Appendix A5

Water Quality Monitoring Plan

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A5.0 WATER QUALITY MONITORING PLAN

A5.1 OVERVIEW

Changes to the concentration of total suspended sediments (TSS) as a result of construction activities can have deleterious effects to fish and aquatic resources downstream of the construction site. Numerous predetermined water quality standards (and monitoring strategies) exist, although none are specifically legislated by the federal *Fisheries Act* for sediment. Instead, it is up to the proponent to identify relevant standards for developing a water quality monitoring (WQM) plan and recommended mitigation.

The *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Canadian Council of Ministers of the Environment [CCME] 2007) are commonly used as the benchmark for turbidity and TSS WQM plans. In addition, those outlined in Alberta Environment and Parks (AEP) Quality Guidelines for Alberta Surface Waters (Alberta Environment [AENV] 2014) are also used. The CCME guidelines indicate that a biologically important average increase in TSS concentration over a short-term period (i.e., 24 hours) is 25 mg/L above background levels during clear flow periods (i.e., winter) (CCME 2007). The CCME (2007) guidelines also indicate that the recommended maximum average increase of TSS for sustained periods (i.e., between 24 hours and 30 days) is 5 mg/L above background levels.

Should WQM rely on turbidity data only for analysis (as measured in NTU), the CCME short-term period threshold (for the same 24-hour time period) is 8 NTU above clear-flow background levels, while the sustained turbidity exceedance criteria (for between 24 hours and 30 days) is 2 NTU above background. Different exceedance criteria for TSS and turbidity, based on *in situ* background values coinciding with the construction at times other than during clear flow periods (e.g., freshet), are also provided in Table 1 of the CCME (2007) guidelines.

In addition to the CCME (2007) and AEP (AENV 2014) guidelines, DFO (2000) has identified risk levels to protect aquatic resources. The risk levels are determined based on the relationship between increasing suspended sediment concentrations and the level of risk that increasing sediment concentrations can have on fish and fish habitat. DFO (2000) indicates that concentrations < 25 mg/L, 25-100 mg/L, 100-200 mg/L, 200-400 mg/L and > 400 mg/L have very low, low, moderate, high and unacceptable risk to fish and fish habitat, respectively. Additional background on these risk levels is discussed in Birtwell (1999).

Newcombe and Jensen (1996) is commonly referenced when assessing potential impacts on fish and fish habitat caused by sediment mobilization events resulting from construction activities. This technical report, based on analysis of numerous published fish responses to suspended sediment, provides six empirical equations that relate biological response to duration of exposure and sediment concentration. Should an exceedance to the CCME guidelines (or other) be expected during construction, the formulas provided can provide a quantitative evaluation of the expected impact on fish and fish habitat if appropriate time referenced WQM data has been collected during a sediment mobilization event.

A5.1.1 Purpose

WQM is required where flow volumes and velocities are sufficient to transport sediment downstream of the construction site where suitable fish habitat is present. WQM is not needed when the watercourse is dry or frozen to bottom at the time of construction, or if there is insufficient flow to cause the downstream transport of sediment.

A qualified aquatic environment specialist (QAES) will determine if water quality monitoring is needed at each isolation location based on:

- Stream flow conditions (i.e., flow volume and velocity) on-site during the proposed construction timing;

- On-site water quality as it relates to fish health during the proposed construction timing;
- Quality and proximity of fish habitat within the zone of influence (ZOI); and
- Fish species present downstream of the isolation location.

To ensure the protection of aquatic resources during construction, the CCME *Canadian Water Quality Guidelines for Protection of Aquatic Life* (CCME 2007) and provincial Quality Guidelines for Alberta Surface Waters (AESRD 2014) for TSS and turbidity may be used but it is expected that TSS will be the main parameter measured. The CCME and AEP guidelines for TSS and turbidity are provided in Table A5.1 for reference.

Table A5.1 CCME AND AEP GUIDELINES FOR TSS AND TURBIDITY

Duration of Exceedance	Water Quality Parameter Exceedance Level			
	CCME		AEP	
	TSS	Turbidity[1]	TSS	Turbidity[1]
CLEAR FLOW PERIODS				
Short-term exposure (i.e., 24 hours)	Maximum average increase of 25 mg/L from background levels.	Maximum average increase of 8 Nephelometric Turbidity (NTU) from background levels.	Maximum average increase of 25 mg/L from background levels.	Maximum average increase of 8 NTU from background levels.
Long-term exposure	Maximum average increase of 5 mg/L from background levels for longer-term exposures (i.e., between 24 hours and 30 days).	Maximum average increase of 2 NTU from background levels for longer-term exposures (i.e., between 24 hours and 30 days).	Maximum average increase of 5 mg/L from background levels for longer-term exposures (i.e., greater than 24 hours).	Maximum average increase of 2 NTU from background levels for longer-term exposures (i.e., greater than 24 hours).
HIGH FLOW PERIODS				
Short-term exposure (i.e., 24 hours)	Maximum increase of 25 mg/L from background levels at any time when	Maximum increase of 8 NTU from background levels at any time when	Maximum increase of 25 mg/L from background levels at any time when	Maximum increase of 8 NTU from background levels at any time when

