7 September 2017

ENVIRONMENTAL MANAGEMENT PLANNING CONSIDERATIONS

Ottawa Wall Repairs Rideau Canal, Ottawa, Ontario

Submitted to:
Alicja Wierzbicka
Public Service and Procurement Canada, Ontario Region
4900 Yonge Street, 11th floor
Toronto, ON
M2N 6A6

REPORT

Final Report
Report Number: 1776320-004-R-Rev0
Distribution:
2 Copies - PSPC
1 e-Copy - Golder Associates Ltd.

Golder Associates

Plain-language Summary

The Ottawa Wall Repairs construction program (the Project) is being done by Parks Canada Agency (PCA) in the Rideau Canal in the City of Ottawa, ON. This project requires excavation in order to restore wall stability, resulting in the incidental disturbance of sediment in Rideau Canal, which is in some places is contaminated. Golder Associates Ltd. (Golder) was hired by Public Works and Government Services Canada (PWGSC) on behalf of PCA to help plan the work so that it does not cause harmful effects in the environment.

Sediment samples were collected from the bottom of the Rideau Canal in 11 separate Work Areas between the north end of the canal and Lansdowne Park to provide information about how disturbing the canal sediments may affect water quality. This information is important for deciding what controls might need to be in place while the wall repair work is done. The samples were sent to a laboratory for analysis and the results showed that in some samples metals, petroleum hydrocarbons, and other substances had concentrations that were higher than environmental quality guidelines. The highest concentrations of substances of concern were in sediments at the surface of the canal bed and in samples from Work Areas at the north end of the Rideau Canal. As a result, there is greater potential for effects to happen in this area if water from inside the Work Areas is not managed properly.

To help identify what the “safe concentration” is for water discharges from the Work Areas is, the information from the sediment sampling was used to make water quality predictions. These predictions showed that PCA’s goal of not exceeding the Canadian Council of Ministers of the Environment (CCME) water quality guideline (WQG) for total suspended solids (TSS) of 25 mg/L above background (up to a maximum of 75 mg/L at the point of discharge regardless of background levels) will protect fish and other aquatic species, as well as people that may use the canal when work is happening.

To help the Contractor chosen to do the repair works do the work safely, it is recommended that: workers use appropriate personal protective equipment (PPE); a turbidity curtain or other means of containing suspended sediments be used; water released from the Work Areas meets the “safe concentration”; the Contractor be prepared to respond to an accidental release of water above the “safe concentration” by having proper equipment at the site and training workers to use that equipment; and an appropriately qualified and independent environmental monitor be hired to inspect the work site, take water quality measurements and notify the Contractor where the work may need to be done differently to meet the environmental protection goals of the project. These requirements should be documented in the Environmental Management Plan (EMP), along with other environmental requirements that will exist but are not part of the scope of this document.

Table of Contents

TABLES

FIGURES

APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

CCME ..... Canadian Council of Ministers of the Environment
COPC ..... contaminant of potential concern
ECCC ..... Environment and Climate Change Canada
EPO ..... environmental performance objective
ISQG ..... interim sediment quality guideline
LC50 ..... "lethal concentration" (concentration at which 50% mortality occurs)
LOAEL ..... lowest observed average effects level
LOEC ..... lowest observed effects concentration
LOEL ..... lowest observed effects level
PAH ..... polycyclic aromatic hydrocarbon
PCA ..... Parks Canada Agency
PEF ..... potency equivalency factor
PEL ..... probable effects level
PPE ..... personal protective equipment
PWGSC ..... Public Works and Government Services Canada
QP ..... qualified professional
QSAR ..... quantitative structure-activity relationship
RBCA ..... risk-based corrective action
SAP ..... sampling and analysis plan
SQGs ..... sediment quality guidelines
TPE ..... total potency equivalent
TPH ..... total petroleum hydrocarbons
TSS ..... total suspended solids
TU ..... toxic unit
US EPA ..... United States Environmental Protection Agency
UV ..... ultraviolet
VOC ..... volatile organic compound
WQG ..... water quality guideline

LIST OF UNITS

km ..... kilometre
m ..... metre
mg/kg ..... milligram per kilogram
mg/L ..... milligram per litre
µm ..... micrometre
NTU ..... nephelometric turbidity unit

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Public Works and Government Services Canada (PWGSC) to support environmental management planning for repair work being undertaken by Parks Canada Agency (PCA) in the Rideau Canal located within the City of Ottawa, ON.

This technical memorandum was prepared in accordance with terms and conditions of the PWGSC Standing Offer #EZ897-160027/002/PWY, dated 7 July 2015, Task Authorization 700361548 and Golder's proposal titled "Revised Proposal: Sediment Assessment and Associated Activities in Support of Rideau Canal Ottawa Wall Repairs, Ottawa, ON", dated 12 June 2017. This technical memorandum is one of several components[1] of a sediment assessment program undertaken for the Ottawa Wall Repairs construction program (herein referred to as the "Project"). The program addressed several proposed construction locations (herein referred to as "Work Areas") along the Rideau Canal in Ottawa, Ontario.

2.0 BACKGROUND

2.1 Objective

The objective of this document was to support environmental management planning for the repair of sections of walls in the Rideau Canal, in particular regarding the potential for effects to the environment and workers from the disturbance of contaminated sediments in the Work Areas.[2] The focus of this document is operational for the purposes of a construction activity. It is expected that the Contractor will, at the outset, undertake the work in a manner that minimizes the potential for accidental releases of water from the Work Area or other spills.

2.2 Project Overview

There are approximately 18 km of concrete walls on the Rideau Canal. Currently approximately 5 km of wall sections are in very poor to poor condition that have been identified for future rehabilitation works. The Rideau Canal Ottawa Wall Repairs project (the Project) is being undertaken to address this poor condition in 11 discrete Work Areas (Figure 1), with the work to be completed by 31 March 2020. The configurations of construction zones may vary across the various Work Areas, but are expected to include cofferdams and an associated dewatering system to isolate the work area in the canal. Additional features of the work areas[3] are expected to include:

- Concrete repairs (or other method of shore stabilization)
- Fabric liners and silt bags to manage/treat water infiltration through the cofferdam
- Silt/turbidity curtains
- Submersible sumps for dewatering the work area

[1] Other tasks addressed as part of this scope of work were as follows: review of environmental reports provided by PWGSC obtain information regarding contaminants of potential concern; development of a sampling and analysis plan for a sediment assessment; implementation of the sediment assessment; and reporting of the findings of the sediment assessment.

[2] The Contractor is also obliged to address other environmental management requirements outlined for the Project elsewhere (e.g., fuel handling and management, use of cementitious [alkaline] material, upland erosion prevention and sediment control).

[3] The details of the work areas are to be designed by the successful proponent for construction—a conceptual description of the anticipated layout is provided here to advance the development of broad environment performance objectives.

WORK AREA #1

WORK AREA #2

WORK AREA #3

WORK AREA #4

WORK AREA #5

WORK AREA #6

WORK AREA #7

WORK AREA #8

WORK AREA #9

WORK AREA #10

WORK AREA #11

KEY MAP

SCALE 1:100,000

LEGEND

SECTION OF WALL TO BE REPAIRED

REFERENCE(S)

1. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, DELORME, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 125 250 500

1:12,500 METRES

CLIENT

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

PROJECT

2017 SEDIMENT AND SURFACE WATER ASSESSMENT
RIDEAU CANAL, OTTAWA, ONTARIO

TITLE

SITE PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-07-04
DESIGNED	KN
PREPARED	JEM
REVIEWED	GL
APPROVED	BW

PROJECT NO.	CONTROL	REV.	FIGURE
1776320	0002	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

Path: N:\Active\Spatial_IM\PWGSC\ONTARIO\OttawaWalls_RideauCanal\99_PRO\A1776320_PWGSC_EnviroA0_PROD\0002_EMP\1776320-0002-HS-0001.mxd

2.3 Summary of Sediment Assessment

To provide an understanding of the contaminants of potential concern (COPCs) that may be present in each work area, a sediment sampling program was undertaken in May 2017. The sediment program design was based on a sampling and analysis plan (SAP) that included a review of environmental reports (e.g., Phase I Environmental Site Assessments [Phase I ESAs], Phase II ESAs, surface soil investigation reports) prepared for land lots adjacent and within 500 m of the Project. These reviews identified historical land uses, potential sources of contamination, and soil and groundwater chemistry results for properties within 250 m of the Project (Golder 2017a).

The results of the sediment sampling are summarized in Appendix A. The sampling methods and detailed analytical data are provided in Golder (2017b). Sampling consisted of a combination of grab samples to obtain information regarding surficial (i.e., top 5 to 7 cm) sediments, and sediment coring (to a maximum depth of 2 m below mudline, and only where the coring equipment could effectively penetrate the substrate), to obtain information regarding the quality of sediments deeper in the sediment profile. Core samples could not be obtained from Work Areas 1 and 11.

The primary COPCs are metals and petroleum hydrocarbons (including polycyclic aromatic hydrocarbons [PAHs]). Sediment quality guideline (SQG) exceedances of up to one order of magnitude (i.e., 10 x) were observed for lead and mercury, and up to two to three orders of magnitude for individual PAHs such as benzo(a)anthracene, pyrene, and 2-methylnaphthalene. Based on total petroleum hydrocarbon (TPH) concentrations, there is potential for hydrocarbon sheens or vapours to occur when the canal sediments are disturbed.

The highest concentrations were generally in the upper 0.5 m of the sediment profile. In a subset of locations where sediment cores could be obtained, exceedances of SQGs were also observed as deep as 1.2 m for PAHs and 1.7 m for metals. The highest concentrations were also observed in samples collected from Work Areas 1, 2, and 3 at the north end of the Rideau Canal. Consequently, there is greater risk for effects to occur in this area should there be an accidental release of water from the Work Areas, and thus greater need for appropriate controls to be in place.

Non-halogenated volatiles (e.g., benzene, toluene, ethylbenzene, xylene) and volatile organic compounds (VOCs; e.g., chlorobenzenes, chloromethanes, chloroethanes) were below or near method detection limits. These parameters were therefore not considered further in this assessment.

2.4 Potential for Exposure to Disturbed Sediments

The potential for aquatic biota in Rideau Canal or people to come into contact with sediments disturbed during the rehabilitation works by various routes is summarized in Table 1. Controls will be expected to be in place to protect workers from contact with sediment in the Work Areas and those controls will form the basis of mitigation measures and best practices recommended in Section 5.0. As summarized in Table 1, there is also potential for aquatic plants and animals, as well as recreational users of Rideau Canal to come into contact with sediment from the Work Area as it is discharged to the canal. The potential for effects from this contact was evaluated through water quality predictions and comparisons to applicable water quality guidelines as described in Section 4.0. Although risk assessment-based tools were used herein, this document is not intended to be an ecological or human health risk assessment.

