February 28, 2017 Reference No. 11102200

Mr. Aaron Stadnyk
Environmental Officer
CN Environment
1 Administration Road
Concord, Ontario
L4K 1B9

Dear Mr. Stadnyk,

Re: Addendum to Sediment Sampling and Results – Fall 2016
CN Timmins Derailment Site, CN Mile Point 88.7, Ruel Subdivision
Gogama, Ontario

1. Introduction

GHD was retained by Canadian National Railway (CN) to provide environmental services associated with a train derailment (Event) that occurred around midnight on March 7, 2015, at Mile Point 88.7 on the Ruel Subdivision of the CN rail line, near Gogama, Ontario (Site). The derailment involved 37 cars containing crude oil, some of which ruptured and caught fire, releasing unknown quantities of contents into the Makami River (River), a branch of the Mattagami River system.

As part of the long-term assessment and management of the Site, GHD completed two rounds of sediment remediation in 2015 and 2016 to remove sediment impacted by the derailment. Remediation and risk management decisions were based on the Preliminary Screening Ecological Risk Assessment (Preliminary ERA) dated July 9, 2015; a Comprehensive Ecological Risk Assessment (Comprehensive ERA) dated September 23, 2015; and a letter summarizing the results of the Fall 2016 sediment characterization sampling (Fall 2016 Letter) dated October 27, 2016. All submittals were distributed to and reviewed by the Ontario Ministry of the Environment and Climate Change (MOECC). This Addendum to the Sediment Sampling and Results – Fall 2016 (Addendum) summarizes the confirmatory sediment sampling conducted between November 15, 2016 and November 25, 2016, following the 2016 sediment remediation, and provides interpretation of the results in terms of risk to the benthic community at the Site.

2. Background

This section presents the background information and a brief summary of work completed by GHD associated with sediment characterization, ecological risk assessment, and sediment remediation.

Following the Event, as part of the environmental emergency response services, GHD investigated the Event's potential impact on surface water, sediment, fish, and benthic invertebrates by completing

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comprehensive sampling programs and detailed analysis of the data. Following the Toxicological Analysis Technical Letter of May 29, 2015, and the Preliminary ERA of July 9, 2015, the Comprehensive ERA was submitted to MOECC on September 23, 2015. The Comprehensive ERA provided a qualitative and quantitative evaluation of the potential for risk to ecological receptors, including benthic invertebrate communities and avian and mammalian wildlife, exposed to contaminants of concern (COCs) associated with the Event (i.e. polycyclic aromatic hydrocarbons [PAHs], benzene, toluene, ethylbenzene, and xylene [BTEX]).

The Comprehensive ERA discussed eight Operational Divisions (Divisions A and C through I; Division B was not designated) that were established in the potentially-impacted water bodies. Samples were also collected from areas not affected by the crude oil spill, upstream of the source, to compare the results to background conditions. The Comprehensive ERA identified a potential for ecological risk to benthic invertebrates in Division A, whereas the potential for risk to avian and mammalian wildlife was determined to be within acceptable limits. The results of the ERA were used to support risk management decisions and remedial actions for the Site.

Between August 18, 2015 and October 8, 2015, CN completed a sediment remediation program to remove impacted sediment from the bottom of the River in Division A. Between September 13, 2015 and October 7, 2015, confirmatory samples were collected during and following the remediation activities to confirm that the remediation was successful. The sediment remediation activities were summarized in the 2015 Comprehensive Sediment Remediation Report dated January 29, 2016, provided to the MOECC, Ministry of Natural Resources and Forestry (MNRF), and Fisheries and Oceans Canada (DFO).

From August 29 through September 10, 2016, additional sediment characterization was completed in the River and the Minisinakwa Lake to address MOECC's comments based on the work completed in 2015, Site observations, and public concerns related to dead fish and sheen observed on the surface of the River. GHD evaluated the data to provide an interpretation in terms of risk to the benthic community for post-remediation conditions. The Fall 2016 Letter was distributed to the MOECC on October 27, 2016. The results and interpretation of the 2016 sediment confirmatory sampling identified three locations in the River near the former derailment site (Rivers 12 and 14 in Division C and River 20 in Division A) with concentrations of PAHs that may not be protective of sensitive benthic communities.

Between November 7, 2016 and December 6, 2016, CN completed the second sediment remediation program to address impacted sediment in the three areas identified as posing a potential risk (River 12, 14, and 20). Approximately 4.63 million liter (L) of water-sediment mixture was removed from the three areas, including 240 cubic metres (m^3) of sediment. After completion of the sediment remediation in each remedial area, confirmatory sediment samples were collected to determine whether additional remedial actions were required. Pursuant to a request from MOECC, MNRF, and DFO, a detailed description of the sediment remediation activities was included in the 2016 Comprehensive Sediment Remediation Report (2016 Sediment Remediation Report) dated December 16, 2016. The analytical results for the confirmatory sediment samples were being evaluated when the 2016 Sediment Remediation Report was submitted; therefore, the results are discussed in this Addendum.

This Addendum to the Sediment Sampling and Results – Fall 2016 summarizes the data collected for the confirmatory sediment sampling conducted between November 15, 2016 through November 25, 2016 following the 2016 sediment remediation, and provides the interpretation of the results in terms of risk to the benthic community at the Site.

3. Additional Sediment Sampling – November 2016

Confirmatory sampling was conducted between November 15, 2016 through November 25, 2016. Sampling locations were accessed by boat. To ensure that the sampling equipment was not in contact or in close proximity to an out board gas motor, the boat was navigated to sampling locations using paddles.

Confirmatory samples were collected at selected locations in the three identified areas in the River (River 12, 14, and 20) as shown in Figure 1 (designated as purple symbols) and Table A.1 (Attachment A). Confirmatory sample locations were determined by a sediment screening process, which was described in detail in the 2016 Sediment Remediation Report and briefly described below. During the screening process, the remedial areas were divided into sampling zones to document and direct the sediment remediation. Screening locations were distributed evenly across sampling zones. Sampling areas consisted of the following:

- River 20 Area consisted of 6 sampling zones, with a total of 23 screening locations.
- River 14 Area consisted of 3 sampling zones, with a total of 16 screening locations.
- River 12 Area consisted of 4 sampling zones, with a total of 8 screening locations.

Sediment samples for screening were collected with a Petite Ponar grab sampler from the upper 0- 15 centimetres (cm) of sediment. The depth of sample collection was determined by the type of substrate and depth to refusal i.e., in most areas refusal was encountered at a depth less than 15 cm; therefore, the sample interval was shallower. The Ponar was then raised slowly to minimize the disturbance of the fine sediments. The collected sediment was subsequently placed into a clean stainless steel bowl and observed for visual and olfactory evidence of impacts. GHD then screened the sediment for total volatile organic compounds (VOCs) using a photoionization detector (PID) by testing the headspace of sealed ziplock bags containing a small quantity of sediment from the bowl.

Six confirmatory samples were collected from the river bottom following the sediment remediation activities using the same methodology used during the screening process. Confirmation sample locations were then selected based on field observations and the screening results following the hierarchy below:

- Containing evidence of visual/olfactory impact
- The highest PID reading in each sampling division

If sheen was observed on the water surface at the time of sampling, the field staff waited until the area was clear or slightly adjusted the sample location to minimize exposure of the equipment to the sheen to prevent cross contamination.

Each confirmatory sample was placed into a clean stainless steel bowl, homogenized by mixing with a stainless steel spoon, and placed into laboratory-supplied containers in accordance with the quality assurance/quality control protocols. All samples were submitted to Maxxam Analytics, an accredited laboratory, and analyzed for 18 parent PAHs and an extended suite of 16 alkyl PAHs, as well as benzene, toluene, ethylbenzene, and xylenes (collectively referred to as BTEX), petroleum hydrocarbon (PHC) Fractions F1 through F4, total organic carbon (TOC), black carbon (BC), total solids, and grain size. Alkyl PAHs were included in the sampling analysis plan for the risk assessment to assess the additive toxicity of individual PAHs. For the assessment of BC, Maxxam Analytics subcontracted the analysis to Bureau Veritas North America Inc., an accredited laboratory that specializes in BC analysis.

Concentrations of COCs in sediment, which are in units of micrograms per gram dry weight ($C_{sed;}$ µg/g dw) are presented in Table A.2 (Attachment A). The PAH results were screened against the Sediment Quality Guidelines (SQGs) from MOECC[1], which are identical to the Provincial Sediment Quality Guidelines (PSQG) Lowest Effect Levels (LELs)[2], and the BTEX results were screened against the United States Environmental Protection Agency (USEPA) Region 5 ecological screening levels (ESLs)[3] (Table A.2).

4. Risk-Based Remedial Endpoints

Similar to the methodology described in the Fall 2016 Letter, a tiered risk-based decision system, based on two chemical lines of evidence[4], was used to process the sediment results and to provide primary risk-based guidance on any remaining impacts in sediments[5]. The implemented methodology included the use of analytical data for bulk sediment and the concept of the toxic unit (TU) for protection of benthic invertebrates.

The Tier 1 assessment is the comparison of one-carbon equilibrium partitioning (EqP) sediment benchmark (ESB) to the concentrations in bulk sediment (Section 4.1). The ESB approach is based on the EqP theory described by the USEPA[6,7]. This approach accounts for the toxicity of each organic chemical to benthic invertebrates, Site-specific chemical bioavailability, and the additive effects of mixtures. Tier 1 approach was employed previously in the Comprehensive ERA and cleanup efforts to evaluate the initial

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1 MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

2 MOE, 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, August, 1993.

3 USEPA, 2003a. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

4 Fall 2016 benthic community structure results are included in the Response to the MOECC Comments (Multiple Letters) as Attachment 1, and submitted concurrently with this Addendum.

5 USEPA, 2012. Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Procedures for the Determination of the Freely Dissolved Interstitial Water Concentrations of Nonionic Organics, December 2012.

6 USEPA, 2003b. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures, November, 2003.

7 USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics.

and post-remediation risk levels (if any) to benthic invertebrates. Sediments in which the sum of ESBTU is equal to or less than 1 using the one-carbon EqP model are not considered toxic to benthic invertebrates and require no further consideration. Sediments in which the sum of ESBTU exceeds 1 using the one-carbon EqP model are further assessed in Tier 2 using a second line of evidence.

The Tier 2 assessment involves the comparison of final chronic values (FCVs) for water to the freely dissolved interstitial water concentration in sediment. The Tier 2 approach uses the interstitial water toxic unit (IWTU) generated with a two-carbon model, which accounts for the association of nonionic organic contaminants with the fraction of BC and the fraction of natural sedimentary organic carbon (NSOC) (Section 4.2). If IWTU is equal or less than 1, the sediment is not considered toxic to the benthic invertebrates.

4.1 Tier 1 Equilibrium Partitioning Sediment Benchmark Toxic Unit – One Carbon Model Approach

Where TOC in sediment is greater than 0.2%, the ESB approach can be used to account for binding of COCs and, thus, calculation of bioavailability/toxicity to biota. The EqP theory is supported by the USEPA[5,6,7] in remediation and cleanup decision making. Assuming equilibrium between sediment and pore water, chronic toxicity in water can be converted into an equivalent toxicity in sediment, and subsequently derived into an ESB[6,7]. ESBs are expressed on an organic carbon (OC) basis (i.e., ESBs are normalized for OC content in sediment). The ESBs for PAHs and BTEX are identified in Tables A.3a, A.3b, A.4a, and A.4b (Attachment A).

Following the procedure used in the Comprehensive ERA, a conservative value equal to one-half of the detection limit was assigned to concentrations reported as not detected. Results based on this conservative assumption are presented in Tables A.3a using the measured TOC for each individual sample. The calculations were repeated by assigning zeroes to non-detects to assess the impact of this source of uncertainty, and the results are presented in Table A.3b. Since the ESBs are expressed on an OC basis, sediment concentrations must be converted to the same measure to ensure unit compatibility. The OC conversion was accomplished by dividing the sediment concentrations by the OC fraction (f_{oc}). The OC-normalized sediment concentrations (C_{oc}; µg/g OC) are provided in Tables A.3a, A.3b, A.4a, and A.4b (Attachment A). Once both measures have identical units, a TU can be calculated as follows:

$$TU_i = \frac{C_{oci}}{ESB_i} \qquad \textbf{Equation 4.1}$$

where:

TU_i = toxic unit for a given chemical (i) (unitless),

C_{oci} = sediment concentration of a chemical (i) normalized for OC (µg/g OC), and

ESB_i = equilibrium partitioning sediment benchmark for a chemical (i) (µg/g OC).