Duration of Exceedance	Water Quality Parameter Exceedance Level			
	CCME		AEP	
	TSS	Turbidity[1]	TSS	Turbidity[1]
Long-term exposure (i.e., between 24 hours and 30 days)	background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is equal to or greater than 250 mg/L.	background levels are between 8 and 80 NTU. Should not increase more than 10% of background levels when background is greater than 80 NTU.	background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is equal to or greater than 250 mg/L.	background levels are between 8 and 80 NTU. Should not increase more than 10% of background levels when background is greater than 80 NTU.

A5.1.2 Correlation of Total Suspended Sediment Data to Turbidity Results and Analysis

For watercourse isolations related to the Remediation Design, turbidity will be measured on-site and CCME guidelines will be followed. Although regulatory agencies prefer to assess potential impacts on aquatic resources with respect to TSS concentrations, its analysis requires the collection and submission of water samples to a certified laboratory which proves impractical when monitoring for construction. As a result, a statistical correlation between TSS and turbidity will be established prior to construction. Turbidity measurements (in NTU) determine how particles in the water column reflect light and, therefore, can be used to provide an indirect measurement of TSS. The amount of light reflected for a given amount of particulates is dependent upon properties of the particles (e.g., shape, colour and reflectivity). Different types of particles that can reflect light include suspended solids (TSS), tannins and phytoplankton, therefore, a correlation between turbidity and TSS is often unique for each location or situation. A unique correlation will be developed as required for APC-1 to APC-4 as well as APC-5 and APC-7.

A sufficient number (n~30) of TSS samples are required to ensure accurate statistical analysis. Ideally, this sample set would consist of a range of samples with associated turbidity values spanning the ones, tens and hundreds (i.e., background to 10 NTU, 10-100 NTU and 100-1,000 NTU). Although crew preparedness and environmental conditions will influence the potential sample collection, all efforts will be made to collect a representative range of turbidity levels. Samples representative of the range of expected TSS concentrations will be submitted to a certified lab for analysis before exact TSS values can be calculated and applied to turbidity data collected on-site. These correlations will be completed in advance of construction.

After TSS analysis data are returned by the laboratory, a regression analysis is used to determine the correlation between TSS values associated with the respective turbidity values recorded during the water sampling process. Generally, a linear regression is used to obtain the relationship, although depending on the graph's "fit" or statistical significance, non-linear regressions may be necessary.

A trend line and coefficient of determination R^2 will be provided during scatter plot graphical analysis. Generally, a regression relationship's suitability increases as the relationship's R^2 approaches and exceeds 0.95 or 95%.

The formula for determining the TSS values from turbidity data is represented as:

$$y = mx + b$$

where y is TSS, x is turbidity, m is the slope of the linear regression line that defines the relationship between TSS and turbidity and b is set to 0 by definition (i.e. 0 NTU = 0 mg/L).

After the empirical relationship between TSS and turbidity has been established, the relationship's formula is applied to all other turbidity values collected during the WQM program so that data can be expressed in terms of mg/L during reporting. Note: application of the regression relationship to data collected via sonde dataloggers and other monitoring devices (e.g., Lamotte hand held) assumes calibration and monitoring results among all instruments. Calibrations will be undertaken as per the manufacturer's instructions.

Once all turbidity data are converted to mg/L, comparative analysis of sampling data among the different sampling locations (via sonde datalogger) can occur. The first step in comparative analysis is establishing a theoretical TSS exceedance threshold, which is based on the CCME (2007) short-term and long-term maximum TSS increase benchmarks. Generally, most exceedance events are short in duration, lasting less than one day. In these instances, adding 25 mg/L to each background turbidity value collected throughout construction (i.e., those collected upstream of construction) will result in an estimated *in situ* exceedance threshold. This moving line (i.e., background turbidity typically ranges daily and over long periods) can then be used to identify potential short-term exceedances. The same process can be applied for potential long-term exceedance events by replacing the 25 mg/L with 8 mg/L.

If an exceedance is suspected based on the graphical analysis, average TSS values, based either over short-term (24 hour) or long-term (1 day to 30 days) periods can be calculated and compared against the background average for the same period.

Regardless of whether the collection of TSS water samples is planned for prior to an instream disturbance or occurs during an unexpected sediment mobilization event (e.g., pump malfunction), specific sequenced events must occur to ensure effective and accurate data collection. When collecting a water sample for TSS analysis, a sample bottle with a minimum capacity of 250 mL should be filled and subsampled manually for turbidity (i.e., from the same sample of water taken from the watercourse to fill the TSS sample bottle). Once filled, the bottle will be sealed and labelled with the date, time, project number, watercourse name, transect identification, sampler's initials, corresponding turbidity value and a sample identification number.