Table 1: Potential for Contact with Disturbed Sediments

Biota/ People?	Route	Potential for Contact?	Addressed in Assessment?
Aquatic biota	Suspended sediments in water discharged from Work Areas	Possible	Yes, through comparison to WQGs
	Contaminants released from suspended sediments in water discharged from Work Areas	Possible	Yes, through comparison to WQGs
Workers	Dermal contact with sediments in Work Areas	No – all workers are expected to wear personal protective equipment (PPE) as discussed in Section 5.0. Potential risks to workers not using appropriate PPE have not been assessed	No
	Dermal contact with water in Work Areas containing contaminants released from sediments		No
	Incidental ingestion of water	No – controls expected to be in place (discussed in Section 5.0)	No
Recreational Users	Dermal contact with sediments	No – the general public will be excluded from the direct Work Area for health and safety reasons (e.g., operation of heavy equipment). The navigable depth of the canal outside the direct Work Area will minimize the potential for recreational workers to come into direct contact with sediments.	No
	Dermal contact with water containing contaminants released from sediments from incidental contact	Possible	Yes, through comparison to WQGs
	Dermal contact with water containing contaminants released from sediments from swimming	Possible	Yes, through comparison to WQGs
	Incidental ingestion of water	Possible	Yes, through comparison to WQGs

Notes:
WQG – water quality guidelines

3.0 REGULATORY CONTEXT

The primary regulatory drivers for establishing environmental performance objectives (EPOs) for environmental management of the Project are related to Section 36 of the *Fisheries Act*, which contains a general prohibition against the deposit of the deleterious substance into waters frequented by fish or in any place under any conditions where the deleterious substance, or any other deleterious substance that results from the deposit of the original deleterious substance, may enter any such water. The *Fisheries Act* applies to the point of discharge. The *Fisheries Act* does not specify what a deleterious substance is except in certain sector-based regulations such as the Metal Mining Effluent Regulations (MMER), which identifies maximum concentrations for specific substances in discharges from mines. Where sector-specific regulations do not exist, the concentration or properties of substance that would be considered deleterious under the *Fisheries Act* are left to interpretation by experts[4]. The 96-h LC_{50} rainbow trout toxicity test[5] has been frequently applied by Environment and Climate Change Canada (ECCC), who have the administrative lead role for Section 36, as a defining endpoint where 96-h $LC_{50} \geq 100\%$ is required to comply.

Although the Rideau Canal is under federal jurisdiction, provincial statutes such as the Ontario *Environmental Protection Act* and *Water Resources Act* provide further definition that is useful in planning for water quality management during a construction project such that aquatic resources are protected. Both of these acts have a shared goal of preventing the discharge of “contaminants” or “pollutants” into the natural environment that cause an “adverse effect”, which includes impairment of the natural environment, injury to plants or animals, or harm to people. These statutes apply to the receiving environment. Ambient water quality guidelines (WQGs), such as the Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines, are generic, conservative concentrations for protection against long-term exposure that are sometimes applied as a screening tool for assessing the potential for adverse effects. WQGs do not have legal standing and are not intended to be applied directly as effluent discharge limits; nor can they on their own be used to directly predict adverse effects (i.e., it cannot be assumed that where WQG concentrations are exceeded that effects will occur). Rather, they provide a generic indication of concentrations at which specific levels of protection may be achieved and include safety factors for broader application to water bodies across the country. Thus, where water concentrations are lower than WQGs, effects would not be expected and the confidence in this conclusion would be high. WQGs have been derived for the protection of several uses: aquatic life, recreation, drinking water (Table 2). WQGs for the protection of aquatic life are typically the most stringent and these have conservatively been used in this assessment to assess the potential for effects to the environment and humans.

Notwithstanding the above discussion of application of WQGs, other management objective may be taken into consideration for a given project area. Management of the Rideau Canal is governed by the Historic Canals Regulations (enabled by the *Department of Transportation Act*), which designates the canal as being under the jurisdiction of PCA. In the context of this Project, PCA has a management objective that WQGs will be met at the point of discharge to the Rideau Canal, in particular for total suspended solids (TSS). Specifically, PCA’s management objective for TSS is a maximum of 25 mg/L above background, which is the CCME short-term exposure guideline. Golder notes that these more stringent limits would meet (exceed) the regulatory requirements identified above.

[4] A person with appropriate education, experience, and knowledge who can reasonably provide a professional opinion about the potential for a substance to harm fish (e.g., based on scientific information such as published journal articles, laboratory tests).

[5] A 96-h LC_{50} rainbow trout test is a laboratory-based test in which 10 rainbow trout juveniles are placed in the test water (Environment Canada 1990). For the test to pass, more than half of the individuals must remain alive in the full strength (i.e., undiluted) test water by the end of the four-day test period.

Table 2: Summary of Canadian Council of Minister of the Environment Water Quality Guidelines for Protection of Aquatic Life, Recreational Users, and Drinking Water

Parameter	Unit	WQG and Screening Benchmarks for the Protection of:		
		Aquatic Life [a]	Recreational Use [b]	Drinking Water [c]
Total suspended solids	mg/L	25 above background (max) 5 above background (average)	n/a	n/a
Turbidity	NTU	8 above background	50 [d]	n/a
Chromium (III)	mg/L	0.0089	0.5	0.05
Copper	mg/L	0.004	1	1 (AO)
Lead	mg/L	0.007	0.1	0.01
Mercury	mg/L	0.000026	0.01	0.001
Zinc	mg/L	0.03	5	5 (AO)
Acenaphthene	mg/L	0.0058	1.06	0.106
Acenaphthylene	mg/L	n/a	n/a	n/a
Anthracene	mg/L	0.000012	3.6	0.36
Benzo[a]anthracene	mg/L	0.000018	n/a	n/a
Benzo[b,j]fluoranthene	mg/L	n/a	n/a	n/a
Benzo[k]fluoranthene	mg/L	n/a	n/a	n/a
Benzo[a]pyrene	mg/L	0.000015	0.0004 [e]	0.00004
Benzo[g,h,i]perylene	mg/L	n/a	n/a	n/a
Chrysene	mg/L	n/a	n/a	n/a
Dibenz[a,h]anthracene	mg/L	n/a	n/a	n/a
Fluoranthene	mg/L	0.00004	1.6	0.16
Fluorene	mg/L	0.003	0.58	0.058
Indeno[1,2,3-cd]pyrene	mg/L	n/a	n/a	n/a
1-methylnaphthalene	mg/L	n/a	0.0022	0.00022
2-methylnaphthalene	mg/L	n/a	0.072	0.0072
Naphthalene	mg/L	0.0011	0.0122	0.00122
Phenanthrene	mg/L	0.0004	n/a	n/a
Pyrene	mg/L	0.000025	0.24	0.024

Notes:
(a) CCME Water Quality Guidelines; water is assumed to be hard (<180 mg/L) for calculating hardness-dependent guidelines
(b) Aesthetic objectives. Where Aesthetic objectives not available, drinking water screening values adjusted by a factor of 10 to reflect an incidental ingestion rate that is 10 times lower than the intake of potable drinking water per WHO (2003) guidance. Where Health Canada guidelines were not available, US EPA (2017) tap-water screening values were used. Predicted PAH concentrations (Appendix B) were used to calculate a total potency equivalent (TPE) relative to benzo(a)pyrene, calculated based on potency equivalency factors (PEFs) from Health Canada (2010).
(c) Health Canada Guidelines for Canadian Drinking Water Quality - Summary Table. Available at: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table-health-canada-2012.html
(d) Health Canada Guidelines for Canadian Recreational Water Quality – Third Edition (available at: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-recreational-water-quality-third-edition.html)
(e) Both benzo(a)pyrene individual and the calculated benzo(a)pyrene TPE were compared to this screening value.
AO – aesthetic objective; CCME – Canadian Council of Ministers of the Environment; n/a – not available; NTU – nephelometric turbidity units; WQG – water quality guideline

4.0 ENVIRONMENTAL PERFORMANCE OBJECTIVES FOR WATER QUALITY

As noted in Section 3.0, PCA has selected the CCME short-term WQG of 25 mg/L for TSS as the preferred EPO for discharges to Rideau Canal. The following sections provide an assessment of this discharge objective with regards to it sufficiency to protect Rideau Canal water quality and to inform potential mitigation measures and monitoring considerations for the project.

4.1 Approach to Assessment

The evaluation of the EPO for application at the point of discharge was approached step-wise:

1) Individual contaminant concentrations in water were predicted for each work area using a mass balance model (described in Section 4.2) based on sediment chemistry data from the recent sampling program presented in Golder (2017b). The potential for physical effects to aquatic organisms and habitat from suspended sediments was incorporated into the mass balance model through the selection of the range of total suspended sediment (TSS) concentrations from 5 to 100 mg/L. The lower value is the CCME long-term exposure WQG and the upper value is provided as a potential TSS concentration during an uncontrolled release to provide an indication of the potential risks associated with such a release. A maximum TSS concentration of 75 mg/L (as an absolute concentration rather than as induced above background) would be expected for discharges from a construction site during wet weather to protect fish from the physical effects of suspended particles (DFO 1992).

2) Predicted water concentrations were screened against CCME ambient WQGs (Section 4.2). Long-term (chronic) WQGs for the protection of freshwater aquatic life (Table 2) were used for this screening because they are conservative and where they are met, aquatic life as well as human uses (e.g., recreation) are also expected to be protected.

3) Where ambient WQGs were exceeded, the safety factor incorporated into the WQG derivation was reviewed and where the predicted aqueous concentration was within the safety factor, the exceedance was not considered to represent an environmentally relevant risk of adverse effects at the point of discharge (Section 4.2).

4) The potential for mixture toxicity (Section 4.3) was briefly evaluated for the work areas with the highest sediment contaminant concentrations using an additivity model and fish acute toxicity benchmarks summarized in Table 2. Toxicity benchmarks were obtained from readily available sources such as guideline derivation documents.

5) The use of the CCME short-term exposure TSS WQG as the EPO for application at the point of discharge was confirmed (Section 4.4), based on the assumption that by controlling the particulates in water discharged from a given work area, the concentration of contaminants present will also be controlled (this assumption is discussed further in Section 4.2). This TSS value is related to a turbidity value of 8 NTU (nephelometric turbidity units), based on an assumed TSS-turbidity relationship of 3:1 (CCME 1999a), that can be used for real-time measurements. EPOs for the receiving environment were set at available ambient WQGs.

6) An evaluation of the uncertainty (Section 4.5) associated with the derivation of the EPO was also undertaken and mitigations (Section 5.0) to help address these potential uncertainties were recommended. Considerations for monitoring are provided in Section 6.0.

4.2 Water Quality Estimates

Potential water concentrations of COPCs resulting from the suspension of sediments during wall repair activities were estimated as the product of the concentration in sediments and a potential TSS concentration in water, as follows:

$$Conc_{COPC\ in\ water} = \frac{Conc_{COPC\ in\ sediment} \times Conc_{TSS\ in\ water}}{1{,}000{,}000}$$

Where:	$Conc_{COPC\ in\ water}$	is the concentration of the contaminant of potential concern (COPC) in water in mg/L
	$Conc_{COPC\ in\ sediment}$	is the concentration of the COPC in sediment in mg/kg
	$Conc_{TSS\ in\ water}$	is the concentration of total suspended solids in water in mg/L
	1,000,000	Is the units conversion from kilograms to milligrams of sediment

Water concentrations were calculated based on:

- Concentrations of COPCs in sediments identified in each work area through screening against federal and provincial sediment and soil quality guidelines as summarized in Appendix A and Golder (2017b).
  - For the purposes of this document, the CCME probable effects level (PEL) sediment quality guidelines (SQGs) for the protection of freshwater aquatic life were used to identify a subset of parameters that warranted further assessment because those parameters exceeding PEL pose a potential risk.[6] This screening identified metals and petroleum hydrocarbons (including polycyclic aromatic hydrocarbons [PAHs]) as COPCs. Other parameters analyzed in the sediments such as halogenated and non-halogenated volatile organic compounds were not considered further because they were generally near or below method detection limits or did not exceed available SQGs.
  - For the petroleum hydrocarbon compounds, PAHs were assumed to be "representative" parameters, and that by addressing the potential for toxicity from PAHs, other hydrocarbon parameters would also be addressed. The rationale for this is that where the Atlantic Risk-based Corrective Action (RBCA) screening benchmark for total petroleum hydrocarbon (TPH) in sediment (calculated parameter; Atlantic PIRI 2012) is also exceeded, the hazard quotient (i.e., sediment concentration / benchmark) is similar among the TPH and individual PAH parameters (i.e., on the order of 10 to 15 times).

