstream shoreline have the potential to cause erosion of materials from the shoreline before closure is achieved, which could result in increased TSS concentrations downstream. For the remaining cofferdams and rock groins, advancement on the closing shoreline does not cause increases in velocities along the shorelines because there is no flow between the advancing face and the shore.	Stockpiles of rockfill materials will be placed strategically around the site for use as secondary mitigation measures. These materials will be used as either riprap for shoreline armoring or for use as rock groins to direct the flow and reduce the potential for erosion of materials from the shorelines.