Because BTEX and PAHs occur in sediments as mixtures, and their toxicities are additive or approximately additive, USEPA recommends summing their individual toxicities[6,7], so that the ESBs for

the combined PAHs and BTEX are sufficiently protective. As such, TUs for each sediment sample are calculated as:

$$\sum ESBTU_s = \sum_{i=1}^{n} \frac{C_{oci}}{ESB_i} \qquad \textbf{Equation 4.2}$$

where:

$\sum ESBTU_s$ = equilibrium partitioning sediment benchmark toxic units for the sample (unitless),

n = 34 for combined 34 parent and alkyl PAHs,

n = 4 for combined BTEX,

C_{oci} = sediment concentration of each chemical (i) normalized for OC (µg/g OC), and

ESB_i = equilibrium partitioning sediment benchmark for each chemical (i) (µg/g OC).

The calculated ΣESBTUs are presented in Table A.3a for assigning one-half of the detection limit to non-detects, and in Table A.3b for assigning zeroes to non-detects using the measured TOC for each individual sample (Attachment A). All results are summarized in Table 1.

4.1.1 TUs for BTEX

The calculated ΣESBTUs for BTEX based on the one-half of the detection limit and zeroes for non-detects are presented in Tables A.3a and A.3b (Attachment A), respectively, and are summarized in Table 1.

4.1.2 TUs for PAHs

To calculate ΣESBTUs for mixtures of PAHs, USEPA[6] selected 34 PAHs, which consist of 18 parent and 16 alkyl PAHs (listed in Tables A.3a, A.3b, A.4a, and A.4b). Combined, they constitute a pragmatic definition of "total PAHs." In the six confirmatory samples collected following the 2016 sediment remediation, all 34 PAHs were analyzed.

In previous sampling programs, 34 PAHs were measured in selected samples in each Division to determine the proportion of the alkyl PAHs relative to the total PAHs. The resulting information, in combination with current results, was used to derive a ΣESBTUs conversion quotient for 12 parent PAHs to 34 parent and alkyl PAHs, which was applied for samples with low organic carbon, as described below (Section 4.1.3).

4.1.3 Samples with Low Organic Carbon

Where TOC in sediment is low (i.e., equal to or less than 0.2% in River 12 samples, SED-11102200-112516-DM-01 and SED-11102200-112516-DM-02), the ESBs may be insufficiently protective of benthic organisms[6,7]. Accordingly, for samples at or below that threshold, the conservative MOECC SQGs were used in the TU calculations. To estimate the $\Sigma ESBTU_{PAH\text{-}34}$ for these locations, the

sample-specific conversion quotient (CQ) determined at the nearest location was applied (Tables A.3a and A.3b). Thus, the sum of the TUs for low OC samples was calculated as:

$$\sum TUs_{MOECC\ SB} = \sum_{i=1}^{n} \frac{C_{sedi}}{MOECC\ SQG_i} \times CQ \qquad \textbf{Equation 4.3}$$

where:

$\sum TUs_{MOECC\ SB}$ = toxic units based on the MOECC SQG for the sample (unitless),

n = 34 for combined 34 parent and alkyl PAHs,

n = 12 for combined 12 parent PAHs with MOECC SQG values,

C_{sedi} = sediment concentration of each chemical (i) (µg/g dry weight),

$MOECC\ SQG_i$ = MOECC sediment quality guideline for each chemical (i) (µg/g dry weight), and

CQ = sample-specific conversion quotient when *n* = 12.

All values for $\Sigma ESBTU_{PAH}$ assessed with the measured TOC in each individual sample are presented in Tables A.3a and A.3b, and summarized in Table 1.

4.1.4 Presumptive Future Site Conditions: TU Calculation with Geometric Mean of TOC

Given the large volume of sediment removed during remediation, the TOC content in the remaining substrate was depleted by the dredging activities, and not necessarily representative of the natural conditions in the area. Furthermore, the remaining substrate depleted of fine sediments would not be an immediately attractive habitat for benthos. Therefore, to minimize undue bias due to transient conditions following remediation, the potential for long-term risks to biota based on the one-half of the detection limit and zeroes for non-detects was also assessed respectively with the geometric mean of the TOC content in pre-remediation samples in Division A and Division C (Tables A.4a and 4b and Table A.5; Attachment A). The expectation is that the remediated areas will naturally replenish over time with organic matter and substrate, which will attract benthic organisms.

4.2 Tier 2 Interstitial Water Toxic Unit – Two Carbon Model Approach

Similar to the one-carbon model, the two-carbon model is also based on the EqP theory, but it accounts for the nonlinear adsorption to BC, as well as the linear absorption to NSOC. The Tier 2 assessment based on two-carbon model approach is only applicable to PAHs due to the availability of the scientific literature values for BC-to-water partition coefficients. The Tier 2 assessment methodology was described in detail in the Fall 2016 Letter.

Tier 2 assessment with ΣIWTU using the two-carbon model approach only applies to sediment samples with detected BC contents and that had ΣESBTUs greater than 1 in the Tier 1 assessment. This is because the two approaches will result in the same TUs if BC is not detected in the sample.

Tier 2 assessment was not applied to the six additional confirmatory samples included in this Addendum because BC was not detected in the one sample (SED-11102200-112416-DM-01 at River 14) which had a ΣESBTU greater than 1 in the Tier 1 assessment (discussed in Section 5.2); therefore, the Tier 2 assessment is not discussed further in this Addendum.

5. Results and Interpretation

No exceedances were identified with PAHs when screened against the available MOECC SQGs[1]. The BTEX results were all below the associated reporting limits, which were below the respective USEPA Region 5 ESLs[3] (Table A.2 in Attachment A).

Based on the tiered risk-based decision system, values for ΣESBTUs less than, or equal to, 1 in Tier 1 assessment are deemed protective of benthic invertebrates. Values for ΣESBTUs greater than 1 in Tier 1 assessment, but ΣIWTUs less than or equal to 1 in Tier 2 assessment, also indicate that the concentration of PAHs in the sediment is acceptable for the protection of benthic invertebrates from chronic toxic effects. This is because BC reduces bioavailability and, thus, toxicity of PAHs. Values for ΣESBTUs greater than 1 in Tier 1 assessment and where BC was not detected, which suggests values of ΣIWTUs also greater than 1, indicate that COC concentrations in sediment may not be protective of sensitive benthic communities. A similar interpretation was provided in the Fall 2016 Letter.

As discussed above in Section 4.2, Tier 2 assessment was not applied to the six additional confirmatory samples included in this Addendum; therefore, ΣESBTUs in Tier 1 assessment was used to make risk decisions. The summary of ΣESBTUs calculated for PAHs and BTEX are presented in Table 1. This table is intended to represent current risk conditions for benthic invertebrates.

5.1 BTEX Results

BTEX compounds in the six additional confirmatory samples were all below the detection limits (Table A.2), and none of the $\Sigma ESBTU_{BTEX}$ for the six samples were greater than 1 for both scenarios that assigned non-detects as one half of the detection limit or zeroes (Table 1). Therefore, the residual concentrations of BTEX are not expected to adversely impact benthic invertebrates at this time. As such, BTEX is not a constituent group of concern under current conditions at the Site.

5.2 PAH Results

No individual PAH exceedances above the MOECC SQGs were identified in the six additional confirmatory samples (Table A.2).

5.2.1 Tier 1 Assessment of $\Sigma ESBTU_{PAH-34}$ with Measured TOC of Individual Samples

5.2.1.1 Non-Detects Assigned as One-Half Detection Limit

When assigning one-half of the detection limit for non-detects and using measured TOC of individual samples, where TOC is below 0.2% at some locations, the $\Sigma ESBTU_{PAH-34}$ for all samples were below, or

equal to, 1 in the Tier 1 assessment except for one location at River 14 (SED-11102200-112416-DM-01) (Individual TOC subheading in Table 1; Table A.3a). Among the 34 analyzed total PAHs, 11 parent PAHs and all 16 alkyl PAHs were detected in this sample, more than those detected in other samples. Generally, the concentrations of 16 alkyl PAHs in this sample were higher than those in other samples, approximately two to three times higher than those detected in the other River 14 sample (SED-11102200-112516-DM-03), up to 69 times higher than those detected in River 12 samples, and up to 29 times higher than those detected in River 20 samples. Since no exceedances were identified with the parent PAHs when screened against the available MOECC SQGs[1], the potential risk in the sediment sample collected from this River 14 location could be primarily associated with the 16 alkyl PAHs.

5.2.1.2 Non-Detects Assigned as Zeroes

When assigning zeroes for non-detects and using measured TOC of individual samples, where TOC is below 0.2% at some locations, the same location at River 14 (SED-11102200-112416-DM-01) was identified with $\Sigma ESBTU_{PAH-34}$ greater than 1 in the Tier 1 assessment (Individual TOC subheading in Table 1; Table A.3b), similar to the assessment based on assigning one-half of the detection limit for non-detects (Section 5.2.1.1). The potential risk in this River 14 sample could be primarily associated with the 16 alkyl PAHs.

5.2.1.3 Area-Wide Assessment

When assessing risk in water bodies, it is appropriate to look at the area-wide effects of contamination with mean exposure concentrations[8]. Looking at the potential for any area-wide effects, the average $\Sigma ESBTU_{PAH-34}$ across all six sampling locations were 0.7 and 0.5 (below the decision criterion of 1) using the measured TOC of individual samples when assigning one-half of the detection limit and zeros for non-detects, respectively. The proportion of TUs > 1 was also below the decision threshold of 20 percent for ecologically-significant impacts[9]. The decision threshold is based on the principle that a benthic community can sustain impacts of up to 20 percent and still maintain viability and ability for ready recovery[8]. Therefore, the overall impacts on the local benthic community are not anticipated.

5.2.2 Tier 1 Assessment of $\Sigma ESBTU_{PAH-34}$ with Geometric Mean of TOC

5.2.2.1 Non-Detects Assigned as One-Half Detection Limit

Using the prospective approach discussed in Section 4.3, where Divisions A and C are expected to return to normal sedimentation and, thus TOC levels[10], none of the $\Sigma ESBTU_{PAH-34}$ exceeded 1 using the geometric mean of TOC for samples in the same Division (Geomean TOC subheading in Table 1; Table A.4a). This suggests that when sedimentary organic matter recovers to natural levels before the dredging,

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8 USEPA, 2015. Supplemental Guidance to ERAGS: Region 4, Ecological Risk Assessment.

9 Suiter II, G.W., 2006, Ecological Risk Assessment, Second Edition, December 6, 2006 by CRC Press.

10 As estimated by the geometric mean of TOC contents for all pre-remediation samples in each division (Table A.5).

and benthic organisms re-colonize the area, the lower PAH levels associated with the fresh sediment will mix with the residual PAHs to levels that are not expected to impact benthic invertebrates.

5.2.2.2 Non-Detects Assigned as Zeroes

Assessing the same data, but using the prospective TOC levels (approach discussed in Section 4.3), none of the $\Sigma ESBTU_{PAH-34}$ exceed 1 using the geometric mean of TOC for samples in the same Division (Geomean TOC subheading in Table 1; Table A.4b).

5.2.2.3 Area-Wide assessment

In consideration of area-wide effects, the average $\Sigma ESBTU_{PAH-34}$ across all sampling locations was 0.5, below the decision criterion of 1, using the geometric mean of TOC for samples in the same Division when assigning one-half of the detection limits and zeros for non-detects. The proportion of TUs > 1 was also below the decision threshold of 20%. Therefore, the overall impacts on the local benthic community are not anticipated.

6. Conclusions and Recommendations

The interpretation of results in the current submittal is based on the analytical chemistry line of evidence. A second line of evidence, benthic community structure, is included in the Response to the MOECC Comments (Multiple Letters) as Attachment 1, and submitted to MOECC concurrently with this Addendum.

The original ERA format was developed and executed in a phased manner, whereby the results of one phase guided the need for the next. Sediment toxicity tests and bioaccumulation/biomagnification studies were not conducted as the concentrations of the COCs in sediment collected as part of the bulk chemistry sampling (first phase) did not justify the need for additional lines of evidence at that time. In the area where sediment concentrations of the COCs may have warranted further analyses (i.e. Division A or source area), such as sediment toxicity testing or bioaccumulation studies, the sediment has been removed through remediation. A Sampling and Analysis Plan (SAP) for 2017, including collection of additional sediment chemistry data, benthic community assessment data, and sediment toxicity data is under preparation and will be distributed to the MOECC when available.

Using the measured TOC of individual samples, the Tier 1 assessment with the ESB line of evidence indicated one sediment sample at one location (SED-11102200-112416-DM-01 at River 14) had ΣESBTUs exceeding 1, when assigning non-detects as one-half of the detection limits (Section 5.2.1.1) and zeroes (Section 5.2.1.2). However, the average ΣESBTU across all six sampling locations was below the decision criterion of 1 (Section 5.2.1.3).

Using the geometric mean of TOC for samples in the same Division, the Tier 1 assessment with the ESB line of evidence indicated that no samples had ΣESBTUs exceeding 1, when assigning non-detects as

one-half of the detection limits (Section 5.2.2.1) and zeroes(Section 5.2.2.2). The average ΣESBTU across all six sampling locations was below the decision criterion of 1 (Section 5.2.2.3).