[6] CCME sediment quality guidelines are available for two levels: the interim sediment quality guidelines (ISQGs) are intended to represent a concentration below which adverse biological effects are expected to occur only rarely, whereas the probable effects level (PEL) is intended to represent a concentration below which adverse effects may occasionally occur (CCME 1999d). Guidelines such as ISQG/PEL are statistically derived from arbitrarily selected percentiles of both effects and non-effects biological data that are correlated to chemical data (Chapman and Mann 1999), also called the co-occurrence method. This statistical evaluation should therefore not be assumed to imply cause and effect for the derived guideline concentrations. Moreover, because of the way these guidelines are derived, the more conservative benchmarks (e.g., ISQG) are more likely to predict effects when no effects are present (i.e., result in false positives) and thus may be overly conservative for a given protection goal.

- The 75th percentile concentrations were assumed to be representative of the sediment that may be disturbed. Sediments suspended in water in a given Work Area are expected to be a mix of sediments disturbed from multiple points and depths within the Work Area which will "average out" the contaminant concentrations. The 75th percentile was conservatively calculated rather than the mean or median concentrations to weight the concentration towards the higher concentrations typically observed in the surficial (i.e., top 0.5 m) of the sediment. The maximum or 95th percentile concentrations were considered to be more conservative than necessary given the spatial (horizontal and vertical) distribution of COPCs. As an example, the 75th percentile concentration for PAH parameters in sediments from Work Area 2 are generally higher than the mean and within the 95th percentile confidence limits for the mean (Figure 2).[7] When the 75th percentile concentrations for PAH parameters are compared among Work Areas, Work Area 1 has the highest concentrations except for 2-methylnaphthalene, which was highest in Work Area 2. For that parameter, the concentration measured in three of 15 samples skewed the mean to be higher than the 75th percentile.

- A range of assumed TSS concentrations (i.e., 5, 10, 25, 50, 75, 100 mg/L) that may be encountered during project activities. The maximum allowable TSS concentration for discharges from enclosed Work Areas will be set at the CCME short-term exposure WQG of 25 mg/L per PCA's protection objectives for the Rideau Canal; higher TSS concentrations were also used to provide an evaluation of the potential for effects if discharges have higher TSS concentrations than 25 mg/L.

The water quality model conservatively assumed that all of the contaminant mass in the bulk sediment would be associated with particles. In reality, contaminants in bedded sediments (i.e., sediments in situ) may be bound to particles or be in the porewater, for example, as part of a complex with organic carbon or other binding phases. Therefore, that assumption for partitioning the sediment-borne contaminants may result in an over estimate of water-borne concentrations. Conversely, the model also assumes that the predicted water-borne concentrations are also a particulate-bound fraction, rather than truly dissolved (which is operationally defined as the fraction that passes through a 0.45-µm filter) may underestimate the total concentration in water. Nonetheless, several aspects of conservatism have been incorporated into this assessment as identified in this document, which reduce the uncertainty associated with these assumptions.

[7] Data from Work Area 2 were used for this evaluation due to the sample size (n=15) compared to Work Area 1 (n=3).

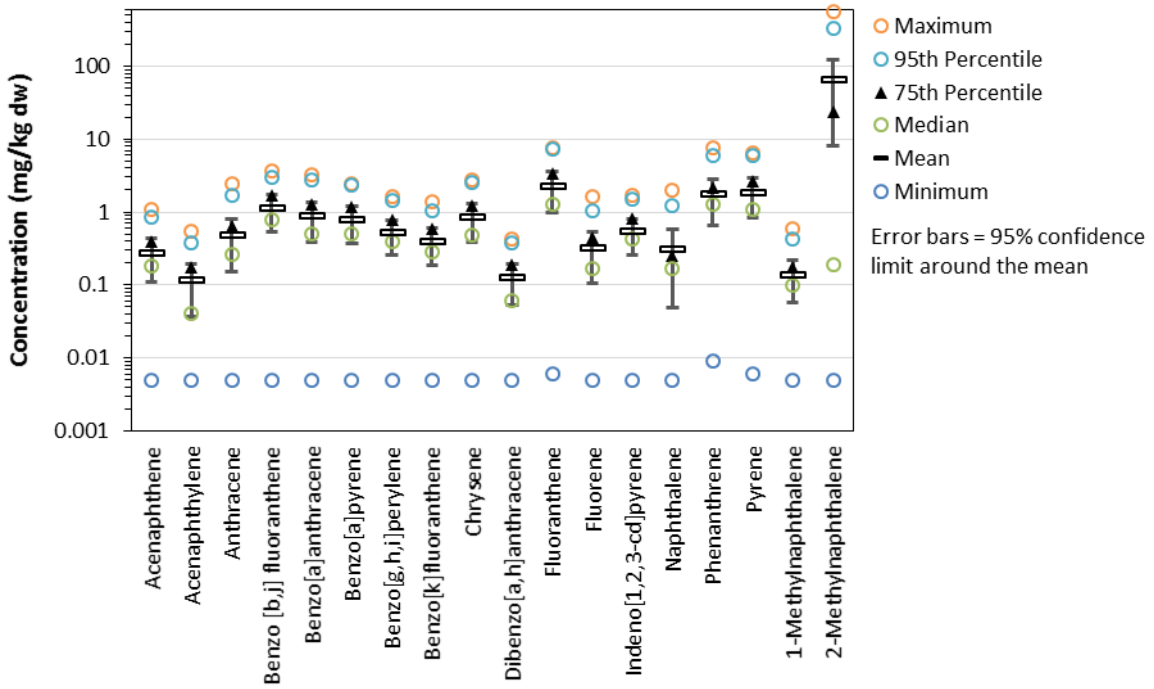

Figure 2: Summary statistics for polycyclic aromatic hydrocarbon concentrations in sediment samples (n=15) from Work Area 2

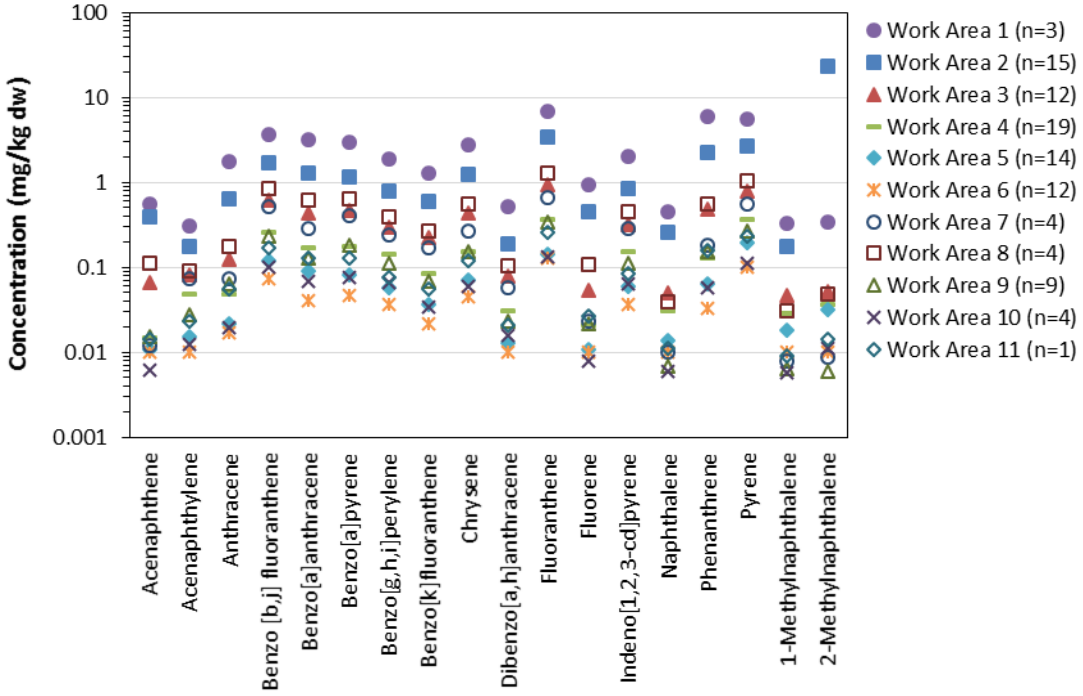

Figure 3: Summary of 75th percentile concentrations in sediments collected from Work Areas 1 through 11

The results of the modelling for each work area are presented in Appendix B. The highest sediment concentrations, and therefore the highest predicted water concentrations and greatest number of WQG exceedances, were for Work Areas 1, 2, and 3. However, as noted in Section 3.0, ambient WQGs are not intended to be applied to the point of discharge. Moreover, the CCME WQGs used are intended to apply to long-term exposure conditions and in several cases they are dated and/or do not reflect more current scientific understanding of potential modifying factors (e.g., hardness, dissolved organic carbon). Rather, WQGs were used as a screening tool to identify parameters for which further assessment was warranted.

Considering the water quality predictions for Work Area 1 for a discharge with a TSS concentration of 100 mg/L, all of the ambient WQG exceedances are at concentrations within the safety factors used in deriving the WQGs (Table 3). For PAHs, the greatest magnitude exceedances (i.e., 10 to 15 times the respective WQG) were predicted for acenaphthylene, benzo[a]anthracene, and fluoranthene, whereas the WQG derivations for these parameters incorporate a 100-fold safety factor. For metals (copper, lead and zinc), the predicted concentrations are less than 10 times the WQG and therefore also within respective safety factors. Predicted water concentrations were lower for the other Work Areas (and lower TSS scenarios) and therefore the WQG exceedances associated with those exposure scenarios were also within the safety factors.

As noted above, the 75th percentile 2-methylnaphthalene concentration in sediment collected from Work Area 2 was higher than that observed in Work Area 1, due to three samples that skewed the statistic higher. CCME has not recommended a WQG for the protection of aquatic life for 2-methylnaphthalene. Other jurisdictions have also not derived freshwater WQGs for this parameter; however, the BC Ministry of Environment has recommended a marine WQG (Nagpal 1993). Predicted water concentrations of 2-methylnaphthalene based on the 75th percentile sediment concentration for Work Area 2 are at or within 10 times this marine WQG of 0.001 mg/L.

Based on this evaluation of individual COPCs, setting a TSS concentration of 25 mg/L as the EPO for application at the point of discharge from the Work Areas is expected to be protective of the Rideau Canal receiving environment.