Once filled, each labelled bottle should be placed in a darkened cooler or refrigerator until the sample set is to be submitted to a certified lab for analysis. For exact handling requirements refer to the Chain of Custody document, which is provided with the sterilized sample bottles. Typical handling requirements include the maintenance of samples at cool temperature (e.g., 4°C) and the submission of samples within four days of collection.

A5.1.3 Transect Locations and Zone of Influence

WQM typically occurs within the established ZOI for the isolation generally located at the downstream (return flow) section. The length of the ZOI is determined in the field based on a variety of factors (e.g., channel depth, flow velocity and channel morphology). The ZOI typically represents the area of the watercourse where 90% of the sediment load caused by construction activities is expected to fall out of suspension and be deposited (AENV 2001, Government of Alberta 2013).

Transect locations will be determined by a QAES and strategically located to help facilitate documenting the decay of any sediment mobilization events that occur as the distance downstream increases. Table A5.2 provides an example of the placement of transects relative to the isolation locations for APC with a ZOI of 400 m. Transect locations will vary per site based on water velocity, water depth, wetted width, uniformity of flow and safety as well as other site-specific variables. Each transect will include a sonde, recording turbidity data at 10-minute intervals throughout the isolation as well as manual sampling. The location, duration and magnitude of effects from increased turbidity will be augmented during daylight hours with manual sampling conducted simultaneously with sonde data. This set-up is designed to detect and locate construction-related effects.

To ensure adequate sampling and that the water quality monitoring crew can cover the entire circuit regularly during daylight hours, the number of sampling stations across all transects (except those upstream of the isolation) has been set at four, although this will be dependent on the site conditions and the discretion of the water quality monitoring crew.

Table A5.2 Example of sample transects relative to the isolation location for APC.

Transect No.	Example Transect Relative to the Isolation Location	No. of Monitoring Stations at Transect	Water Quality Sampling Method
T1 (control transect)	upstream of isolation	One in thalweg	Data sonde and manual sampling
T2	100 m downstream of isolation	One in thalweg	Data sonde and manual sampling
T3	200 m downstream of isolation	One in thalweg	Data sonde and manual sampling
T4	400 m downstream of isolation	One in thalweg	Data sonde and manual sampling

As T1 (i.e., upstream of the isolation) is assumed to be the least likely of these transects to be affected by construction activities, turbidity data collected here will serve as a control and will represent the theoretical background levels throughout construction. As such, the establishment of a single monitoring station where access is most convenient for the sampling crew (e.g., along either bank) will be sufficient. By sampling within the thalweg, a single station at T1 will also sufficiently capture background turbidity and TSS levels. Monitoring stations will be maintained within the thalweg at each of the remaining downstream transects allowing for monitoring of the magnitude and duration of mobilized sediment (regardless of location and time) to be tracked at multiple locations downstream within the expected ZOI. The number of monitoring stations may increase depending on flow and fish habitat present at the time of construction. It is expected that the sondes will be anchored in place either to the left or right bank, or to the watercourse bed.

A5.1.4 Manual Water Quality Monitoring

Supplemental manual water quality monitoring will also occur at each station, between stations and downstream of T4 as required using a hand-held turbidity meter. Manual water quality monitoring will be used to verify data sonde readings and to supplement data loggers at high priority areas based on the construction schedule or in the event of an inadvertent release of sediment related to construction activities.

When collecting water samples for turbidity analysis, the scoop to collect water will be triple-rinsed prior to sample collection. The sample will be collected from 60% depth. The sampling cuvette will be rinsed with deionized or distilled water between samples. The cuvette will be filled from the scoop with no rinses to prevent settling of the sediment and will be cleaned with a lint-free cloth before being placed into the meter to obtain a turbidity measurement. Turbidity measurements will be taken immediately once the water is poured into the cuvette to limit particle settlement. Samples that are not measured quickly will be mixed prior to obtaining a turbidity reading. Data will be recorded in the field and retained for future analysis as required.

A5.2 REPORTING

In the event that any TSS or turbidity thresholds are exceeded, or in the event that unforeseen circumstances or issues are encountered during construction, a detailed report will be prepared and provided to the appropriate regulatory agencies within prescribed timelines (e.g., within 7 days to the province), as required. Turbidity and TSS results will be correlated to the sequence of construction activities so that potential effects on water quality can be determined and quantified. Potential adverse effects of sediment suspension during construction will be discussed in the context of the duration, magnitude and distance of travel of the plume(s).

In addition to immediate reporting, a summary report will be prepared upon the completion of the water quality monitoring and fish salvage programs for APC.

A5.3 REFERENCES

Alberta Environment and Sustainable Resource Development. 2014. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Policy Division. Edmonton, AB. 48 pp.

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