Therefore, the results of this analysis indicate no overall potential impacts on the health of the benthic community in the River near the former derailment site (River 12, 14, and 20) following the 2016 sediment remediation. Similar to the Fall 2016 Letter, the interpretation of results in the current submittal is based on the analytical chemistry line of evidence. Additional lines of evidence will be considered in the 2017 SAP, including benthic community assessment data, and sediment toxicity data. On-Site and background sediment toxicity testing may be considered during future monitoring to evaluate the potential for any ongoing effect of the residual concentrations of constituents in combination with the other lines of evidence (i.e., analytical chemistry, benthic community structure). Remedial decisions will consider all applicable and appropriate lines of evidence.

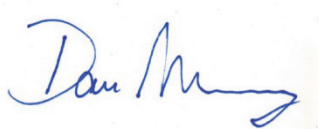
However, any remedial and risk management decisions should be weighed against the net environmental benefit of allowing natural recovery and continued influx of organic matter, versus creating a significant physical disturbance associated with sediment removal. It is expected that the remediated areas will naturally replenish over time with organic matter and substrate, which will facilitate re-colonization of the benthic community.

Should you have any questions on the above, please do not hesitate to contact us.

Sincerely,

GHD

Yaning Yang, Ph.D., P.E.
Risk Assessor



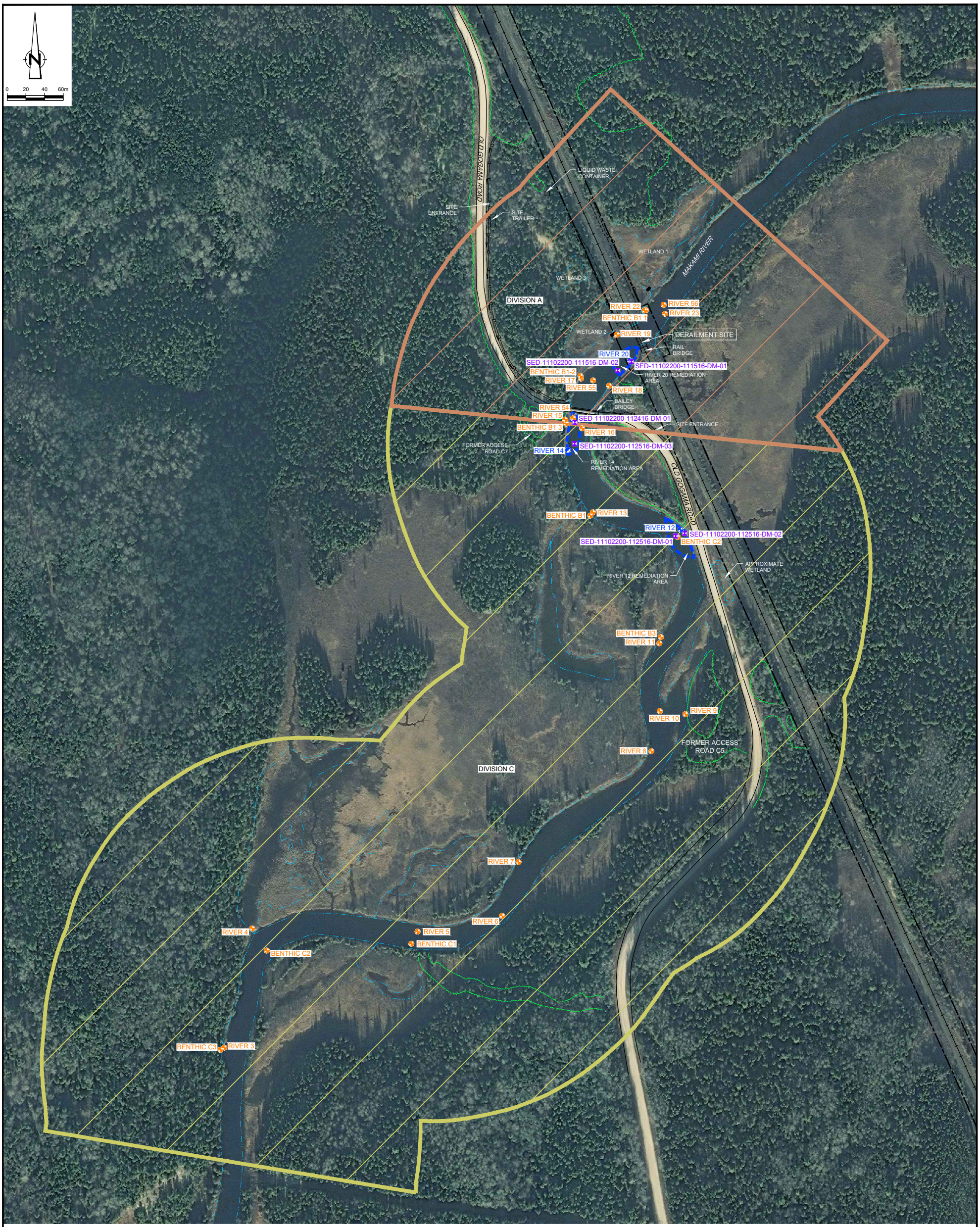
Daniel Murray, P.Eng
Project Manager

Steve Jones, Ph.D.
Senior Ecologist/Risk Assessor

YY/aj/25

Encl.

cc: Frederic Gauthier (CN)
Normand Pellerin (CN)
Roger Schieck (GHD)
Laura Lawlor (GHD)
Ryan Shepherd (GHD)



LEGEND

- APPROXIMATE CN RIGHT-OF-WAY
- RAILWAY CENTRE LINE
- WATER BODY (APPROXIMATE)
- BRIDGE GUARDRAIL
- SAFETY FENCE
- DRAINAGE DITCH
- TREE LINE

RIVER 3 — SEDIMENT SAMPLE LOCATION (AUGUST 2016)

RIVER 12 — SEDIMENT SAMPLE LOCATION USED TO IDENTIFY SEDIMENT REMEDIATION AREA (AUGUST 2016)

SED-11102200-112416-DM-01 — APPROXIMATE CONFIRMATORY SEDIMENT SAMPLE LOCATION (NOVEMBER 2016)

APPROXIMATE SEDIMENT REMEDIATION AREA

SOURCE:
AERIAL IMAGE SOURCE: © COPYRIGHT 2015 DIGITALGLOBE, INC., LONGMONT CO USA 80503. WORLDVIEW-2 IMAGERY, CAPTURED NOVEMBER 15 2011.

Nº	Revision	Date	Initial

SCALE VERIFICATION

THIS BAR MEASURES 50mm ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

CN DERAILMENT - RUEL MP 88.7 GOGAMA, ONTARIO

ADDENDUM TO SEDIMENT SAMPLING AND RESULTS - FALL 2016

SEDIMENT SAMPLING LOCATIONS

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
D. MURRAY	Y. YANG	February 2017	
Scale: AS SHOWN	Project Nº: 11102200-02	Report Nº: STAD025-REV01	Drawing Nº: figure 1

11102200-02(STAD025-REV01)GN-WA003 FEB 28, 2017

Table 1

Additional Sediment Sample TU results
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

No	Location	Division	Sample ID	Date	Final Total PAH ESBTU with One Carbon Model ($\Sigma ESBTU_{PAH-34}$)				Final Petroleum Products ESBTU ($\Sigma ESBTU_{BTEX}$)[b]			
					ND=1/2DL		ND=0		ND=1/2DL		ND=0	
					Individual TOC	Geomean TOC	Individual TOC	Geomean TOC	Individual TOC	Geomean TOC	Individual TOC	Geomean TOC
1	RIVER 20-1A	A	SED-11102200-111516-DM-01	11/15/2016	0.1	0.1	0.1	0.1	0.01	0.01	0	0
2	RIVER 20-5A/C	A	SED-11102200-111516-DM-02	11/15/2016	0.2	0.2	0.2	0.1	0.02	0.01	0	0
3	RIVER 14	C	SED-11102200-112416-DM-01	11/24/2016	**2**	1	**2**	1	0.02	0.02	0	0
4	RIVER 14	C	SED-11102200-112516-DM-03	11/25/2016	0.5	0.8	0.5	0.7	0.01	0.02	0	0
5	RIVER 12	C	SED-11102200-112516-DM-01	11/25/2016	0.4[a]	0.1	0[a]	0.04	--[c]	0.02	--[c]	0
6	RIVER 12	C	SED-11102200-112516-DM-02	11/25/2016	1[a]	0.5	0.8[a]	0.5	--[c]	0.02	--[c]	0
Average of All Samples					0.6	0.5	0.6	0.5	0.01	0.02	0	0
%TU>1					17%	0	17%	0	0	0	0	0

Notes:

PAH = Polycyclic aromatic hydrocarbons
BTEX = Benzene, toluene, ethylbenzene, and xylene
ESB = Equilibrium partioning sediment benchmark
TU = Toxic unit
TOC = Toal organic carbon
Individual TOC = TU calculation used the measured TOC content in each sample.
Geomean TOC = TU calculation used the geometric mean of TOC contents for all pre-remediation samples in each division, which represents the normal TOC content in sediment before the remediaion activities.
2 = Boxed cells with bold font indicate locations where sensitive benthic organisms may be affected.

[a] The calculation of ESBs for PAHs according to the equilibrium partioning method apply to sediments with TOC > 0.2%. Given that TOC was < 0.2% in this sample, the MOECC sediment screening values were used to calculate the TU for PAHs.

[b] No Ministry of the Environment and Climate Change (MOECC) sediment screening values are available for toluene, ethylbenzene, or xylenes to calculate the TU.The United States Environmental Protection Agency (USEPA) Region 5 ecological screening levels (ESLs) (2003) for toluene, ethylbenzene, or xylenes were used instead.

[c] The TOC of this background sample was < 0.2%, however, no MOECC sediment screening values are available for toluene, ethylbenzene, or xylenes to calculate the toxic unit. It should be noted that toluene, ethylbenzene, and xylenes were not detected in this sample.

Attachment A

Table A.1

Field Sample Key - November 2016 Additional Sediment Sampling
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

Date	Time	Sample ID	Analyses	Location
11/15/2016	13:50	SED-11102200-111516-DM-01	Black Carbon, Particle Size Distribution, CCME Petroleum Hydrocarbons (Silica Gel Clean Up) incl. BTEX, TOC, Total Solids, PAH Compounds by GCMS (SIM), Moisture	River #20 Area
11/15/2016	16:35	SED-11102200-111515-DM-02	Black Carbon, Particle Size Distribution, CCME Petroleum Hydrocarbons (Silica Gel Clean Up) incl. BTEX, TOC, Total Solids, PAH Compounds by GCMS (SIM), Moisture	River #20 Area
11/24/2016	11:50	SED-11102200-112416-DM-01	Black Carbon, Particle Size Distribution, CCME Petroleum Hydrocarbons (Silica Gel Clean Up) incl. BTEX, TOC, Total Solids, PAH Compounds by GCMS (SIM), Moisture	River #14 Area
11/25/2016	15:10	SED-11102200-112516-DM-03	Black Carbon, Particle Size Distribution, CCME Petroleum Hydrocarbons (Silica Gel Clean Up) incl. BTEX, TOC, Total Solids, PAH Compounds by GCMS (SIM), Moisture	River #14 Area
11/25/2016	12:40	SED-11102200-112516-DM-01	Black Carbon, Particle Size Distribution, CCME Petroleum Hydrocarbons (Silica Gel Clean Up) incl. BTEX, TOC, Total Solids, PAH Compounds by GCMS (SIM), Moisture	River #12 Area
11/25/2016	13:20	SED-11102200-112516-DM-02	Black Carbon, Particle Size Distribution, CCME Petroleum Hydrocarbons (Silica Gel Clean Up) incl. BTEX, TOC, Total Solids, PAH Compounds by GCMS (SIM), Moisture	River #12 Area

Notes:

BTEX - Benzene, toluene, ethylbenzene, and xylenes
PHC F1-F4 - Petroleum hydrocarbon fractions F1 to F4
TOC - Total organic carbon
PAHs - Polycyclic aromatic hydrocarbons

Table A.2

Analytical and Screening Results Summary - November 2016 Additional Sediment Sampling
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