Table 3: Summary of Canadian Council of Minister of the Environment Water Quality Guidelines for the Protection of Aquatic Life from Exposure to Contaminants of Potential Concern

Parameter	CCME WQG		Fish Acute Toxicity Benchmark	
	mg/L	Derivation	mg/L	Rationale
Chromium (III)	0.0089	0.1 safety factor applied to 102-d LOEC for rainbow trout (CCME 1999b)	3.3	Lowest LC_{50} for fish in literature reviewed by CCME (1999b), for 96-h exposure of the guppy *Lebistes reticulatus*
Copper	0.004	At H >180 mg/L. Based on Demayo and Taylor (1981), which is not available for review, with adaptations from US EPA (1985a).	0.092	Based on equation developed by Spear and Pierce (1979) for predicting copper toxicity to salmonids: LC_{50} (mg/L Cu) = $0.0014*H^{0.79}$
Lead	0.007	At H > 180 mg/L. Based on US EPA (1985b)	2.45	Species mean acute toxicity value for rainbow trout (US EPA 1985b).
Mercury	0.000026	0.1 safety factor applied to most sensitive LOAEL of 0.00026 mg/L for effects on growth of juvenile fathead minnow (CCME 2003)	0.15	Lowest LC_{50} for fish in literature reviewed by CCME (2003), for 96-h exposure of fathead minnow
Zinc	0.03	Tentative value adopted from IJC (1976), based on no-effect concentrations for rainbow trout and fathead minnow (CCREM 1987)	66	96-h LC_{50} (at low hardness) for rainbow trout (BC MELP 1999)
Acenaphthene	0.0058	0.01 safety factor applied to a 96-h LC_{50} of 0.580 mg/L for brown trout (*Salmo trutta*) (CCME 1999c)	0.51	Lower 95% confidence limit of the lowest available data point (96-h LC_{50} for juvenile brown trout [*Salmo trutta*])
Acenaphthylene	n/a	n/a	1.77	QSAR based on methods of DiToro et al. (2000)
Anthracene	0.000012	0.01 safety factor applied to a 15-min LT_{50} of 0.0012 mg/L (acute value) for *Daphnia pulex* (CCME 1999c)	0.005	Lowest available toxicity data point (96-h LC_0 for fathead minnow fry [*Pimephales promelas*]. Oris and Giesy 1987)
Benzo[a]anthracene	0.000018	0.01 safety factor applied to 48-h LC_{50} of 0.0018 mg/L for *Daphnia magna* (CCME 1999c)	0.0018	Lowest available toxicity data point (96-h LC_0 for fathead minnow fry [*Pimephales promelas*]. Oris and Giesy 1987)
Benzo[b,j]fluoranthene	n/a	n/a	0.0086	QSAR based on methods of DiToro et al. (2000)
Benzo[k]fluoranthene	n/a	n/a	0.0086	QSAR based on methods of DiToro et al. (2000)

Parameter	CCME WQG		Fish Acute Toxicity Benchmark	
	mg/L	Derivation	mg/L	Rationale
Benzo[a]pyrene	0.000015	0.01 safety factor applied to 4-h LC_{50} of 0.0015 mg/L for *Daphnia magna* (CCME 1999c)	0.0056	Lowest available toxicity data point (96-h LC_0 for fathead minnow fry [*Pimephales promelas*]. Oris and Giesy 1987)
Benzo[g,h,i]perylene	n/a	n/a	n/a	n/a
Chrysene	n/a	n/a	0.0086	QSAR based on methods of DiToro et al. (2000)
Dibenz[a,h]anthracene	n/a	n/a	0.001	QSAR based on methods of DiToro et al. (2000)
Fluoranthene	0.00004	0.01 safety factor applied to 1-h LC_{50} of 0.004 mg/L for *Daphnia magna* exposed to UV light (CCME 1999c)	0.091	Lowest available toxicity data point (an unbounded 96-h LC_{50} for rainbow trout [*Oncorhynchus mykiss*]. Spehar et al. 1999)
Fluorene	0.003	0.1 safety factor applied to 14-d LOEC of 0.125 mg/L, with a 0.24 correction factor, for *Daphnia magna* (CCME 1999c)	0.55	Lower 95% confidence limit of the lowest available data point (96-h LC_{50} for rainbow trout embryos)
Indeno[1,2,3-cd]pyrene	n/a	n/a	n/a	n/a
1-methylnaphthalene	n/a	n/a	0.065	Lowest available toxicity data point (96-h LC_{29} for cod embryos) with a 10-fold safety factor.
2-methylnaphthalene	n/a	n/a	0.058	Lowest available toxicity data point (96-h LC_{29} for cod embryos) with a 10-fold safety factor.
Naphthalene	0.0011	0.1 safety factor applied to chronic LOEL of 0.011 mg/L for rainbow trout embryo-larval stage (CCME 1999c)	0.1	Lower 95% confidence limit of the lowest available data point (96-h LC_{50} for rainbow trout embryos)
Phenanthrene	0.0004	0.1 safety factor applied to chronic LOEL of 0.004 mg/L for rainbow trout embryo-larval stage (CCME 1999c)	0.0234	Lowest available toxicity data point (96-h LC_{50} for bluegill [*Lepomis macrochirus*]. Call et al. 1986) with 10-fold safety factor.
Pyrene	0.000025	0.01 safety factor applied to LC_{50} of 0.0025 mg/L for mosquito larvae (*Aedes aegypti*) (CCME 1999c)	0.0256	Lowest available toxicity data point (96-h LC_0 for fathead minnow fry [*Pimephales promelas*]. Oris and Giesy 1987)

Notes:
EC_{50} – concentration at which a 50% effect occurs; H – hardness (as mg/L $CaCO_3$); LC_{50} – concentration at which 50% mortality occurs; LOAEL – lowest observed average effects level; LOEC – lowest observed effects concentration; LOEL – lowest observed effects level; LT_{50} – time at which 50% mortality occurs; n/a – not available; QSAR – quantitative structure-activity relationship; UV – ultraviolet; WQG – water quality guideline

4.3 Potential for Mixture Toxicity

The potential discharge water from a given work area could contain several metals and PAHs present in different compositions among areas, plus additional parameters for which WQGs and toxicity data may not exist. The assessment of individual effects from each of these substances assessed individually could incorrectly predict the toxicological risk due to the influence of the mixture of COPCs. Accordingly, assessment of the potential environmental effects from water discharges from the work areas used an additivity model, the sum of Toxic Units (TUs)[8], to test whether predicted concentrations could result in acute effects when additivity is taken into account. The model assumes a similar mode of toxicity among the COPCs included in the sum. Because the mode of toxicity of PAHs is different than metals, adding TUs from these two groups of contaminants could over-predict the potential for mixture toxicity. Conversely, metals have been shown in some literature to enhance the toxicity of PAHs; therefore, the model could under-predict the potential for mixture toxicity. The model also relies on the reported toxicity data, which are not available for all of the hydrocarbon parameters present in the sediments. As noted in Section 3.2, for the purposes of this assessment, it is assumed that by addressing potential for toxicity from PAHs, other hydrocarbon parameters will also be addressed.

The TU is defined in Equation 1. Following the calculation of the TU, the summation of toxicity was carried out as shown in Equation 2. Where ΣTU < 1, then effects are not expected. If the ΣTU > 1, then effects may be predicted.

Equation 1: Example Calculation of a Toxic Unit (TU)

$$TU_{PAH1} = \frac{Cw_{COPC1}}{LC50_{COPC1}}$$

Where: *Cw* = Concentration in water of a given COPC (COPC1); and
LC$_{50}$ = Acutely lethal concentration of COPC1 (from Table 3)

Equation 2: Additive Toxicity Model (Sum of TUs) Used to Develop Threshold for Combined Substances

$$\sum TU = \frac{Cw_{COPC1}}{LC50_{COPC1}} + \frac{Cw_{COPC2}}{LC50_{COPC2}} + \frac{Cw_{COPC3}}{LC50_{COPC3}} + \cdots \Rightarrow$$

Where: *Cw* = Concentration of (COPC) in water; and
LC$_{50}$ = Acutely lethal concentration of (COPC) (from Table 3).

Table 4 summarized the calculation of the sum of toxic units for Work Area 1, for a discharge with a TSS concentration of 100 mg/L. The ΣTU was 0.48, which suggests that this mixture of metals and PAHs would not cause acute lethality to fish. The ΣTU is also notably lower than one, which allows for some uncertainty with how other parameters may contribute to toxicity at the point of discharge. Where the TSS concentration at the point of discharge is less than 100 mg/L, mixture toxicity would not be expected. Therefore, the 25 mg/L TSS EPO is also expected to be protective against acute lethality to fish.

[8] The Toxic Unit (TU) approach normalizes the contribution of each COPC relative to its acute toxicity value (LC_{50}) (Rand and Petrocelli 1985). When the sum of individual COPC TUs (ΣTUs) is less than one, acute mixture toxicity is not expected. Where ΣTUs is greater than one, acute mixture toxicity could occur.

Table 4: Sum of Toxic Units for Work Area 1

Parameter	Predicted Water Concentration at 100 mg/L TSS and 75th Percentile Sediment Concentrations	Acute Endpoint (mg/L) (a)	Toxic Unit
Chromium	0.0057	3.3	0.0017
Copper	0.014	0.092	0.15
Lead	0.016	2.45	0.0065
Mercury	0.000022	0.15	0.00015
Zinc	0.058	66	0.00088
Acenaphthene	0.000064	0.51	0.0001
Acenaphthylene	0.000034	1.77	0.000017
Anthracene	0.00018	0.005	0.035
Benzo [b,j] fluoranthene	0.00037	0.0086	0.042
Benzo[a]anthracene	0.00032	0.0086	0.037
Benzo[a]pyrene	0.0003	0.0056	0.053
Benzo[g,h,i]perylene	0.00019	n/a	n/a
Benzo[k]fluoranthene	0.000127	0.0086	0.015
Chrysene	0.00028	0.0086	0.032
Dibenzo[a,h]anthracene	0.000053	0.001	0.053
Fluoranthene	0.00068	0.091	0.0075
Fluorene	0.0001	0.55	0.0002
Indeno[1,2,3-cd]pyrene	0.0002	n/a	n/a
Naphthalene	0.000049	0.1	0.0005
Phenanthrene	0.0006	0.0234	0.025
Pyrene	0.00056	0.0256	0.022
1-Methylnaphthalene	0.000034	0.065	0.0005
2-Methylnaphthalene	0.000035	0.058	0.0006
ΣTU			**0.48**

Notes:
(a) Values taken from Table 3, based on data for acute lethality to fish
n/a – not available; ΣTU – sum of toxic units; TSS – total suspended solids

4.4 Project Environmental Performance Objectives

4.4.1 Point of Discharge

The above evaluation of the potential for suspension of bedded sediments during the Rideau Canal wall repair works to expose aquatic life to contaminants of potential concern verified that use of the CCME short-term TSS WQG of 25 mg/L will also be protective against effects from contaminants. Therefore, a TSS concentration of 25 mg/L is proposed as the primary EPO for application at the point of discharge from the Work Areas. Based on an assumed TSS-turbidity relationship of 3:1 (CCME 1999a), the "equivalent" turbidity value is 8 NTU.

Both the TSS and turbidity values are intended to be applied as "above background" levels. However, because suspended particulates can also have a physical effect on fish, a maximum TSS value of 75 mg/L is also recommended as per DFO's Land Development Guidelines (1992). It is recommended that the 75 mg/L also be applied at the point of discharge as a maximum absolute value rather as an induced above background concentration. A maximum TSS concentration at the point of discharge is also important to minimize the potential for effects due to sediment-associated contaminants. As described above, the assessment in this document that confirms that effects are not expected at 75 mg/L within the bounds of uncertainty associated with the available information. This TSS value of 75 mg/L will be the upper action threshold to protect aquatic organisms, and will act as the level at which a stop work order will be initiated regardless of the form of discharge or upstream conditions that may be related to storm water, high water events and/or canal water being raised unexpectedly.