Sample Location:			RIVER 20-1A	RIVER 20-5A/C	RIVER 14	RIVER 14	RIVER 12	RIVER 12
Sample ID:			SED-11102200-111516-DM-01	SED-11102200-111516-DM-02	SED-11102200-112416-DM-01	SED-11102200-112516-DM-03	SED-11102200-112516-DM-01	SED-11102200-112516-DM-02
Sample Date:			11/15/2016	11/15/2016	11/24/2016	11/25/2016	11/25/2016	11/25/2016
Parameters	**Units**	**MOECC or USEPA Region 5 Screening Value[a] (µg/g dw)**						
Volatile Organic Compounds								
Benzene	ug/g	NV	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Ethylbenzene	ug/g	0.175	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
m&p-Xylenes	ug/g	NV	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)
o-Xylene	ug/g	0.433	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Toluene	ug/g	1.22	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Xylenes (total)	ug/g	NV	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)	ND (0.040)
Semi-volatile Organic Compounds								
1-Methyl-7-isopropylphenanthrene	ug/g	NV	0.061	0.056	0.41	0.61	ND (0.0050)	0.0092
1-Methylnaphthalene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
2-Methylnaphthalene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.010)	0.0060	ND (0.0050)	ND (0.0050)
Acenaphthene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Acenaphthylene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Acridine	ug/g	NV	ND (0.010) J	ND (0.010) J	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Anthracene	ug/g	0.22	ND (0.0050)	ND (0.0050)	0.012	ND (0.0050)	ND (0.0050)	0.011
Benzo(a)anthracene	ug/g	0.32	ND (0.0050)	ND (0.0060)	0.0059	ND (0.0050)	ND (0.0050)	ND (0.0050)
Benzo(a)pyrene	ug/g	0.37	ND (0.0050)	ND (0.0050)	0.0051	ND (0.0050)	ND (0.0050)	ND (0.0050)
Benzo(b)fluoranthene/Benzo(j)fluoranthene	ug/g	NV	ND (0.0050)	ND (0.0050)	0.0079	0.0050	ND (0.0050)	0.0051
Benzo(b)pyridine (Quinoline)	ug/g	NV	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Benzo(c)phenanthrene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Benzo(e)pyrene	ug/g	NV	ND (0.0050)	ND (0.0050)	0.013	ND (0.0050)	ND (0.0050)	ND (0.0050)
Benzo(g,h,i)perylene	ug/g	0.17	ND (0.0050)	ND (0.0050)	0.0074	ND (0.0050)	ND (0.0050)	0.0080
Benzo(k)fluoranthene	ug/g	0.24	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Biphenyl (1,1-Biphenyl)	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
C1-Acenaphthene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
C1-Benzo(b,j,k)fluoranthene/Benzo(a)pyrene	ug/g	NV	0.0051	ND (0.0050)	0.034	0.012	ND (0.0050)	0.011
C1-Biphenyl (1,1-Biphenyl)	ug/g	NV	ND (0.0050)	0.0087	0.053	0.035	ND (0.0050)	0.013
C1-Dibenzothiophenes	ug/g	NV	ND (0.0050)	ND (0.0050)	0.036	0.013	ND (0.0050)	0.010
C1-Fluorenes	ug/g	NV	ND (0.0050)	ND (0.0050)	0.038	0.020	ND (0.0050)	0.011
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	0.0056	0.0076	0.035	0.016	ND (0.0050)	0.015
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	0.017	0.019	0.12	0.047	0.0059	0.034
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	0.011	0.015	0.11	0.047	ND (0.0050)	0.036
C1-Naphthalenes	ug/g	NV	0.012	ND (0.0050)	0.011	0.0074	0.0065	ND (0.0050)
C2-Alkylated fluoranthene/Pyrenes (C2-202 isomers)	ug/g	NV	0.014	0.027	0.17	0.072	0.0097	0.059
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	0.0083	0.013	0.10	0.044	ND (0.0050)	0.040
C2-Benzo(b,j,k)fluoranthene/Benzo(a)pyrene	ug/g	NV	ND (0.0050)	ND (0.0050)	0.036	0.014	ND (0.0050)	0.011
C2-Biphenyl (1,1-Biphenyl)	ug/g	NV	0.0062	0.013	0.13	0.067	ND (0.0050)	0.043
C2-Dibenzothiophenes	ug/g	NV	0.011	0.035	0.31	0.13	0.0066	0.12
C2-Fluorenes	ug/g	NV	0.0063	0.016	0.17	0.072	ND (0.0050)	0.043
C2-Naphthalenes	ug/g	NV	0.012	0.0083	0.033	0.020	ND (0.0050)	ND (0.0050)
C2-Phenanthrenes/Anthracenes	ug/g	NV	0.011	0.026	0.26	0.10	0.0068	0.10
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	0.032	0.050	0.35	0.19	0.013	0.13
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	ND (0.0050)	0.0091	0.050	0.025	ND (0.0050)	0.020
C3-Dibenzothiophenes	ug/g	NV	0.011	0.033	0.28	0.11	0.0074	0.11
C3-Fluoranthenes/Pyrenes	ug/g	NV	0.017	0.038	0.27	0.12	0.010	0.10
C3-Fluorenes	ug/g	NV	0.026	0.064	0.76	0.28	0.011	0.24
C3-Naphthalenes	ug/g	NV	0.018	0.014	0.066	0.034	0.0099	0.018
C4-Alkylated fluoranthene/Pyrenes (C4-202 isomers)	ug/g	NV	ND (0.0050)	ND (0.0050)	0.18	ND (0.0050)	ND (0.0050)	ND (0.0050)
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	0.044	0.060	0.42	0.37	0.013	0.12
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	ND (0.0050)	ND (0.0050)	0.0074	ND (0.0050)	ND (0.0050)	ND (0.0050)
C4-Dibenzothiophenes	ug/g	NV	0.011	0.020	0.19	0.12	ND (0.0050)	0.091
C4-Naphthalenes	ug/g	NV	ND (0.0050)	ND (0.0050)	0.074	0.038	ND (0.0050)	0.027
Chrysene	ug/g	0.34	ND (0.0050)	ND (0.0050)	0.0084	0.0051	ND (0.0050)	0.0059
Dibenz(a,h)anthracene	ug/g	0.06	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Dibenzothiopene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Fluoranthene	ug/g	0.75	ND (0.0050)	0.013	0.023	0.013	ND (0.0050)	0.013
Fluorene	ug/g	0.19	ND (0.0050)	ND (0.0050)	ND (0.020)	ND (0.010)	ND (0.0050)	ND (0.020)
Indeno(1,2,3-cd)fluoranthene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Indeno(1,2,3-cd)pyrene	ug/g	0.2	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Naphthalene	ug/g	NV	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Perylene	ug/g	NV	0.054	0.013	0.0062	0.012	ND (0.0050)	ND (0.0050)
Phenanthrene	ug/g	0.56	ND (0.0050)	0.012	0.027	0.017	ND (0.0050)	0.017
Pyrene	ug/g	0.49	ND (0.0050)	0.019	0.041	0.024	ND (0.0050)	0.040
Total benzo(a)pyrene equivalents	ug/g	NV	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)

Table A.2

Analytical and Screening Results Summary - November 2016 Additional Sediment Sampling
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

Sample Location:			RIVER 20-1A	RIVER 20-5A/C	RIVER 14	RIVER 14	RIVER 12	RIVER 12
Sample ID:			SED-11102200-111516-DM-01	SED-11102200-111516-DM-02	SED-11102200-112416-DM-01	SED-11102200-112516-DM-03	SED-11102200-112516-DM-01	SED-11102200-112516-DM-02
Sample Date:			11/15/2016	11/15/2016	11/24/2016	11/25/2016	11/25/2016	11/25/2016
Parameters	**Units**	**MOECC or USEPA Region 5 Screening Value[a] (µg/g dw)**						
Petroleum Products								
Chromatogram to baseline at nC50	ug/g	NV	YES	YES	YES	YES	YES	YES
Petroleum hydrocarbons F1 (C6-C10)	ug/g	NV	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Petroleum hydrocarbons F1 (C6-C10) - less BTEX	ug/g	NV	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Petroleum hydrocarbons F2 (C10-C16)	ug/g	NV	ND (10)	21	32	27	ND (10)	77
Petroleum hydrocarbons F3 (C16-C34)	ug/g	NV	ND (50)	110	220	120	ND (50)	330
Petroleum hydrocarbons F4 (C34-C50)	ug/g	NV	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Geotech								
#10 sieve (passed)	%	NV	100.0	100.0	98.7	74.9	100.0	98.8
#100 sieve (passed)	%	NV	43.9	42.3	36.7	16.1	4.4	22.4
#20 sieve (passed)	%	NV	97.5	99.1	89.5	52.0	98.8	93.5
#200 sieve (passed)	%	NV	20.4	17.0	11.0	7.7	3.6	5.0
#4 sieve (passed)	%	NV	100.0	100.0	100.0	79.6	100.0	100.0
#40 sieve (passed)	%	NV	79.3	89.3	73.7	28.5	48.6	78.1
Clay	%	NV	0.3	0.0	1.7	1.6	0.0	1.0
Hydrometer passing 1 min.	%	NV	8.0	6.0	3.3	1.6	0.5	2.0
Hydrometer passing 10 min.	%	NV	3.4	3.6	1.6	1.6	0.5	1.0
Hydrometer passing 1080 min.	%	NV	0.0	0.0	1.6	1.2	0.0	1.0
Hydrometer passing 270 min.	%	NV	1.1	0.0	1.6	1.2	0.0	1.0
Hydrometer passing 3 min.	%	NV	4.6	4.8	2.5	1.6	0.5	1.0
Hydrometer passing 30 min.	%	NV	2.3	1.2	1.6	1.6	0.0	1.0
Hydrometer passing 90 min.	%	NV	1.1	0.0	1.6	1.6	0.0	1.0
Moisture	%	NV	20	21	20	17	21	21
Sand	%	NV	92.4	94.2	96.8	97.9	99.5	98.1
Silt	%	NV	7.3	5.8	1.5	0.5	0.5	0.9
General Chemistry								
Black carbon	%	NV	NO	1	NO	NO	NO	NO
Moisture	%	NV	26 / 22	21 / 21	18	18	19	21
Total organic carbon (TOC)	ug/g	NV	4000	2300	2300	3900	ND (500)	1000
Total solids	%	NV	78.5	78.4	-	-	-	-

Notes:

µg/g dw = Microgram per gram dry weight
ND = Not detected at the associated reporting limit
NV = No value is prescribed for associated paramter
26 / 22 indicates duplicate results
USEPA = United States Environmental Protection Agency
MOECC = Ministry of the Environment and Climate Change
SQG = Sediment Quality Guidelines
PSQG = Provincial Sediment Quality Guidelines

[a] Screening values for PAHs are based on SQG of MOECC (2011), which are identical to PSQG of MOE (1993), and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003).

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.
MOE, 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, August, 1993.
USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

Table A.3a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark												
Sample Location:				**RIVER 20-1A**			**RIVER 20-5A/C**			**RIVER 14**		
Sample ID:		**MOECC or USEPA Region 5**		**SED-11102200-111516-DM-01**			**SED-11102200-111516-DM-02**			**SED-11102200-112416-DM-01**		
Sample Date:		**Screening Value[a]**	**ESB_i**	**11/15/2016**			**11/15/2016**			**11/24/2016**		
Parameters	**Units**	**(µg/g dw)**	**(µg/g OC)**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**
34 PAHs considered by USEPA (2003a)[b]												
Acenaphthene	ug/g	NV	491	ND (0.0050)	0.63	0.0013	ND (0.0050)	1.09	0.0022	ND (0.0050)	1.09	0.0022
Acenaphthylene	ug/g	NV	452	ND (0.0050)	0.63	0.0014	ND (0.0050)	1.09	0.0024	ND (0.0050)	1.09	0.0024
Anthracene	ug/g	0.22	594	ND (0.0050)	0.63	0.0011	ND (0.0050)	1.09	0.0018	0.012	5.22	0.0088
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.63	0.0007	ND (0.0060)	1.30	0.0016	0.0059	2.57	0.0031
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0011	0.0051	2.22	0.0023
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	NV	980	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0011	0.0079	3.43	0.0035
Benzo(e)pyrene	ug/g	NV	967	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0011	0.013	5.65	0.0058
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0010	0.0074	3.22	0.0029
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0011	ND (0.0050)	1.09	0.0011
C1-Fluorenes	ug/g	NV	611	ND (0.0050)	0.63	0.0010	ND (0.0050)	1.09	0.0018	0.038	16.52	0.0270
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	929	0.0056	1.40	0.0015	0.0076	3.30	0.0036	0.035	15.22	0.0164
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	770	0.017	4.25	0.0055	0.019	8.26	0.0107	0.12	52.17	0.0678
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	670	0.011	2.75	0.0041	0.015	6.52	0.0097	0.11	47.83	0.0714
C1-Naphthalenes	ug/g	NV	444	0.012	3.00	0.0068	ND (0.0050)	1.09	0.0024	0.011	4.78	0.0108
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	1008	0.0083	2.08	0.0021	0.013	5.65	0.0056	0.1	43.48	0.0431
C2-Fluorenes	ug/g	NV	686	0.0063	1.58	0.0023	0.016	6.96	0.0101	0.17	73.91	0.1077
C2-Naphthalenes	ug/g	NV	510	0.012	3.00	0.0059	0.0083	3.61	0.0071	0.033	14.35	0.0281
C2-Phenanthrenes/Anthracenes	ug/g	NV	746	0.011	2.75	0.0037	0.026	11.30	0.0152	0.26	113.04	0.1515
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	829	0.032	8.00	0.0097	0.05	21.74	0.0262	0.35	152.17	0.1836
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	1112	ND (0.0050)	0.63	0.0006	0.0091	3.96	0.0036	0.05	21.74	0.0195
C3-Fluorenes	ug/g	NV	769	0.026	6.50	0.0085	0.064	27.83	0.0362	0.76	330.43	0.4297
C3-Naphthalenes	ug/g	NV	581	0.018	4.50	0.0077	0.014	6.09	0.0105	0.066	28.70	0.0494
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	913	0.044	11.00	0.0120	0.06	26.09	0.0286	0.42	182.61	0.2000
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	1214	ND (0.0050)	0.63	0.0005	ND (0.0050)	1.09	0.0009	0.0074	3.22	0.0027
C4-Naphthalenes	ug/g	NV	657	ND (0.0050)	0.63	0.0010	ND (0.0050)	1.09	0.0017	0.074	32.17	0.0490
Chrysene	ug/g	0.34	844	ND (0.0050)	0.63	0.0007	ND (0.0050)	1.09	0.0013	0.0084	3.65	0.0043
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0010	ND (0.0050)	1.09	0.0010
Fluoranthene	ug/g	0.75	707	ND (0.0050)	0.63	0.0009	0.013	5.65	0.0080	0.023	10.00	0.0141
Fluorene	ug/g	0.19	538	ND (0.0050)	0.63	0.0012	ND (0.0050)	1.09	0.0020	ND (0.020)	4.35	0.0081
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.63	0.0006	ND (0.0050)	1.09	0.0010	ND (0.0050)	1.09	0.0010
Naphthalene	ug/g	NV	385	ND (0.0050)	0.63	0.0016	ND (0.0050)	1.09	0.0028	ND (0.0050)	1.09	0.0028
Perylene	ug/g	NV	967	0.054	13.50	0.0140	0.013	5.65	0.0058	0.0062	2.70	0.0028
Phenanthrene	ug/g	0.56	596	ND (0.0050)	0.63	0.0010	0.012	5.22	0.0088	0.027	11.74	0.0197
Pyrene	ug/g	0.49	697	ND (0.0050)	0.63	0.0009	0.019	8.26	0.0119	0.041	17.83	0.0256
PAH sum of $ESBTUI^d$						0.1018			0.2298			1.5692
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured												
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.												
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured												
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured												
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.1			0.2			2

Table A.3a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX												
Ethylbenzene		0.175	970	ND (0.020)	2.50	0.0026	ND (0.020)	4.35	0.0045	ND (0.020)	4.35	0.0045
m&p-Xylenes		NV	980	ND (0.040)	5.00	0.0051	ND (0.040)	8.70	0.0089	ND (0.040)	8.70	0.0089
Toluene		1.22	810	ND (0.020)	2.50	0.0031	ND (0.020)	4.35	0.0054	ND (0.020)	4.35	0.0054
Xylenes (total)		0.43	980	ND (0.040)	5.00	0.0051	ND (0.040)	8.70	0.0089	ND (0.040)	8.70	0.0089
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[e]						0.01			0.02			0.02
Total organic carbon (TOC)	ug/g			4000			2300			2300		
foc				0.0040			0.0023			0.0023		
Black carbon	%			NO			NO			NO		

Notes:

NV = No value is prescribed for associated paramter
µg/g dw = Microgram per gram dry weight
J = Estimated concentration
ND = Not detected at the associated reporting limit
R = Rejected
C = Concentration
MOECC = Ministry of the Environment and Climate Change

TOC = Total organic carbon
PAH = Polycylic aromatic hydrocarbon
BTEX = Benzene, toluene, ethylbenzene, and xylene
ESB = Equilibrium partitioning sediment benchmark
ΣESBTU = Sum of equilibrium partitioning sediment benchmark
TU = Toxic unit
USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned either a value equal to one-half of the detection limit (DL).

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] The calculation of ESBs according to the equilibrium partioning method apply to sediments with TOC > 0.2%. Given that TOC was < 0.2% in this sample, the MOECC sediment screening values (see note "a") were used to calculate the TU for PAHs.

[e] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

[f] The organic carbon content of this background sample was less than 0.2%, however, no MOECC sediment screening values are available for toluene, ethylbenzene, or xylenes to calculate the toxic unit. It should be noted that toluene, ethylbenzene, and xylenes were not detected in this sample.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.3a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark Sample Location: Sample ID: Sample Date: Parameters	Units	MOECC or USEPA Region 5 Screening Value[a] (µg/g dw)	ESB_i (µg/g OC)	RIVER 14 SED-11102200-112516-DM-03 11/25/2016 C_{sed} (µg/g dw)	C_{oc} (µg/g OC)	$ESBTU_i$	RIVER 12 SED-11102200-112516-DM-01 11/25/2016 C_{sed} (µg/g dw)	$TU_{MOECC\ SB}$[d]	RIVER 12 SED-11102200-112516-DM-02 11/25/2016 C_{sed} (µg/g dw)	$TU_{MOECC\ SB}$[d]
34 PAHs considered by USEPA (2003a)[b]										
Acenaphthene	ug/g	NV	491	ND (0.0050)	0.64	0.0013	ND (0.0050)	-	ND (0.0050)	-
Acenaphthylene	ug/g	NV	452	ND (0.0050)	0.64	0.0014	ND (0.0050)	-	ND (0.0050)	-
Anthracene	ug/g	0.22	594	ND (0.0050)	0.64	0.0011	ND (0.0050)	0.0114	0.011	0.0500
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.64	0.0008	ND (0.0050)	0.0078	ND (0.0050)	0.0078
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.64	0.0007	ND (0.0050)	0.0068	ND (0.0050)	0.0068
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	NV	980	0.005	1.28	0.0013	ND (0.0050)	-	0.0051	-
Benzo(e)pyrene	ug/g	NV	967	ND (0.0050)	0.64	0.0007	ND (0.0050)	-	ND (0.0050)	-
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.64	0.0006	ND (0.0050)	0.0147	0.008	0.0471
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.64	0.0007	ND (0.0050)	0.0104	ND (0.0050)	0.0104
C1-Fluorenes	ug/g	NV	611	0.02	5.13	0.0084	ND (0.0050)	-	0.011	-
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	929	0.016	4.10	0.0044	ND (0.0050)	-	0.015	-
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	770	0.047	12.05	0.0157	0.0059	-	0.034	-
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	670	0.047	12.05	0.0180	ND (0.0050)	-	0.036	-
C1-Naphthalenes	ug/g	NV	444	0.0074	1.90	0.0043	0.0065	-	ND (0.0050)	-
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	1008	0.044	11.28	0.0112	ND (0.0050)	-	0.04	-
C2-Fluorenes	ug/g	NV	686	0.072	18.46	0.0269	ND (0.0050)	-	0.043	-
C2-Naphthalenes	ug/g	NV	510	0.02	5.13	0.0101	ND (0.0050)	-	ND (0.0050)	-
C2-Phenanthrenes/Anthracenes	ug/g	NV	746	0.1	25.64	0.0344	0.0068	-	0.1	-
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	829	0.19	48.72	0.0588	0.013	-	0.13	-
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	1112	0.025	6.41	0.0058	ND (0.0050)	-	0.02	-
C3-Fluorenes	ug/g	NV	769	0.28	71.79	0.0934	0.011	-	0.24	-
C3-Naphthalenes	ug/g	NV	581	0.034	8.72	0.0150	0.0099	-	0.018	-
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	913	0.37	94.87	0.1039	0.013	-	0.12	-
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	1214	ND (0.0050)	0.64	0.0005	ND (0.0050)	-	ND (0.0050)	-
C4-Naphthalenes	ug/g	NV	657	0.038	9.74	0.0148	ND (0.0050)	-	0.027	-
Chrysene	ug/g	0.34	844	0.0051	1.31	0.0015	ND (0.0050)	0.0074	0.0059	0.0174
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.64	0.0006	ND (0.0050)	0.0417	ND (0.0050)	0.0417
Fluoranthene	ug/g	0.75	707	0.013	3.33	0.0047	ND (0.0050)	0.0033	0.013	0.0173
Fluorene	ug/g	0.19	538	ND (0.010)	1.28	0.0024	ND (0.0050)	0.0132	ND (0.020)	0.0526
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.64	0.0006	ND (0.0050)	0.0125	ND (0.0050)	0.0125
Naphthalene	ug/g	NV	385	ND (0.0050)	0.64	0.0017	ND (0.0050)	-	ND (0.0050)	-
Perylene	ug/g	NV	967	0.012	3.08	0.0032	ND (0.0050)	-	ND (0.0050)	-
Phenanthrene	ug/g	0.56	596	0.017	4.36	0.0073	ND (0.0050)	0.0045	0.017	0.0304
Pyrene	ug/g	0.49	697	0.024	6.15	0.0088	ND (0.0050)	0.0051	0.040	0.0816
PAH sum of ESBTUi[d]						0.4646		0.1386		0.3755
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured										
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.								3.2		3.2
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured								0.4436		1.2017
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured								C4		C4
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.5		0.4		1.2

Table A.3a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX									
Ethylbenzene		0.175	970	ND (0.020)	2.56	0.0026	ND (0.020)	-	ND (0.020)	-
m&p-Xylenes		NV	980	ND (0.040)	5.13	0.0052	ND (0.040)	-	ND (0.040)	-
Toluene		1.22	810	ND (0.020)	2.56	0.0032	ND (0.020)	-	ND (0.020)	-
Xylenes (total)		0.43	980	ND (0.040)	5.13	0.0052	ND (0.040)	-	ND (0.040)	-
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[e]						0.01		-[f]		-[f]
Total organic carbon (TOC)	ug/g			3900			ND (500)		1000	
foc				0.0039			0.00025		0.0010	
Black carbon	%			NO			NO		NO	

Notes:

NV = No value is prescribed for associated paramter
µg/g dw = Microgram per gram dry weight
J = Estimated concentration
ND = Not detected at the associated reporting limit
R = Rejected
C = Concentration
MOECC = Ministry of the Environment and Climate Change

TOC = Total organic carbon
PAH = Polycylic aromatic hydrocarbon
BTEX = Benzene, toluene, ethylbenzene, and xylene
ESB = Equilibrium partitioning sediment benchmark
ΣESBTU = Sum of equilibrium partitioning sediment benchmark
TU = Toxic unit
USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned either a value equal to one-half of the detection limit (DL).

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] The calculation of ESBs according to the equilibrium partioning method apply to sediments with TOC > 0.2%. Given that TOC was < 0.2% in this sample, the MOECC sediment screening values (see note "a") were used to calculate the TU for PAHs.