The TSS turbidity-relationship outlined in CCME (1999a) is generic and it is possible that the relationship for suspended sediments in Rideau Canal are different.[9] The Contractor should collect site-specific data to refine this relationship.

Recommended responses to exceedances of the recommended EPOs at the point of discharge are as follows:

- In the event that the maximum TSS value of 75 mg/L (or 25 NTU) is exceeded at the point of discharge (irrespective of background), or TSS is <75 mg/L but more than 25 mg/L above background for >24 hours, the work should be stopped and the work site and methods reviewed to determine appropriate mitigations to reduce TSS. Once the mitigations are implemented, work can resume.
- In the event that TSS is lower than 75 mg/L at the point of discharge (irrespective of background) but more than 25 mg/L above background for <24 hours, the work site and work activities should be reviewed to determine appropriate mitigations to reduce TSS.

Additional monitoring recommendations are provided in Section 6.0 to address routine activities and accidents/malfunctions.

[9] TSS is a gravimetric measurement (mass per volume) whereas turbidity is an optical measurement which can be influenced by particle size, shape, color and reflectivity. Therefore, two materials occurring at the same TSS concentration in a given waterbody may result in different turbidity values.

4.4.2 Receiving Environment

For the receiving environment outside the Work Area, the EPO is proposed to be ambient aquatic life CCME WQGs for parameters indicative of discharge of dewatering effluent from the Work Area (e.g., the parameters identified in Appendix B as having potential to exceed WQGs). For TSS, this value is a maximum of 25 mg/L above background for short-term exposure (i.e., 24-hour period) and 5 mg/L above background on average for long-term exposure (i.e., lasting between 24-hour and 30 days; CCME 1999a). For turbidity, the WQG values are 8 NTU (short-term exposure) and 2 NTU (long-term exposure).

For other parameters, the interpretation of potential WQG exceedances will also need to consider the potential for WQGs to already be exceeded upstream of the Work Area. For example, metals and petroleum hydrocarbons (including PAHs) may enter the Canal via surface water runoff from roadways discharged through storm drains during rain events or from poorly maintained boats travelling through the Canal. Intermittent exceedances of WQGs due to incremental additions from the Project should not automatically be assumed to result in harm to the environment. Rather, the Contractor's qualified professional (QP)[10] will need to take into consideration the magnitude and duration of exceedance and provide a professional opinion regarding the potential for effect and appropriate management actions that may need to be undertaken.

Recommended responses to exceedances of the recommended EPOs for the receiving environment are as follows:

- For a >24-hour exceedance of 25 mg/L above background (with an absolute maximum TSS of 75 mg/L at the point of discharge has not been exceeded), the contractor should stop the work, inspect the work site, and review their work procedures to determine appropriate mitigation actions. Once the mitigations are implemented, work can resume.
- For a <24-hour exceedance of 25 mg/L above background (with an absolute maximum TSS of 75 mg/L at the point of discharge has not been exceeded) the work site and methods should be reviewed to determine appropriate mitigations to manage TSS.
- In the event that TSS in the receiving environment is on average >5 mg/L above background for >30 days (i.e., if the work in a given area requires more than 30 days), the contractor should inspect the work site and review their work procedures to determine appropriate mitigation actions.

Additional monitoring recommendations are provided in Section 6.0 to address routine activities and accidents/malfunctions.

[10] A qualified professional is registered with an appropriate professional organization (where such registration is available) and through suitable education, experience, accreditation and knowledge, may reasonably be relied upon to provide advice regarding environmental management of the Project

4.5 Uncertainty Assessment

This technical assessment was a predictive exercise with the objective of identifying EPOs to be applied during repair works in the Rideau Canal to manage water quality such that aquatic resources are protected. Although predictive tools are useful and provide a reasonable and commonly used prediction of likely conditions, it is important to identify the major uncertainties and to consider the implication of these uncertainties on predictions made. Finally, where the findings of the technical assessment and analysis of uncertainties provide sufficient confidence that the proposed EPOs are protective of the receiving environment, the identification of uncertainties will assist in recommendation of appropriate mitigation measures and monitoring tools for the Project. The main uncertainties are as summarized in Table 5.

Table 5: Summary of Uncertainty Assessment

Assumption	Uncertainty	Under-/over-estimate of impact	Rationale
Sediment quality is as identified by the sediment sampling program	Low	Over to neutral	In some Work Areas, relatively few samples were collected; however, the 75th percentile of sediment concentrations was used to weight the assessment to concentrations more reflective of surface conditions. Monitoring will be undertaken to confirm the findings of the assessment (see Section 6.0).
Dewatering effluent quality from the Work Areas will be as predicted for COPCs.	Moderate	Neutral	The assessment assumed that the 75th percentile concentration of every parameter would co-occur simultaneously. Monitoring will be undertaken to confirm the findings of this assessment (see Section 6.0).
Interaction of contaminant mixtures will not result in effects greater than estimated through the use of WQGs and additivity modelling	Low	Neutral	The WQGs used in the initial screening of the water quality estimates were conservative and applicable to chronic exposure scenarios. The additivity model was consistent in suggesting that acute lethality to fish would not occur at or close to the recommended TSS-based EPO. Monitoring will be undertaken to confirm the findings of this assessment.

5.0 MITIGATION MEASURES

The activities that have the potential to disturb bedded sediments during the work are summarized in Table 6. During the mobilization, execution and de-mobilization phases, several activities have the potential to introduce sediment into Rideau Canal outside the enclosed Work Area. The potential for effects to occur from these different activities varies (e.g., in relation to the degree to which the activity will suspended bedded sediment into the water column, as well as the sediment chemistry), and therefore the controls, or mitigation measures, that need to be in place during the different activities may also need to change. Of the activities identified in Table 6, the greatest potential for mobilization of bedded sediments and accidental release is expected to occur during active dewatering of the Work Area, followed by removal of containment structures after the Work Area is re-watered.

Table 6: Overview of Project Phases and Activities

Project Phase	Activities	Relative Level of Concern
Mobilization	Installation of turbidity curtain followed by coffer dam	Lowest
Execution	Initial dewatering	Highest
	On-going dewatering	
	Physical disturbance of bedded sediments	
Demobilization	Re-watering Work Area	Moderate
	Removal and decontamination of equipment	

The following mitigation measures are recommended for the Rideau Canal wall rehabilitation work. These are not intended to be tender specifications. Rather, they are general considerations only because the specific construction methods may change based on the Contractor's expertise and desired approaches. As the Contractor will be developing this specificity, the Contractor should also be responsible for the development of an EMP that meets, among other environmental requirements, the water quality EPO developed here. The contractor will also need to develop a specific health and safety plan that takes into account the specific conditions in which workers may find themselves. In addition to the health and safety requirements applicable to the physical works, that health and safety plan should include specific provisions to address the potential for workers encountering contaminated sediments and potentially vapours emanating from those.

- An Environmental Management Plan should be developed by the contractor and reviewed and accepted by PCA before construction work starts. The EMP should cover the full range of environmental issues in addition to those identified with regard to water and sediment quality in the present document.
- Workers are expected to wear appropriate personal protective equipment (PPE) to minimize potential exposure to sediment and water in the Work Areas. Appropriate PPE is considered to include, at a minimum: gloves, long-sleeved shirts, long pants, water-proof/chemical-resistant footwear, safety glasses. In the event that divers are used (e.g., to anchor turbidity curtains), the equipment used (e.g., wetsuit, face mask) should minimize bare skin exposure to the work zone. The Contractor should provide appropriate wash stations to remove adhered sediments from PPE, as well as hand-wash stations. The wash-off material should be contained and disposed of offsite. Wash water should not be allowed to enter the canal either directly or through a storm sewer. Contractors are also expected to be familiar with applicable health and safety requirements for workers.

- A means of containing suspended sediments within a given Work Area (e.g., with an impermeable turbidity curtain or coffer dam or other suitable method identified by the Contractor) such that a TSS concentration greater than 25 mg/L does not occur at the point of discharge (i.e., diffuse discharge through the containment system or point of discharge during active dewatering). The method selected by the Contractor should be suitable for containing fine particles (e.g., silt and clay). For example, turbidity curtains must be appropriately anchored (e.g., to the substrate, between turbidity curtain panels, the canal walls) to prevent gaps that may allow suspended sediments to escape. Where material such as concrete lock blocks or similar are used, an impermeable geotextile lining may need to be used to cover gaps between the blocks.
- In the event that the Contractor's selected methods for control of suspended particulates in discharge waters involves the use of flocculants, the contractor should provide a toxicity evaluation of the specific commercial formulation intended for use and shall use that flocculant in a manner that does not result in toxicity.
- As noted in Section 2.3, there is potential for release of hydrocarbon sheens or vapours during the works, in particular in Work Areas 1, 2, and 3.
    - Where sheens occur, they may be addressed in a similar manner as a spill of fuel. An appropriate spill kit (e.g., containing absorbent socks or pads) should be maintained on site and the Contractor's staff should be trained in the use of the kit. The Contractor should also prepare and post in an accessible location a spill response plan that includes contact information for the Departmental Representative responsible for the work and applicable spill response agencies. The Contractor should also have a plan in place to notify municipal authorities and the public for incidents above a pre-determined threshold, such as if a sheen is observed in the receiving environment and the sheen can be linked to the Work Area (i.e., via the dewatering effluent discharge or leakage outside the containment structure (e.g., the turbidity curtain or coffer dam). Based on the assessment in this document, it is also recommended that for Work Areas 1, 2, and 3 that 75 mg/L TSS be considered a threshold for reporting.
    - The potential magnitude of vapours was not assessed in this document. Conditions as encountered at the time the project is implemented will need to be planned for, monitored, and managed. Because reliable predictions of vapours cannot be made with the current level of information available, the Contractor should test for the presence of vapours and other hydrocarbon-related hazards as encountered and appropriate measures taken to protect worker health and safety based on monitoring results).
    - Depending on the configuration of the coffer dam, the Work Area could potentially be considered a "confined space"; the Contractor will evaluate this risk in accordance with applicable health and safety regulations.
- The pumping system to transfer dewatering effluent from the enclosed Work Area to the canal will need to be situated in such a way that it does not resuspend sediment from the canal bed within the Work Area or otherwise pump water from which particulates have not been allowed to settle. The pumping system may need a pre-filtration step to further minimize the transfer of suspended sediments.
- Discharges from the Work Area should be undertaken in such a way that scouring of the canal bed outside the Work Area does not occur.

- An alternative means of treatment or disposal of impacted water should be identified prior to commencement of the work in the event that the EPO cannot be met or water in the enclosed Work Area is found to be acutely lethal to fish. This could include active water treatment (the Contractor is responsible for determining the specific treatment steps that may be required to meet the EPO), or other suitable method to be determined by the Contractor in the EMP.
- During installation and removal of the containment structure, care should be taken to minimize disturbance of substrate. Where a coffer dam (or similar structure) is installed or removed, an impermeable turbidity curtain shall be placed around the structure to contained disturbed sediment. The turbidity curtain will be left in place until suspended particles have re-settled and the EPO is met. The contractor should be afforded an opportunity to present alternative control methods to that of a turbidity curtain but such methods must prevent the distribution of sediment.
- After the Work Area is dewatered, a barrier may need to be placed on the substrate to minimize disruption of the sediment. Where fluidized sediment (i.e., mud) is created, additional control of the potential for sediment release may be needed, in particular for Work Areas 1, 2 and 3 where contaminant concentrations are highest.
- Material removed from the canal bed during the works will be disposed of at an off-site facility. The Contractor will return the grade to the pre-work elevation. Material imported to the site for this purpose should be tested for potential contaminants of concern (e.g., metals, hydrocarbons) and confirmed to be “clean” (i.e., meets sediment quality guidelines). Care should be taken in the transport of construction equipment and material (e.g., coffer dams, turbidity curtains) out of the project area to prevent loss of adhered material from the equipment to sidewalks and streets. Where the material is rinsed or otherwise cleaned at the work site, the wash-off material should be contained and disposed of offsite. Wash water should not be allowed to enter the canal either directly or through a storm sewer.
- Materials used to contain the Work Areas should be appropriately disposed of in accordance with provincial regulations following the completion of the work.
- The Contractor should engage an appropriately-qualified and independent Environmental Monitor to inspect the work site, collect water quality measurements and samples, and notify the Contractor where modifications to the work, including stopping the work temporarily, may be necessary to meet the environmental protection objectives for the project. Minimum monitoring requirements are provided in Section 6.0.