[e] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

[f] The organic carbon content of this background sample was less than 0.2%, however, no MOECC sediment screening values are available for toluene, ethylbenzene, or xylenes to calculate the toxic unit. It should be noted that toluene, ethylbenzene, and xylenes were not detected in this sample.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.3b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark				RIVER 20-1A			RIVER 20-5A/C			RIVER 14		
Sample Location:												
Sample ID:		**MOECC or USEPA Region 5**		**SED-11102200-111516-DM-01**			**SED-11102200-111516-DM-02**			**SED-11102200-112416-DM-01**		
Sample Date:		**Screening Value[a]**	**ESB_i**	**11/15/2016**			**11/15/2016**			**11/24/2016**		
Parameters	**Units**	**(µg/g dw)**	**(µg/g OC)**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**
34 PAHs considered by USEPA (2003a)[b]												
Acenaphthene	ug/g	-	491	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Acenaphthylene	ug/g	-	452	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Anthracene	ug/g	0.22	594	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.012	5.22	0.0088
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.00	0.0000	ND (0.0060)	0.00	0.0000	0.0059	2.57	0.0031
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0051	2.22	0.0023
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	-	980	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0079	3.43	0.0035
Benzo(e)pyrene	ug/g	-	967	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.013	5.65	0.0058
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0074	3.22	0.0029
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
C1-Fluorenes	ug/g	-	611	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.038	16.52	0.0270
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	-	929	0.0056	1.40	0.0015	0.0076	3.30	0.0036	0.035	15.22	0.0164
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	-	770	0.017	4.25	0.0055	0.019	8.26	0.0107	0.12	52.17	0.0678
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	-	670	0.011	2.75	0.0041	0.015	6.52	0.0097	0.11	47.83	0.0714
C1-Naphthalenes	ug/g	-	444	0.012	3.00	0.0068	ND (0.0050)	0.00	0.0000	0.011	4.78	0.0108
C2-Benzo(a)anthracenes/chrysenes	ug/g	-	1008	0.0083	2.08	0.0021	0.013	5.65	0.0056	0.1	43.48	0.0431
C2-Fluorenes	ug/g	-	686	0.0063	1.58	0.0023	0.016	6.96	0.0101	0.17	73.91	0.1077
C2-Naphthalenes	ug/g	-	510	0.012	3.00	0.0059	0.0083	3.61	0.0071	0.033	14.35	0.0281
C2-Phenanthrenes/Anthracenes	ug/g	-	746	0.011	2.75	0.0037	0.026	11.30	0.0152	0.26	113.04	0.1515
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	-	829	0.032	8.00	0.0097	0.05	21.74	0.0262	0.35	152.17	0.1836
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	-	1112	ND (0.0050)	0.00	0.0000	0.0091	3.96	0.0036	0.05	21.74	0.0195
C3-Fluorenes	ug/g	-	769	0.026	6.50	0.0085	0.064	27.83	0.0362	0.76	330.43	0.4297
C3-Naphthalenes	ug/g	NV	581	0.018	4.50	0.0077	0.014	6.09	0.0105	0.066	28.70	0.0494
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	-	913	0.044	11.00	0.0120	0.06	26.09	0.0286	0.42	182.61	0.2000
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	-	1214	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0074	3.22	0.0027
C4-Naphthalenes	ug/g	-	657	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.074	32.17	0.0490
Chrysene	ug/g	0.34	844	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0084	3.65	0.0043
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Fluoranthene	ug/g	0.75	707	ND (0.0050)	0.00	0.0000	0.013	5.65	0.0080	0.023	10.00	0.0141
Fluorene	ug/g	0.19	538	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.020)	0.00	0.0000
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Naphthalene	ug/g	-	385	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Perylene	ug/g	-	967	0.054	13.50	0.0140	0.013	5.65	0.0058	0.0062	2.70	0.0028
Phenanthrene	ug/g	0.56	596	ND (0.0050)	0.00	0.0000	0.012	5.22	0.0088	0.027	11.74	0.0197
Pyrene	ug/g	0.49	697	ND (0.0050)	0.00	0.0000	0.019	8.26	0.0119	0.041	17.83	0.0256
PAH sum of ESBTUi[d]						0.0837			0.2015			1.5507
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured												
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.												
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured												
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured												
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.08			0.2			**2**

Table A.3b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX												
Ethylbenzene		0.175	970	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000
m&p-Xylenes		-	980	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000
Toluene		1.22	810	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000
Xylenes (total)		0.43	980	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[e]						0			0			0
Total organic carbon (TOC)	ug/g			4000			2300			2300		
foc				0.0040			0.0023			0.0023		
foc < 0.002												
Black carbon	%											

Notes:

NV = No value is prescribed for associated paramter	TOC = Total organic carbon
µg/g dw = Microgram per gram dry weight	PAH = Polycylic aromatic hydrocarbon
J = Estimated concentration	BTEX = Benzene, toluene, ethylbenzene, and xylene
ND = Not detected at the associated reporting limit	ESB = Equilibrium partitioning sediment benchmark
R = Rejected	ΣESBTU = Sum of equilibrium partitioning sediment benchmark
C = Concentration	TU = Toxic unit
MOECC = Ministry of the Environment and Climate Change	USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned a value equal to zero.

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] The calculation of ESBs according to the equilibrium partioning method apply to sediments with TOC > 0.2%. Given that TOC was < 0.2% in this sample, the MOECC sediment screening values (see note "a") were used to calculate the TU for PAHs.

[e] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

[f] The organic carbon content of this background sample was less than 0.2%, however, no MOECC sediment screening values are available for toluene, ethylbenzene, or xylenes to calculate the toxic unit. It should be noted that toluene, ethylbenzene, and xylenes were not detected in this sample.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.3b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark Sample Location: Sample ID: Sample Date: Parameters	Units	MOECC or USEPA Region 5 Screening Value[a] (µg/g dw)	ESB_i (µg/g OC)	RIVER 14 SED-11102200-112516-DM-03 11/25/2016 C_{sed} (µg/g dw)	C_{oc} (µg/g OC)	$ESBTU_i$	RIVER 12 SED-11102200-112516-DM-01 11/25/2016 C_{sed} (µg/g dw)	$TU_{MOECC\ SB}$[d]	RIVER 12 SED-11102200-112516-DM-02 11/25/2016 C_{sed} (µg/g dw)	$TU_{MOECC\ SB}$[d]
34 PAHs considered by USEPA (2003a)[b]										
Acenaphthene	ug/g	-	491	ND (0.0050)	0.00	0.0000	ND (0.0050)	-	ND (0.0050)	-
Acenaphthylene	ug/g	-	452	ND (0.0050)	0.00	0.0000	ND (0.0050)	-	ND (0.0050)	-
Anthracene	ug/g	0.22	594	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	0.011	0.0500
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	ND (0.0050)	0.0000
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	ND (0.0050)	0.0000
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	-	980	0.005	1.28	0.0013	ND (0.0050)	-	0.0051	-
Benzo(e)pyrene	ug/g	-	967	ND (0.0050)	0.00	0.0000	ND (0.0050)	-	ND (0.0050)	-
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	0.008	0.0471
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	ND (0.0050)	0.0000
C1-Fluorenes	ug/g	-	611	0.02	5.13	0.0084	ND (0.0050)	-	0.011	-
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	-	929	0.016	4.10	0.0044	ND (0.0050)	-	0.015	-
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	-	770	0.047	12.05	0.0157	0.0059	-	0.034	-
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	-	670	0.047	12.05	0.0180	ND (0.0050)	-	0.036	-
C1-Naphthalenes	ug/g	-	444	0.0074	1.90	0.0043	0.0065	-	ND (0.0050)	-
C2-Benzo(a)anthracenes/chrysenes	ug/g	-	1008	0.044	11.28	0.0112	ND (0.0050)	-	0.04	-
C2-Fluorenes	ug/g	-	686	0.072	18.46	0.0269	ND (0.0050)	-	0.043	-
C2-Naphthalenes	ug/g	-	510	0.02	5.13	0.0101	ND (0.0050)	-	ND (0.0050)	-
C2-Phenanthrenes/Anthracenes	ug/g	-	746	0.1	25.64	0.0344	0.0068	-	0.1	-
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	-	829	0.19	48.72	0.0588	0.013	-	0.13	-
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	-	1112	0.025	6.41	0.0058	ND (0.0050)	-	0.02	-
C3-Fluorenes	ug/g	-	769	0.28	71.79	0.0934	0.011	-	0.24	-
C3-Naphthalenes	ug/g	NV	581	0.034	8.72	0.0150	0.0099	-	0.018	-
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	-	913	0.37	94.87	0.1039	0.013	-	0.12	-
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	-	1214	ND (0.0050)	0.00	0.0000	ND (0.0050)	-	ND (0.0050)	-
C4-Naphthalenes	ug/g	-	657	0.038	9.74	0.0148	ND (0.0050)	-	0.027	-
Chrysene	ug/g	0.34	844	0.0051	1.31	0.0015	ND (0.0050)	0.0000	0.0059	0.0174
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	ND (0.0050)	0.0000
Fluoranthene	ug/g	0.75	707	0.013	3.33	0.0047	ND (0.0050)	0.0000	0.013	0.0173
Fluorene	ug/g	0.19	538	ND (0.010)	0.00	0.0000	ND (0.0050)	0.0000	ND (0.020)	0.0000
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.0000	ND (0.0050)	0.0000
Naphthalene	ug/g	-	385	ND (0.0050)	0.00	0.0000	ND (0.0050)	-	ND (0.0050)	-
Perylene	ug/g	-	967	0.012	3.08	0.0032	ND (0.0050)	-	ND (0.0050)	-
Phenanthrene	ug/g	0.56	596	0.017	4.36	0.0073	ND (0.0050)	0.0000	0.017	0.0304
Pyrene	ug/g	0.49	697	0.024	6.15	0.0088	ND (0.0050)	0.0000	0.04	0.0816
PAH sum of ESBTUi[d]						0.4518		0.0000		0.2437
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured										
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.								3.2		3.2
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured								0.0000		0.7800
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured								C4		C4
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.5		0.0		0.8

Table A.3b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Measured Organic Carbon Content in Each Sample (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX									
Ethylbenzene		0.175	970	ND (0.020)	0.00	0.0000	ND (0.020)	-	ND (0.020)	-
m&p-Xylenes		-	980	ND (0.040)	0.00	0.0000	ND (0.040)	-	ND (0.040)	-
Toluene		1.22	810	ND (0.020)	0.00	0.0000	ND (0.020)	-	ND (0.020)	-
Xylenes (total)		0.43	980	ND (0.040)	0.00	0.0000	ND (0.040)	-	ND (0.040)	-
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[e]						0		-[f]		-[f]
Total organic carbon (TOC)	ug/g			3900			ND (500)		1000	
foc				0.0039			0.00025		0.0010	
foc < 0.002										
Black carbon	%									

Notes:
NV = No value is prescribed for associated paramter
µg/g dw = Microgram per gram dry weight
J = Estimated concentration
ND = Not detected at the associated reporting limit
R = Rejected
C = Concentration
MOECC = Ministry of the Environment and Climate Change
TOC = Total organic carbon
PAH = Polycylic aromatic hydrocarbon
BTEX = Benzene, toluene, ethylbenzene, and xylene
ESB = Equilibrium partitioning sediment benchmark
ΣESBTU = Sum of equilibrium partitioning sediment benchmark
TU = Toxic unit
USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned a value equal to zero.

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] The calculation of ESBs according to the equilibrium partioning method apply to sediments with TOC > 0.2%. Given that TOC was < 0.2% in this sample, the MOECC sediment screening values (see note "a") were used to calculate the TU for PAHs.

[e] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

[f] The organic carbon content of this background sample was less than 0.2%, however, no MOECC sediment screening values are available for toluene, ethylbenzene, or xylenes to calculate the toxic unit. It should be noted that toluene, ethylbenzene, and xylenes were not detected in this sample.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.4a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark												
Sample Location:				RIVER 20-1A			RIVER 20-5A/C			RIVER 14		
Sample ID:		MOECC or USEPA Region 5		SED-11102200-111516-DM-01			SED-11102200-111516-DM-02			SED-11102200-112416-DM-01		
Sample Date:		Screening Value[a]	ESB_i	11/15/2016			11/15/2016			11/24/2016		
Parameters	**Units**	**(µg/g dw)**	**(µg/g OC)**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**
34 PAHs considered by USEPA (2003a)[b]												
Acenaphthene	ug/g	NV	491	ND (0.0050)	0.78	0.0016	ND (0.0050)	0.78	0.0016	ND (0.0050)	1.04	0.0021
Acenaphthylene	ug/g	NV	452	ND (0.0050)	0.78	0.0017	ND (0.0050)	0.78	0.0017	ND (0.0050)	1.04	0.0023
Anthracene	ug/g	0.22	594	ND (0.0050)	0.78	0.0013	ND (0.0050)	0.78	0.0013	0.012	4.98	0.0084
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.78	0.0009	ND (0.0060)	0.93	0.0011	0.0059	2.45	0.0029
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.78	0.0008	ND (0.0050)	0.78	0.0008	0.0051	2.12	0.0022
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	NV	980	ND (0.0050)	0.78	0.0008	ND (0.0050)	0.78	0.0008	0.0079	3.28	0.0033
Benzo(e)pyrene	ug/g	NV	967	ND (0.0050)	0.78	0.0008	ND (0.0050)	0.78	0.0008	0.013	5.40	0.0056
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.78	0.0007	ND (0.0050)	0.78	0.0007	0.0074	3.07	0.0028
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.78	0.0008	ND (0.0050)	0.78	0.0008	ND (0.0050)	1.04	0.0011
C1-Fluorenes	ug/g	NV	611	ND (0.0050)	0.78	0.0013	ND (0.0050)	0.78	0.0013	0.038	15.79	0.0258
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	929	0.0056	1.74	0.0019	0.0076	2.36	0.0025	0.035	14.54	0.0157
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	770	0.017	5.28	0.0069	0.019	5.90	0.0077	0.12	49.85	0.0647
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	670	0.011	3.42	0.0051	0.015	4.66	0.0070	0.11	45.69	0.0682
C1-Naphthalenes	ug/g	NV	444	0.012	3.73	0.0084	ND (0.0050)	0.78	0.0017	0.011	4.57	0.0103
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	1008	0.0083	2.58	0.0026	0.013	4.04	0.0040	0.1	41.54	0.0412
C2-Fluorenes	ug/g	NV	686	0.0063	1.96	0.0029	0.016	4.97	0.0072	0.17	70.62	0.1029
C2-Naphthalenes	ug/g	NV	510	0.012	3.73	0.0073	0.0083	2.58	0.0051	0.033	13.71	0.0269
C2-Phenanthrenes/Anthracenes	ug/g	NV	746	0.011	3.42	0.0046	0.026	8.08	0.0108	0.26	108.00	0.1448
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	829	0.032	9.94	0.0120	0.05	15.53	0.0187	0.35	145.39	0.1754
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	1112	ND (0.0050)	0.78	0.0007	0.0091	2.83	0.0025	0.05	20.77	0.0187
C3-Fluorenes	ug/g	NV	769	0.026	8.08	0.0105	0.064	19.88	0.0259	0.76	315.70	0.4105
C3-Naphthalenes	ug/g	NV	581	0.018	5.59	0.0096	0.014	4.35	0.0075	0.066	27.42	0.0472
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	913	0.044	13.67	0.0150	0.06	18.64	0.0204	0.42	174.47	0.1911
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	1214	ND (0.0050)	0.78	0.0006	ND (0.0050)	0.78	0.0006	0.0074	3.07	0.0025
C4-Naphthalenes	ug/g	NV	657	ND (0.0050)	0.78	0.0012	ND (0.0050)	0.78	0.0012	0.074	30.74	0.0468
Chrysene	ug/g	0.34	844	ND (0.0050)	0.78	0.0009	ND (0.0050)	0.78	0.0009	0.0084	3.49	0.0041
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.78	0.0007	ND (0.0050)	0.78	0.0007	ND (0.0050)	1.04	0.0009
Fluoranthene	ug/g	0.75	707	ND (0.0050)	0.78	0.0011	0.013	4.04	0.0057	0.023	9.55	0.0135
Fluorene	ug/g	0.19	538	ND (0.0050)	0.78	0.0014	ND (0.0050)	0.78	0.0014	ND (0.020)	4.15	0.0077
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.78	0.0007	ND (0.0050)	0.78	0.0007	ND (0.0050)	1.04	0.0009
Naphthalene	ug/g	NV	385	ND (0.0050)	0.78	0.0020	ND (0.0050)	0.78	0.0020	ND (0.0050)	1.04	0.0027
Perylene	ug/g	NV	967	0.054	16.78	0.0173	0.013	4.04	0.0042	0.0062	2.58	0.0027
Phenanthrene	ug/g	0.56	596	ND (0.0050)	0.78	0.0013	0.012	3.73	0.0063	0.027	11.22	0.0188
Pyrene	ug/g	0.49	697	ND (0.0050)	0.78	0.0011	0.019	5.90	0.0085	0.041	17.03	0.0244
PAH sum of ESBTUi[d]						0.1265			0.1642			1.4993
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured												
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.												
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured												
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured												
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.1			0.2			1

Table A.4a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX											
Ethylbenzene		0.175	970	ND (0.020)	3.11	0.0032	ND (0.020)	3.11	0.0032	ND (0.020)	4.15	0.0043
m&p-Xylenes		-	980	ND (0.040)	6.21	0.0063	ND (0.040)	6.21	0.0063	ND (0.040)	8.31	0.0085
Toluene		1.22	810	ND (0.020)	3.11	0.0038	ND (0.020)	3.11	0.0038	ND (0.020)	4.15	0.0051
Xylenes (total)		0.43	980	ND (0.040)	6.21	0.0063	ND (0.040)	6.21	0.0063	ND (0.040)	8.31	0.0085
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[d]						0.01			0.01			0.02
Geomean of Total organic carbon (TOC)	ug/g			3219			3219			2407		
Geomean of foc				0.0032			0.0032			0.0024		
Black carbon	%											

Notes:

NV = No value is prescribed for associated paramter	TOC = Total organic carbon
µg/g dw = Microgram per gram dry weight	PAH = Polycylic aromatic hydrocarbon
J = Estimated concentration	BTEX = Benzene, toluene, ethylbenzene, and xylene
ND = Not detected at the associated reporting limit	ESB = Equilibrium partitioning sediment benchmark
R = Rejected	ΣESBTU = Sum of equilibrium partitioning sediment benchmark
C = Concentration	TU = Toxic unit
MOECC = Ministry of the Environment and Climate Change	USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned either a value equal to one-half of the detection limit (DL).

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.4a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark												
Sample Location:				**RIVER 14**			**RIVER 12**			**RIVER 12**		
Sample ID:		**MOECC or USEPA Region 5**		**SED-11102200-112516-DM-03**			**SED-11102200-112516-DM-01**			**SED-11102200-112516-DM-02**		
Sample Date:		**Screening Value[a]**	**ESB_i**	**11/25/2016**			**11/25/2016**			**11/25/2016**		
Parameters	**Units**	**(µg/g dw)**	**(µg/g OC)**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**
34 PAHs considered by USEPA (2003a)[b]												
Acenaphthene	ug/g	NV	491	ND (0.0050)	1.04	0.0021	ND (0.0050)	1.04	0.0021	ND (0.0050)	1.04	0.0021
Acenaphthylene	ug/g	NV	452	ND (0.0050)	1.04	0.0023	ND (0.0050)	1.04	0.0023	ND (0.0050)	1.04	0.0023
Anthracene	ug/g	0.22	594	ND (0.0050)	1.04	0.0017	ND (0.0050)	1.04	0.0017	0.011	4.57	0.0077
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	1.04	0.0012	ND (0.0050)	1.04	0.0012	ND (0.0050)	1.04	0.0012
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	NV	980	0.005	2.08	0.0021	ND (0.0050)	1.04	0.0011	0.0051	2.12	0.0022
Benzo(e)pyrene	ug/g	NV	967	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009	0.008	3.32	0.0030
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011
C1-Fluorenes	ug/g	NV	611	0.02	8.31	0.0136	ND (0.0050)	1.04	0.0017	0.011	4.57	0.0075
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	929	0.016	6.65	0.0072	ND (0.0050)	1.04	0.0011	0.015	6.23	0.0067
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	770	0.047	19.52	0.0254	0.0059	2.45	0.0032	0.034	14.12	0.0183
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	670	0.047	19.52	0.0291	ND (0.0050)	1.04	0.0015	0.036	14.95	0.0223
C1-Naphthalenes	ug/g	NV	444	0.0074	3.07	0.0069	0.0065	2.70	0.0061	ND (0.0050)	1.04	0.0023
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	1008	0.044	18.28	0.0181	ND (0.0050)	1.04	0.0010	0.04	16.62	0.0165
C2-Fluorenes	ug/g	NV	686	0.072	29.91	0.0436	ND (0.0050)	1.04	0.0015	0.043	17.86	0.0260
C2-Naphthalenes	ug/g	NV	510	0.02	8.31	0.0163	ND (0.0050)	1.04	0.0020	ND (0.0050)	1.04	0.0020
C2-Phenanthrenes/Anthracenes	ug/g	NV	746	0.1	41.54	0.0557	0.0068	2.82	0.0038	0.1	41.54	0.0557
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	829	0.19	78.93	0.0952	0.013	5.40	0.0065	0.13	54.00	0.0651
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	1112	0.025	10.38	0.0093	ND (0.0050)	1.04	0.0009	0.02	8.31	0.0075
C3-Fluorenes	ug/g	NV	769	0.28	116.31	0.1512	0.011	4.57	0.0059	0.24	99.70	0.1296
C3-Naphthalenes	ug/g	NV	581	0.034	14.12	0.0243	0.0099	4.11	0.0071	0.018	7.48	0.0129
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	913	0.37	153.70	0.1683	0.013	5.40	0.0059	0.12	49.85	0.0546
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	1214	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009
C4-Naphthalenes	ug/g	NV	657	0.038	15.79	0.0240	ND (0.0050)	1.04	0.0016	0.027	11.22	0.0171
Chrysene	ug/g	0.34	844	0.0051	2.12	0.0025	ND (0.0050)	1.04	0.0012	0.0059	2.45	0.0029
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009
Fluoranthene	ug/g	0.75	707	0.013	5.40	0.0076	ND (0.0050)	1.04	0.0015	0.013	5.40	0.0076
Fluorene	ug/g	0.19	538	ND (0.010)	2.08	0.0039	ND (0.0050)	1.04	0.0019	ND (0.020)	4.15	0.0077
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009	ND (0.0050)	1.04	0.0009
Naphthalene	ug/g	NV	385	ND (0.0050)	1.04	0.0027	ND (0.0050)	1.04	0.0027	ND (0.0050)	1.04	0.0027
Perylene	ug/g	NV	967	0.012	4.98	0.0052	ND (0.0050)	1.04	0.0011	ND (0.0050)	1.04	0.0011
Phenanthrene	ug/g	0.56	596	0.017	7.06	0.0118	ND (0.0050)	1.04	0.0017	0.017	7.06	0.0118
Pyrene	ug/g	0.49	697	0.024	9.97	0.0143	ND (0.0050)	1.04	0.0015	0.04	16.62	0.0238
PAH sum of ESBTUi[d]						0.7527			0.0769			0.5264
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured												
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.												
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured												
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured												
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.8			0.1			0.5

Table A.4a

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0.5DL)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX											
Ethylbenzene		0.175	970	ND (0.020)	4.15	0.0043	ND (0.020)	4.15	0.0043	ND (0.020)	4.15	0.0043
m&p-Xylenes		-	980	ND (0.040)	8.31	0.0085	ND (0.040)	8.31	0.0085	ND (0.040)	8.31	0.0085
Toluene		1.22	810	ND (0.020)	4.15	0.0051	ND (0.020)	4.15	0.0051	ND (0.020)	4.15	0.0051
Xylenes (total)		0.43	980	ND (0.040)	8.31	0.0085	ND (0.040)	8.31	0.0085	ND (0.040)	8.31	0.0085
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[d]						0.02			0.02			0.02
Geomean of Total organic carbon (TOC)	ug/g			2407			2407			2407		
Geomean of foc				0.0024			0.00241			0.0024		
Black carbon	%											

Notes:

NV = No value is prescribed for associated paramter	TOC = Total organic carbon
µg/g dw = Microgram per gram dry weight	PAH = Polycylic aromatic hydrocarbon
J = Estimated concentration	BTEX = Benzene, toluene, ethylbenzene, and xylene
ND = Not detected at the associated reporting limit	ESB = Equilibrium partitioning sediment benchmark
R = Rejected	ΣESBTU = Sum of equilibrium partitioning sediment benchmark
C = Concentration	TU = Toxic unit
MOECC = Ministry of the Environment and Climate Change	USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned either a value equal to one-half of the detection limit (DL).

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.4b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark												
Sample Location:				**RIVER 20-1A**			**RIVER 20-5A/C**			**RIVER 14**		
Sample ID:		**MOECC or USEPA Region 5**		**SED-11102200-111516-DM-01**			**SED-11102200-111516-DM-02**			**SED-11102200-112416-DM-01**		
Sample Date:		**Screening Value[a]**	**ESB_i**	**11/15/2016**			**11/15/2016**			**11/24/2016**		
Parameters	**Units**	**(µg/g dw)**	**(µg/g OC)**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**
34 PAHs considered by USEPA (2003a)[b]												
Acenaphthene	ug/g	NV	491	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Acenaphthylene	ug/g	NV	452	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Anthracene	ug/g	0.22	594	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.012	4.98	0.0084
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.00	0.0000	ND (0.0060)	0.00	0.0000	0.0059	2.45	0.0029
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0051	2.12	0.0022
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	NV	980	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0079	3.28	0.0033
Benzo(e)pyrene	ug/g	NV	967	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.013	5.40	0.0056
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0074	3.07	0.0028
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
C1-Fluorenes	ug/g	NV	611	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.038	15.79	0.0258
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	929	0.0056	1.74	0.0019	0.0076	2.36	0.0025	0.035	14.54	0.0157
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	770	0.017	5.28	0.0069	0.019	5.90	0.0077	0.12	49.85	0.0647
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	670	0.011	3.42	0.0051	0.015	4.66	0.0070	0.11	45.69	0.0682
C1-Naphthalenes	ug/g	NV	444	0.012	3.73	0.0084	ND (0.0050)	0.00	0.0000	0.011	4.57	0.0103
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	1008	0.0083	2.58	0.0026	0.013	4.04	0.0040	0.1	41.54	0.0412
C2-Fluorenes	ug/g	NV	686	0.0063	1.96	0.0029	0.016	4.97	0.0072	0.17	70.62	0.1029
C2-Naphthalenes	ug/g	NV	510	0.012	3.73	0.0073	0.0083	2.58	0.0051	0.033	13.71	0.0269
C2-Phenanthrenes/Anthracenes	ug/g	NV	746	0.011	3.42	0.0046	0.026	8.08	0.0108	0.26	108.00	0.1448
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	829	0.032	9.94	0.0120	0.05	15.53	0.0187	0.35	145.39	0.1754
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	1112	ND (0.0050)	0.00	0.0000	0.0091	2.83	0.0025	0.05	20.77	0.0187
C3-Fluorenes	ug/g	NV	769	0.026	8.08	0.0105	0.064	19.88	0.0259	0.76	315.70	0.4105
C3-Naphthalenes	ug/g	NV	581	0.018	5.59	0.0096	0.014	4.35	0.0075	0.066	27.42	0.0472
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	913	0.044	13.67	0.0150	0.06	18.64	0.0204	0.42	174.47	0.1911
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	1214	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0074	3.07	0.0025
C4-Naphthalenes	ug/g	NV	657	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.074	30.74	0.0468
Chrysene	ug/g	0.34	844	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.0084	3.49	0.0041
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Fluoranthene	ug/g	0.75	707	ND (0.0050)	0.00	0.0000	0.013	4.04	0.0057	0.023	9.55	0.0135
Fluorene	ug/g	0.19	538	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.020)	0.00	0.0000
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Naphthalene	ug/g	NV	385	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Perylene	ug/g	NV	967	0.054	16.78	0.0173	0.013	4.04	0.0042	0.0062	2.58	0.0027
Phenanthrene	ug/g	0.56	596	ND (0.0050)	0.00	0.0000	0.012	3.73	0.0063	0.027	11.22	0.0188
Pyrene	ug/g	0.49	697	ND (0.0050)	0.00	0.0000	0.019	5.90	0.0085	0.041	17.03	0.0244
PAH sum of ESBTUi[d]						0.1040			0.1440			1.4815
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured												
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.												
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured												
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured												
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.1			0.1			1