6.0 MONITORING

This section provides expected outcomes and general considerations for the development a work-specific monitoring plan. These are not intended to be tender specifications; rather, they are general considerations only. The Contractor will retain an appropriately qualified professional to design and implement a water quality monitoring program that take into account the Contractor's specific work methods, the findings of this document, and other activities as appropriate (e.g., use of cementitious materials). The specifics of the monitoring plan should be provided to PCA for review prior to commencement of the work.

The expected outcomes of the monitoring program are as follows:

- Verification:
  - That the EPOs are being met
  - That the EPOs are protective of water quality in the Rideau Canal
  - Of water quality predictions made in this document
- Provide information to support an impact assessment in the event of an accidental release of sediment-laden water from a Work Area to Rideau Canal.

It is expected that *in situ* turbidity measurements will be used for day-to-day monitoring and to inform the Contractor of the potential need to implement management actions:

- For the point of discharge, turbidity should be measured on an hourly basis during periods of active discharge
- For the receiving environment, turbidity measurements should be collected up and downstream of the Work Area:
  - If manual monitoring is the selected method, the frequency of monitoring can be varied based on the cloudiness of the discharge water and the receiving environment. When the discharge water is not visibly cloudy, spot measurements should be made a minimum of twice daily. When the discharge water is visibly cloudy, more frequent measurements should be made.
  - Turbidity measurements can also be collected with a continuous recorder with a data logger, with one placed upstream and one downstream of the Work Area. The data logger should be downloaded weekly and supplemented with manual spot measurements.

Samples should be collected for laboratory analysis as follows:

- Once at each Work Area from the point of discharge during active dewatering, and concurrently upstream and downstream of the Work Area to verify that WQGs for chemical parameters are being met in the Rideau Canal and to provide information that can be used to verify the water quality predictions made in this document.

- In the event of an accidental release of sediment-laden water with a TSS concentration of 75 mg/L or greater, samples should be collected as follows:
  - Samples of the discharge water should be submitted for concurrent chemical analysis of total and dissolved metals, PAHs, pH, total organic carbon, TSS and turbidity; and toxicity testing following Environment Canada protocols for rainbow trout or fathead minnow (Environment Canada 1990, 2011).
  - Samples of water from Rideau Canal up and downstream of the Work Area should be submitted for chemical analysis of total and dissolved metals, PAHs, pH, total organic carbon, TSS and turbidity.
  - It may also be necessary to collect other types of samples depending on the nature of the accidental release. Additional sampling requirements should be discussed with PCA and/or other agencies as necessary (e.g., the provincial Ministry of the Environment and Climate Change or ECCC).

7.0 STUDY LIMITATIONS

This technical memorandum was prepared for the exclusive use of Public Works and Government Services Canada (Ontario Region) and Parks Canada Agency. The services performed as described in this report were conducted in a manner consistent with the level of care and skill normally exercised by other members of the science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services. Toxicity benchmarks were obtained from readily available sources such as guideline derivation documents. A detailed literature review and toxicity testing could be undertaken to reduce the degree of conservatism applied in this report. The content of this report is based on our present understanding of site conditions, the assumptions stated in this report, and our professional judgment in light of such information at the time of this report. This report provides professional opinion and, therefore, no warranty is expressed, implied, or made as to the conclusions, advice and recommendations offered in this report. This report does not provide a legal opinion regarding compliance with applicable laws or regulations. Any use that a third party may make of this report, or any reliance on or decisions made based on it, is the responsibility of the third parties.

The assessments provided in this report rely on data and information provided by sub-consultants (analytical laboratories) and third parties (i.e., previous consultants and provincial agencies who have conducted investigations at the site). In evaluating the data, we have relied in good faith on information provided by the laboratories. For the purpose of this study, we assume that the information provided by the laboratories is factual and accurate. We accept no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of omissions, misinterpretations, or errors committed by sub-consultants or previous investigators. Assessment has been made using the results of discrete chemical analyses from discrete sampling times and sample media, and therefore, results cannot necessarily be extrapolated to all times or sample media. Additional study can reduce the inherent uncertainties associated with this type of study.

The findings and conclusions of this report are valid only as of the date of the report. If new information is discovered in future work, or if the assumptions stated in this report are not met, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

8.0 CLOSURE

We trust that this report provides sufficient information for your present needs. If you have any questions, please contact the undersigned at 604-296-4200.

Yours truly,

GOLDER ASSOCIATES LTD.

Barbara Wernick, MSc, RPBio
Principal, Senior Environmental Scientist

Gary Lawrence, MRM, RPBio
Associate, Senior Environmental Scientist

BW/KN/GL/kv

o:\final\2017\3 proj\1776320_pwgsc_ottawa walls_rideau canal\1776320-004-r-rev0\1776320-004-r-rev0-rideau perform objectives-07sep_17.docx

9.0 REFERENCES

Atlantic PIRI (Partnership in RBCA Implementation). 2012. ATLANTIC RBCA (Risk-Based Corrective Action) Version 3: Ecological Screening Protocol for Petroleum Impacted Sites in Atlantic Canada.

BC MELP (British Columbia Ministry of Environment, Lands, and Parks). 1999. Ambient water quality guidelines for zinc: overview. Water Management Branch.

BC MOE (British Columbia Ministry of Environment). 2002. Ambient water quality guidelines for arsenic: overview report. Water Protection Branch, Ministry of Environment.

CCME (Canadian Council of Ministers of the Environment). 1999a (updated 2002). Canadian water quality guidelines for the protection of aquatic life: total particulate matter. Canadian Council of Ministers of the Environment, Winnipeg.

CCME. 1999b. Canadian water quality guidelines for the protection of aquatic life: chromium (hexavalent chromium and trivalent chromium)

CCME. 1999c. Canadian water quality guidelines for the protection of aquatic life: polycyclic aromatic hydrocarbons. Canadian Council of Ministers of the Environment, Winnipeg.

CCME. 1999d. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life: Introduction. Canadian Environmental Quality Guidelines, 1999, CCME, Winnipeg, MB

CCME. 2003. Canadian water quality guidelines for the protection of aquatic life: mercury (inorganic mercury and methylmercury)

CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian Water Quality Guidelines. Chapter 3: Freshwater aquatic life.

Call DJ, Brooke LT, Harting SL, Poirer SH, McCauley DJ. 1986. Toxicity of phenanthrene to several freshwater species. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior.

Chapman PM, Mann GS. 1999. Sediment quality values (SQVs) and ecological risk assessment (ERA). Mar Pollut Bull 38(5):3398-344.

DFO (Department of Fisheries and Oceans and Ministry of Environment Lands and Parks). 1992. Land development guidelines for the protection of aquatic habitat. Available at: http://www.dfo-mpo.gc.ca/Library/165353.pdf.

DiToro DM, McGrath JA, Hansen DJ. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. Environ Toxicol Chem 19(8): 1951-1970.

Environment Canada. 1990. Biological test method: acute lethality test using rainbow trout. Environmental Protection Series EPS 1/RM/9.

Environment Canada. 2011. Biological test method: test of larval growth and survival using fathead minnows. Environmental Protection Series EPS 1/RM/22.

Golder (Golder Associates Ltd.). 2017a. Sampling and analysis plan, Rideau Canal, Ottawa, Ontario: 2017 sediment and surface water assessment. Reference No. 1776320-001-R-Rev0.

Golder. 2017b. Ottawa Wall Repairs Rideau Canal, Ottawa, Ontario: Sediment and surface water assessment – factual report. Reference No. 1776320-003-R-Rev0.

Health Canada 2010 (updated 2012). Federal Contaminated Sites Guidance on Human Health Risk Assessment in Canada Part I: Human Health Preliminary Quantitative Risk Assessment (PQRA).

Nagpal NK. 1993. Ambient water quality criteria for polycyclic aromatic hydrocarbons (PAHs). Ministry of Environment, Lands and Parks, Water Quality Branch. Available at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/pahs-tech.pdf.

Oris JT, Giesy JP. 1987. The photo-induced toxicity of polycyclic aromatic hydrocarbons to larvae of the fathead minnow (*Pimephales promelas*). Chemosphere 16: 1395-1404

Spear PA, Pierce RC. 1979. Copper in the aquatic environment: chemistry, distribution and toxicology. National Research Council of Canada. Associate Committee on Scientific Criteria for Environmental Quality, Pub. No. 16454.

Spehar RL, Poucher S, Brooke LT, Hansen DJ, Champlin D, Cox DA. 1999. Comparative toxicity of fluoranthene to freshwater and saltwater species under fluorescent and ultraviolet light. Arch Environ Contam Toxicol 37:496-502.

US EPA (United States Environment Protection Agency). 1985a. Ambient Water Quality Criteria for Copper - 1984. Criteria and Standards Division, U.S. Environmental Protection Agency, Washington, D.C. EPA-440/5-84-031.

US EPA. 1985b. Ambient water Quality Criteria for Lead - 1984. Criteria and Standards Division, U.S. Environmental Protection Agency, Washington, D.C. EPA-440/5-84-027.

US EPA. 2015. Regional Screening Levels (June 2015). Available at: http://www3.epa.gov/region09/superfund/prg/.

WHO (World Health Organization). 2003. Guidelines for safe recreational water environments. Volume 1, Coastal and Fresh Waters. Geneva, Switzerland.