Table A.4b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX												
Ethylbenzene		0.175	970	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000
m&p-Xylenes		-	980	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000
Toluene		1.22	810	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000
Xylenes (total)		0.43	980	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[d]						0			0			0
Geomean of Total organic carbon (TOC)	ug/g			3219			3219			2407		
Geomean of foc				0.0032			0.0032			0.0024		
Black carbon	%											

Notes:

NV = No value is prescribed for associated paramter
µg/g dw = Microgram per gram dry weight
J = Estimated concentration
ND = Not detected at the associated reporting limit
R = Rejected
C = Concentration
MOECC = Ministry of the Environment and Climate Change
TOC = Total organic carbon
PAH = Polycylic aromatic hydrocarbon
BTEX = Benzene, toluene, ethylbenzene, and xylene
ESB = Equilibrium partitioning sediment benchmark
ΣESBTU = Sum of equilibrium partitioning sediment benchmark
TU = Toxic unit
USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned a value equal to zero.

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.4b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

One Carbon Model-Equilibrium Partitioning Sediment Benchmark												
Sample Location:				**RIVER 14**			**RIVER 12**			**RIVER 12**		
Sample ID:		**MOECC or USEPA Region 5**		**SED-11102200-112516-DM-03**			**SED-11102200-112516-DM-01**			**SED-11102200-112516-DM-02**		
Sample Date:		**Screening Value[a]**	**ESB_i**	**11/25/2016**			**11/25/2016**			**11/25/2016**		
Parameters	**Units**	**(µg/g dw)**	**(µg/g OC)**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**	**C_{sed} (µg/g dw)**	**C_{oc} (µg/g OC)**	**$ESBTU_i$**
34 PAHs considered by USEPA (2003a)[b]												
Acenaphthene	ug/g	NV	491	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Acenaphthylene	ug/g	NV	452	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Anthracene	ug/g	0.22	594	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.011	4.57	0.0077
Benzo(a)anthracene	ug/g	0.32	841	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Benzo(a)pyrene	ug/g	0.37	965	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Benzo(b)fluoranthene/Benzo(j)fluoranthene[c]	ug/g	NV	980	0.005	2.08	0.0021	ND (0.0050)	0.00	0.0000	0.0051	2.12	0.0022
Benzo(e)pyrene	ug/g	NV	967	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Benzo(g,h,i)perylene	ug/g	0.17	1095	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	0.008	3.32	0.0030
Benzo(k)fluoranthene	ug/g	0.24	981	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
C1-Fluorenes	ug/g	NV	611	0.02	8.31	0.0136	ND (0.0050)	0.00	0.0000	0.011	4.57	0.0075
C1-Methylated benzo(a)anthracene chrysenes (C1-228 isomers)	ug/g	NV	929	0.016	6.65	0.0072	ND (0.0050)	0.00	0.0000	0.015	6.23	0.0067
C1-Methylated fluoranthene/Pyrenes (C1-202 isomers)	ug/g	NV	770	0.047	19.52	0.0254	0.0059	2.45	0.0032	0.034	14.12	0.0183
C1-Methylated phenanthrene/Anthracenes (C1-178 isomers)	ug/g	NV	670	0.047	19.52	0.0291	ND (0.0050)	0.00	0.0000	0.036	14.95	0.0223
C1-Naphthalenes	ug/g	NV	444	0.0074	3.07	0.0069	0.0065	2.70	0.0061	ND (0.0050)	0.00	0.0000
C2-Benzo(a)anthracenes/chrysenes	ug/g	NV	1008	0.044	18.28	0.0181	ND (0.0050)	0.00	0.0000	0.04	16.62	0.0165
C2-Fluorenes	ug/g	NV	686	0.072	29.91	0.0436	ND (0.0050)	0.00	0.0000	0.043	17.86	0.0260
C2-Naphthalenes	ug/g	NV	510	0.02	8.31	0.0163	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
C2-Phenanthrenes/Anthracenes	ug/g	NV	746	0.1	41.54	0.0557	0.0068	2.82	0.0038	0.1	41.54	0.0557
C3-Alkylated phenanthrene/Anthracenes (C3-178 isomers)	ug/g	NV	829	0.19	78.93	0.0952	0.013	5.40	0.0065	0.13	54.00	0.0651
C3-Benzo(a)anthracene/Chrysenes (C3-228 isomers)	ug/g	NV	1112	0.025	10.38	0.0093	ND (0.0050)	0.00	0.0000	0.02	8.31	0.0075
C3-Fluorenes	ug/g	NV	769	0.28	116.31	0.1512	0.011	4.57	0.0059	0.24	99.70	0.1296
C3-Naphthalenes	ug/g	NV	581	0.034	14.12	0.0243	0.0099	4.11	0.0071	0.018	7.48	0.0129
C4-Alkylated phenanthrene/Anthracenes (C4-178 isomers)	ug/g	NV	913	0.37	153.70	0.1683	0.013	5.40	0.0059	0.12	49.85	0.0546
C4-Benzo(a)anthracene/Chrysenes (C4-228 Isomers)	ug/g	NV	1214	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
C4-Naphthalenes	ug/g	NV	657	0.038	15.79	0.0240	ND (0.0050)	0.00	0.0000	0.027	11.22	0.0171
Chrysene	ug/g	0.34	844	0.0051	2.12	0.0025	ND (0.0050)	0.00	0.0000	0.0059	2.45	0.0029
Dibenz(a,h)anthracene	ug/g	0.06	1123	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Fluoranthene	ug/g	0.75	707	0.013	5.40	0.0076	ND (0.0050)	0.00	0.0000	0.013	5.40	0.0076
Fluorene	ug/g	0.19	538	ND (0.010)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.020)	0.00	0.0000
Indeno(1,2,3-cd)pyrene	ug/g	0.2	1115	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Naphthalene	ug/g	NV	385	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Perylene	ug/g	NV	967	0.012	4.98	0.0052	ND (0.0050)	0.00	0.0000	ND (0.0050)	0.00	0.0000
Phenanthrene	ug/g	0.56	596	0.017	7.06	0.0118	ND (0.0050)	0.00	0.0000	0.017	7.06	0.0118
Pyrene	ug/g	0.49	697	0.024	9.97	0.0143	ND (0.0050)	0.00	0.0000	0.04	16.62	0.0238
PAH sum of ESBTUI[d]						0.7319			0.0385			0.4990
PAH sum of $ESBTU_i$ for the 16 PAHs that were measured in every sample for samples where all 34 PAHs were measured												
Ratio of $\Sigma ESBTU_{PAH-34}$ to $\Sigma ESBTU_{PAH-16}$ for samples where all 34 PAHs were measured.												
PAH sum total of $ESBTU_i$ multiplied by a conversion quotient determined by closest location where all 34 PAHs were measured												
Location used to calculate a conversion quotient for locations where only 16 PAHs were measured												
Final PAH Sum total of $ESBTU_i$ ($\Sigma ESBTU_{PAH-34}$)						0.7			0.04			0.5

Table A.4b

Development of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) Using Geometric Mean of Organic Carbon Content (ND=0)
CN Gogama Derailment - Ruel MP 88.7
Gogama, Ontario

BTEX											
Ethylbenzene		0.175	970	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000
m&p-Xylenes		-	980	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000
Toluene		1.22	810	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000	ND (0.020)	0.00	0.0000
Xylenes (total)		0.43	980	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000	ND (0.040)	0.00	0.0000
BTEX sum of ESBTU$_i$ (ΣESBTU$_{BTEX}$)[d]						0			0			0
Geomean of Total organic carbon (TOC)	ug/g			2407			2407			2407		
Geomean of foc				0.0024			0.00241			0.0024		
Black carbon	%											

Notes:

NV = No value is prescribed for associated paramter	TOC = Total organic carbon
µg/g dw = Microgram per gram dry weight	PAH = Polycylic aromatic hydrocarbon
J = Estimated concentration	BTEX = Benzene, toluene, ethylbenzene, and xylene
ND = Not detected at the associated reporting limit	ESB = Equilibrium partitioning sediment benchmark
R = Rejected	ΣESBTU = Sum of equilibrium partitioning sediment benchmark
C = Concentration	TU = Toxic unit
MOECC = Ministry of the Environment and Climate Change	USEPA = United States Environmental Protection Agency

6.2 = Boxed cells with bold text indicate locations where sensitive benthic organisms may be affected.

Non-detect concentrations are assigned a value equal to zero.

[a] Screening values for PAHs are based on MOECC (2011) and screening values for BTEX are based on USEPA Region 5 ecological screening levels (ESLs) (USEPA, 2003b).

[b] The PAHs included here are the 34 PAHs considered as "total PAHs" by the USEPA (2003a).

[c] Average values of benzo(b)fluoranthene and benzo(j)fluoranthene.

[d] Chemicals included in ΣESBTU$_{BTEX}$ are toluene, ethylbenzene, and xylenes (total). Benzene was not included in the calculation given that it was not identified as a COC.

References:

MOECC, 2011. Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, PIBS #7382e01, Sediment Quality Guidelines, April 15, 2011.

USEPA, 2003a. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. November 2003

USEPA, 2003b. Ecological Screening Levels for RCRA Appendix IX Hazardous Constituents. August 2003.

USEPA, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compedium of Tier 2 Values for Nonionic Organics. March 2008.

Table A.5

Geometric Mean of Organic Carbon Content in Samples Collected from Divisions A and C

Division	Sample Location	Sample ID	Sample Date	Total Organic Carbon (µg/g)
C	RIVER 3	SED-11102200-082916-HP-008	8/29/2016	7500
	RIVER 4	SED-11102200-083016-HP-09	8/30/2016	14000
	RIVER 5	SED-11102200-083016-HP-10	8/30/2016	610
	RIVER 6	SED-11102200-083016-HP-11	8/30/2016	4700
	RIVER 7	SED-11102200-083016-HP-12	8/30/2016	3600
	RIVER 8	SED-11102200-083016-HP-13	8/30/2016	750
	RIVER 9	SED-11102200-083016-HP-14	8/30/2016	5200
	RIVER 10	SED-11102200-083016-HP-15	8/30/2016	2500
	RIVER 11	SED-11102200-083016-HP-16	8/30/2016	ND (500)
	RIVER 12	SED-11102200-083016-HP-17	8/30/2016	3900
	RIVER 13	SED-11102200-083016-HP-18	8/30/2016	5700
	RIVER 14	SED-11102200-083016-HP-19	8/30/2016	12000
	RIVER 15	SED-11102200-083116-HP-20	8/31/2016	12000
	RIVER 16	SED-11102200-083116-HP-21	8/31/2016	ND (500)
	RIVER 16 (Duplicate)	SED-11102200-083116-HP-22	8/31/2016	ND (500)
	Geomean			2407
A	RIVER 17	SED-11102200-083116-HP-23	8/31/2016	8500
	RIVER 18	SED-11102200-083116-HP-24	8/31/2016	8100
	RIVER 19	SED-11102200-083116-HP-25	8/31/2016	5300
	RIVER 20	SED-11102200-083116-HP-26	8/31/2016	4400
	RIVER 22	SED-11102200-090116-HP-28	9/1/2016	4400
	RIVER 23	SED-11102200-090116-HP-29	9/1/2016	3400
	RIVER 54	SED-11102200-091016-HP-65	9/10/2016	6500
	RIVER 55	SED-11102200-091016-HP-66	9/10/2016	950
	RIVER 56	SED-11102200-091016-HP-67	9/10/2016	ND (500)
	Geomean			3219