APPENDIX A

Summary of Sediment Chemistry Results

Appendix A:
Summary of Results of the Sediment Assessment in Proporsed Work Areas 1 to 11 in the Rideau Canal

Parameter	Lowest Method Detection Level	MOECC Table 9 Sediment Standards	MOECC Table 7 Shallow Soils - Commercial Property	Atlantic RBCA 2012	CCME ISQG (Freshwater)	CCME PEL (Freshwater)	Work Area 1 No. Samples	Work Area 1 Minimum Concentration	Work Area 1 Mean Concentration	Work Area 1 Maximum Concentration	Work Area 2 No. Samples	Work Area 2 Minimum Concentration	Work Area 2 Mean Concentration	Work Area 2 Maximum Concentration	Work Area 3 No. Samples	Work Area 3 Minimum Concentration	Work Area 3 Mean Concentration	Work Area 3 Maximum Concentration	Work Area 4 No. Samples	Work Area 4 Minimum Concentration	Work Area 4 Mean Concentration	Work Area 4 Maximum Concentration	Work Area 5 No. Samples	Work Area 5 Minimum Concentration	Work Area 5 Mean Concentration	Work Area 5 Maximum Concentration
Grain Size																										
Sand (%)	--						3	56	63	77	15	8.4	38	81	12	14	40	89	19	15	34	69	14	12	39	89
Silt (%)	--						3	17	29	36	15	14	35	49	12	8.2	32	51	19	12	22	40	14	7	17	30
Clay (5)	--						3	5.6	8	10	15	5.2	26	50	12	2.7	29	60	19	8.2	43	65	14	4	43	67
Moisture (%)	--						3	26	41	49	15	20	34	54	12	13	32	51	19	26	44	71	14	28	40	54
Total Organic Carbon																										
Total Organic Carbon (%)	500						3	5.3	5.53	5.8	15	0.05	3.4	8	12	0.05	1.8	5.6	17	0.21	2.65	8.6	14	0.2	2.2	7.1
Metals																										
Antimony	0.2						3	1.2	1.8	2.5	15	<	1.8	5.5	12	<	0.6	2.4	19	<	1.1	4.2	14	<	0.51	2.9
Arsenic	1	6			**5.9**	17	3	2.5	3.1	4.4	15	<	3.3	**8.4**	12	<	2.0	5.5	19	1.2	2.6	**7**	14	1.1	1.95	4.7
Barium	0.5						3	85	125.0	170	15	73	186.3	330	12	66	189.6	310	19	160	324.7	410	14	87	242	330
Beryllium	0.2						3	<	0.3	0.33	15	<	0.5	0.77	12	<	0.4	0.68	19	0.37	0.8	0.94	14	<	0.68	0.92
Boron (Hot Water Soluble)	0.05						3	0.33	0.3	0.37	15	0.13	0.3	0.51	12	0.097	0.3	0.54	19	0.2	0.7	1	14	0.25	0.48	0.85
Cadmium	0.1	0.6			**0.6**	3.5	3	0.24	**0.7**	**0.98**	15	<	0.3	**0.88**	12	0.1	0.3	**0.92**	19	<	0.2	**0.81**	14	<	0.16	0.34
Chromium (Total)	1	26			**37.3**	90	3	**46**	**53.3**	**60**	15	24	**54.5**	**85**	12	22	**48.5**	**96**	19	**53**	**113**	**140**	14	27	**93**	**130**
Chromium (Hexavalent, VI)	0.2						3	<	<	<	15	<	<	<	12	<	<	<	19	<	<	<	14	<	<	<
Cobalt	0.1	50					3	6.7	9.7	13	15	7	11.4	19	12	5.2	10.1	17	19	9.3	22.5	28	14	5.3	18	25
Copper	0.5	16			**35.7**	197	3	**70**	**116.7**	**170**	15	16	**62.8**	**120**	12	15	**40.1**	**100**	19	**55**	**68.6**	**93**	14	35	**61**	**210**
Lead	1	31			**35**	91.3	3	**60**	**126.7**	**190**	15	5.3	**104**	**320**	12	4	**67.1**	**210**	19	9.6	**98**	**710**	14	8	34	**130**
Mercury	0.05	0.2			**0.17**	0.486	3	<	0.15	**0.23**	15	<	**0.5**	**4**	12	<	0.2	**0.62**	19	<	**0.2**	**1.2**	14	<	0.06	0.13
Molybdenum	0.5						3	2	2.6	3	15	0.77	1.7	3.5	12	0.5	1.1	2.2	19	0.9	1.3	2.5	14	<	1.00	2.2
Nickel	0.5	16					3	15	20.0	24	15	15	28.3	45	12	12	23.6	37	19	24	63.4	80	14	12	52	74
Phosphorus	50						0	-	-	-	12	750	946	1100	7	670	926	1100	19	870	943	1000	14	710	842	940
Selenium	0.5						3	<	<	<	15	<	0.6	1	12	<	0.5	0.78	19	<	0.6	1.2	14	<	0.52	0.68
Silver	0.2	0.5					3	0.55	0.6	0.67	15	<	0.3	0.52	12	<	0.3	0.53	19	<	0.2	0.43	14	<	<	<
Sulfur	50						3	1600	2567	3200	12	570	1745	2900	12	380	1300	3000	19	280	1441	6500	14	220	1603	7500
Thallium	0.05						3	0.11	0.2	0.21	15	0.13	0.3	0.49	12	0.1	0.2	0.37	19	0.2	0.4	0.49	14	0.11	0.32	0.43
Tin	1						3	5	8.3	11	14	<	9.0	37	12	<	4.4	14	19	1.5	8.4	29	14	1.3	3.91	27
Uranium	0.05						3	0.47	0.6	0.66	15	0.48	0.9	1.2	12	0.46	0.9	1.5	19	0.85	1.3	1.9	14	0.57	1.19	2
Vanadium	5						3	20	27.0	31	15	21	51.1	87	12	19	47.2	83	19	37	98.9	130	14	19	79.5	110
Zinc	5	120			**123**	315	3	**380**	**513**	**700**	15	39	**214**	**620**	12	40	**149**	**360**	19	**130**	**180**	**390**	14	89	**140**	**270**
Phenols																										
Total Phenols	0.04		*9.4*				0	-	-	-	5	<	<	<	7	<	<	<	0	-	-	-	4	<	<	<
Petroleum Hydrocarbons																										
Total Petroleum Hydrocarbons (Calculated)	--			***500***			3	***3031***	***4143***	***6357***	13	102	***2164***	***5898***	8	240	***1480***	***5507***	6	110	***1527***	***3766***	4	58	***757***	***1100***
Polycyclic Aromatic Hydrocarbons																										
Acenaphthene	0.005				**0.00671**	0.0889	3	**0.05**	**0.38**	**0.72**	15	<	**0.27**	**1.1**	12	0.0057	**0.08**	**0.29**	19	<	**0.03**	**0.12**	14	0.0054	**0.02**	**0.063**
Acenaphthylene	0.005				**0.00587**	0.128	3	**0.05**	**0.22**	**0.37**	15	<	**0.11**	**0.55**	12	<	**0.09**	**0.44**	19	<	**0.03**	**0.14**	14	**0.0093**	**0.02**	**0.05**
Anthracene	0.005	0.22			**0.0469**	0.245	3	**0.14**	**1.21**	**2.20**	15	<	**0.48**	**2.4**	12	<	**0.15**	**0.66**	19	<	0.05	**0.22**	14	<	0.02	**0.05**
Benzo [b,j] fluoranthene	0.005						3	0.41	2.57	4.60	15	<	1.12	3.6	12	0.011	0.71	3.6	19	<	0.25	1.3	14	<	0.07	0.28
Benzo[a]anthracene	0.005	0.32			**0.0317**	0.385	3	**0.32**	**2.24**	**4.00**	15	<	**0.88**	**3.2**	12	0.0069	**0.46**	**2.2**	19	<	**0.16**	**0.86**	14	<	**5.47**	**59**
Benzo[a]pyrene	0.005	0.37			**0.0319**	0.782	3	**0.3**	**2.07**	**3.80**	15	<	**0.79**	**2.4**	12	0.0069	**0.46**	**2.1**	19	<	**0.16**	**0.86**	14	<	**0.05**	**0.19**
Benzo[g,h,i]perylene	0.005	0.17					3	0.29	1.36	2.40	15	<	0.51	1.6	12	<	0.27	1.1	19	<	0.13	0.71	14	<	0.04	0.16
Benzo[k]fluoranthene	0.005	0.24					3	0.13	0.89	1.60	15	<	0.40	1.4	12	<	0.23	1.1	19	<	0.09	0.48	14	<	0.03	0.097
Chrysene	0.005	0.34			**0.0571**	0.862	3	**0.28**	**1.93**	**3.40**	15	<	**0.84**	**2.8**	12	0.0077	**0.47**	**2.3**	19	<	**0.16**	**0.85**	14	<	0.05	**0.18**
Dibenzo[a,h]anthracene	0.005	0.06			**0.00622**	0.135	3	<	**0.37**	**0.69**	15	<	**0.12**	**0.42**	12	<	**0.08**	**0.36**	19	<	**0.03**	**0.15**	14	**0.0073**	**0.01**	**0.05**
Fluoranthene	0.005	0.75			**0.111**	2.355	3	**0.77**	**4.79**	**7.80**	15	0.0061	**2.26**	**7.6**	12	0.021	**1.14**	**6**	19	<	**0.36**	**2**	14	<	0.11	**0.41**
Fluorene	0.005	0.190			**0.021**	0.144	3	<	**0.65**	**1.10**	15	<	**0.32**	**1.6**	12	<	**0.10**	**0.41**	19	<	**0.03**	**0.13**	14	0.0087	0.01	**0.05**
Indeno[1,2,3-cd]pyrene	0.005	0.2					3	0.23	1.41	2.60	15	<	0.54	1.7	12	0.0052	0.30	1.3	19	<	0.13	0.67	14	<	0.04	0.15
Naphthalene	0.005				**0.0346**	0.391	3	<	**0.32**	**0.53**	15	<	**0.31**	**2.8**	12	<	**0.09**	**0.53**	19	<	0.03	**0.13**	14	<	0.02	**0.05**
Phenanthrene	0.005	0.560			**0.0419**	0.515	3	**0.41**	**4.10**	**6.60**	15	0.009	**1.73**	**7.7**	12	0.0097	**0.56**	**2.1**	19	<	**0.16**	**1.1**	14	<	**0.05**	**0.15**
Pyrene	0.005	0.490			**0.053**	0.875	3	**0.72**	**3.94**	**6.50**	15	0.0061	**1.88**	**6.6**	12	0.019	**0.94**	**4.8**	19	<	**0.32**	**1.7**	14	<	**8.87**	**110**
1-Methylnaphthalene	0.005						3	<	0.23	0.36	15	<	0.14	1.5	12	0.0066	0.05	0.17	19	<	0.04	0.099	14	<	0.02	0.05
2-Methylnaphthalene	0.005				**0.0202**	0.201	3	<	**0.24**	**0.36**	15	<	**65**	**0.58**	12	0.0084	**0.07**	**0.24**	19	<	**0.04**	**0.14**	14	<	**9.15**	**74**
Non-Halogenated Volatiles																										
Benzene	0.006		*0.4*				3	<	<	<	10	<	0.017	0.038	5	<	0.010	0.02	18	<	0.01	0.05	12	<	<	<
Toluene	0.02		*78*				3	0.035	0.05	0.07	10	<	0.07	0.28	5	<	0.04	0.098	18	<	0.03	0.098	12	<	0.02	0.04
Ethylbenzene	0.01		*19*				3	<	<	<	10	<	0.02	0.047	5	<	0.01	0.018	18	<	0.03	0.16	12	<	0.01	0.031
Xylenes, Total	0.02		*30*				3	<	0.022	0.023	10	<	0.08	0.23	5	<	0.04	0.091	18	<	0.04	0.13	12	<	0.02	0.06
m,p-Xylenes	0.02						3	<	0.022	0.023	10	<	0.06	0.17	5	<	0.03	0.06	18	<	0.03	0.072	12	<	0.02	0.032
o-Xylene	0.02						3	<	<	<	10	<	0.03	0.067	5	<	0.02	0.03	18	<	0.03	0.058	12	<	0.02	0.028

Parameter	Work Area 6 No. Samples	Work Area 6 Minimum Concentration	Work Area 6 Mean Concentration	Work Area 6 Maximum Concentration	Work Area 7 No. Samples	Work Area 7 Minimum Concentration	Work Area 7 Mean Concentration	Work Area 7 Maximum Concentration	Work Area 8 No. Samples	Work Area 8 Minimum Concentration	Work Area 8 Mean Concentration	Work Area 8 Maximum Concentration	Work Area 9 No. Samples	Work Area 9 Minimum Concentration	Work Area 9 Mean Concentration	Work Area 9 Maximum Concentration	Work Area 10 No. Samples	Work Area 10 Minimum Concentration	Work Area 10 Mean Concentration	Work Area 10 Maximum Concentration	Work Area 11 No. Samples	Work Area 11 Result
Grain Size																						
Sand (%)	12	12	34	68	5	40	68	84	4	66	70	72	9	55	75	95	4	40	65	84	1	82
Silt (%)	12	13	22	43	5	9	17	27	4	11	19	26	9	3.1	15	26	4	8	23	40	1	13
Clay (5)	12	9	44	74	5	6	15	40	4	8.4	12	16	9	2.3	10	19	4	6	13	20	1	5.8
Moisture (%)	12	27	43	84	5	27	34	52	4	21	40	73	9	18	26	69	4	17	21	24	1	20
Total Organic Carbon																						
Total Organic Carbon (%)	9	0.27	0.85	2	4	0.93	1.3	1.7	3	1	1.3	1.9	9	0.05	0.96	5.7	4	0.05	0.62	1.6	1	1.4
Metals																						
Antimony	12	<	0.5	2.2	5	<	0.24	0.41	4	0.58	0.73	0.87	9	<	0.34	1.4	4	<	0.3	0.57	1	0.42
Arsenic	12	<	1.7	2.7	5	<	1.22	1.7	4	1.7	2.0	2.8	9	<	1.47	2	4	1.5	1.9	2.4	1	2
Barium	12	160	272	390	5	59	158	290	4	93	126	160	9	32	73	130	4	43	50	54	1	75
Beryllium	12	0.29	0.6	0.84	5	0.2	0.27	0.39	4	0.34	0.39	0.43	9	<	0.32	0.53	4	0.21	0.3	0.34	1	0.27
Boron (Hot Water Soluble)	12	0.17	0.3	1.2	5	0.18	0.28	0.48	4	0.2	0.35	0.53	9	<	0.13	0.3	4	<	0.2	0.27	1	0.25
Cadmium	12	<	0.3	**1.3**	5	0.1	0.14	0.2	4	0.16	0.43	**0.99**	9	<	0.13	0.3	4	0.1	0.1	0.13	1	0.11
Chromium (Total)	12	35	**88**	**130**	5	22	34.4	**50**	4	33	**40**	**52**	9	16	25	36	4	16	24	31	1	20
Chromium (Hexavalent, VI)	12	<	<	<	5	<	<	<	4	0.2	0.2	0.2	9	<	0.29	0.5	4	<	0.3	0.4	1	<
Cobalt	12	7.1	17.5	26	5	4.8	6.5	10	4	6.8	8.7	10	9	3.3	6.27	8.2	4	4.1	5.7	7.5	1	5.9
Copper	12	22	**47**	**73**	5	6.7	22	**48**	4	24	**38**	**63**	9	6.2	15	27	4	11	15	19	1	18
Lead	12	17	**101**	**330**	5	6.7	**139**	**420**	4	**52**	**110**	**170**	9	3.1	21	**82**	4	3.5	21	**52**	1	24
Mercury	12	<	**0.4**	**1.4**	5	0.063	**1.3**	**4.5**	4	0.079	**0.210**	**0.3**	9	<	0.06	0.096	4	<	0.1	0.05	1	<
Molybdenum	12	<	1.0	2.9	5	0.5	0.542	0.71	4	0.75	1.33	2.6	9	<	0.54	0.84	4	<	0.9	1.8	1	0.87
Nickel	12	18	48	75	5	11	16.6	27	4	19	23	26	9	7.6	15	22	4	11	13.3	16	1	13
Phosphorus	12	730	880	960	5	520	722	860	4	860	895	920	9	740	877	1200	2	840	840	840	1	800
Selenium	12	<	0.6	1.1	5	<	<	<	4	0.5	0.62	0.99	9	<	0.51	0.62	4	<	<	<	1	<
Silver	12	<	0.2	0.41	5	<	<	<	4	<	<	0.21	9	<	<	<	4	<	<	<	1	<
Sulfur	12	210	2472	14000	5	320	1308	4500	4	510	2748	8100	8	<	584	3300	4	<	735	1600	1	1300
Thallium	12	0.15	0.3	0.48	5	0.069	0.12	0.19	4	0.14	0.17	0.22	9	<	0.10	0.14	4	0.072	0.1	0.11	1	0.11
Tin	12	1.4	3.3	6.1	5	<	3.56	10	4	1.8	2.5	3.9	9	1	1.49	2.8	4	<	1.1	1.4	1	1
Uranium	12	0.64	1.1	1.3	5	0.35	0.50	0.64	4	0.57	0.84	1.4	9	0.41	0.61	0.81	4	0.57	0.9	1.5	1	0.73
Vanadium	12	34	76.2	120	5	24	30.8	49	4	31	37	42	9	23	34	49	4	20	29.3	38	1	24
Zinc	12	67	**151**	**350**	5	33	70	110	4	72	**149**	**290**	9	25	45	110	4	31	39	44	1	65
Phenols																						
Total Phenols	8	<	0.048	0.10	2	<	<	<	0	-	-	-	0	-	-	-	0	-	-	-	0	-
Petroleum Hydrocarbons																						
Total Petroleum Hydrocarbons (Calculated)	5	140	***1881***	***5493***	3	79	470	***1244***	4	***597***	***1352***	***2104***	4	88	490.5	***964***	2	143	145	146	1	490
Polycyclic Aromatic Hydrocarbons																						
Acenaphthene	12	<	**0.031**	**0.098**	5	<	**0.009**	**0.014**	4	**0.058**	**0.10**	**0.17**	9	<	**0.043**	**0.32**	4	<	0.006	**0.01**	1	**0.014**
Acenaphthylene	12	<	**0.033**	**0.19**	5	<	**0.048**	**0.1**	4	**0.067**	**0.08**	**0.094**	9	<	**0.056**	**0.34**	4	<	**0.011**	**0.024**	1	**0.023**
Anthracene	12	<	0.045	**0.19**	5	<	0.044	**0.092**	4	**0.14**	**0.16**	**0.2**	9	<	**0.128**	**0.96**	4	<	0.016	0.044	1	**0.055**
Benzo [b,j] fluoranthene	12	<	0.234	1.3	5	<	0.293	0.52	4	0.65	0.80	0.97	9	<	0.427	2.9	4	<	0.071	0.21	1	0.17
Benzo[a]anthracene	12	<	**0.196**	**1.00**	5	0.0056	**0.218**	**0.46**	4	**0.46**	**0.56**	**0.72**	9	<	**0.298**	**2.1**	4	<	**0.051**	**0.15**	1	**0.13**
Benzo[a]pyrene	12	<	**0.187**	**1.00**	5	<	**0.233**	**0.43**	4	**0.49**	**0.59**	**0.74**	9	<	**0.327**	**2.2**	4	<	**0.055**	**0.16**	1	**0.13**
Benzo[g,h,i]perylene	12	<	0.130	0.65	5	<	0.148	0.26	4	0.32	0.37	0.41	9	<	0.198	1.3	4	<	0.044	0.12	1	0.076
Benzo[k]fluoranthene	12	<	0.080	0.43	5	<	0.098	0.17	4	0.24	0.27	0.3	9	<	0.149	1	4	<	0.026	0.072	1	0.055
Chrysene	12	<	**0.157**	**0.85**	5	0.0072	**0.197**	**0.41**	4	**0.45**	**0.52**	**0.64**	9	<	**0.277**	**1.9**	4	<	0.042	**0.12**	1	**0.12**
Dibenzo[a,h]anthracene	12	<	**0.034**	**0.19**	5	<	**0.038**	**0.076**	4	**0.088**	**0.10**	**0.12**	9	<	**0.059**	**0.4**	4	<	**0.013**	**0.034**	1	**0.021**
Fluoranthene	12	0.0063	**0.425**	**2**	5	0.013	**0.463**	**1.1**	4	**1.1**	**1.23**	**1.5**	9	<	**0.638**	**4.5**	4	<	0.093	**0.27**	1	**0.26**
Fluorene	12	<	**0.032**	**0.094**	5	<	0.019	**0.036**	4	**0.064**	**0.09**	**0.15**	8	<	**0.081**	**0.57**	4	<	0.008	0.017	1	**0.027**
Indeno[1,2,3-cd]pyrene	12	<	0.136	0.75	5	<	0.175	0.32	4	0.36	0.42	0.5	9	<	0.237	1.6	4	<	0.046	0.13	1	0.083
Naphthalene	12	<	0.017	**0.049**	5	<	0.010	0.018	4	0.015	0.03	**0.044**	9	<	0.027	**0.19**	4	<	0.006	0.0088	1	0.011
Phenanthrene	12	<	**0.193**	**0.75**	5	0.0051	**0.130**	0.34	4	**0.38**	**0.50**	**0.62**	9	<	**0.366**	**2.8**	4	<	0.042	**0.12**	1	**0.16**
Pyrene	12	0.0062	**0.349**	**1.7**	5	0.012	**0.398**	**0.95**	4	**0.91**	**1.02**	**1.2**	9	<	**0.493**	**3.4**	4	<	**0.079**	**0.23**	1	**0.23**
1-Methylnaphthalene	12	<	0.012	0.025	5	<	0.007	0.011	4	0.013	0.03	0.047	9	<	0.025	0.17	4	<	0.006	0.0068	1	0.0092
2-Methylnaphthalene	12	<	**6.68**	**60**	5	<	0.015	**0.05**	4	0.016	**0.04**	**0.05**	9	<	**0.032**	**0.20**	4	<	0.009	0.016	1	0.014
Non-Halogenated Volatiles																						
Benzene	6	<	0.010	0.024	2	<	<	<	5	<	0.009	0.018	4	<	0.011	0.025	3	<	0.012	0.023	0	-
Toluene	6	<	0.037	0.08	2	<	0.023	0.025	5	<	0.03	0.06	4	<	0.031	0.062	3	<	0.04	0.08	0	-
Ethylbenzene	6	<	0.024	0.065	2	<	<	<	5	<	0.02	0.03	4	<	0.01	<	3	<	0.01	0.01	0	-
Xylenes, Total	6	<	0.033	0.08	2	<	<	<	5	<	0.04	0.06	4	<	0.023	0.032	3	<	0.024	0.032	0	-
m,p-Xylenes	6	<	0.033	0.08	2	<	<	<	5	<	0.03	0.06	4	<	0.023	0.032	3	<	0.024	0.032	0	-
o-Xylene	6	<	0.033	0.08	2	<	<	<	5	<	0.03	0.06	4	<	0.02	<	3	<	0.02	0.02	0	-

Notes
All units in micrograms per gram (µg/g) except otherwise noted.
% = percent; mg/L = milligrams per litre
m bml = metres below mudline
MOECC = Ontario Ministry of Enviroment and Climate Change
Table 9 Sediment Standards = For all types of property use for sediment in generic site condition for use within 30 m of a water body in a non-potable groundwater condition (O. Reg 153 [2011])
Table 7 Shallow Soil Standards = For commercial property use for shallow soils in a non-potable
PSQG LEL = Provincial Sediment Quality Guidelines Lowest Effect Level (OMOE 2008)
PSQG SEL = Provincial Sediment Quality Guidelines Severe Effect Level (OMOE 2008)
Atlantic RBCA = Atlantic Risk-Based Corrective Action, Non-Narcosis Sediment Benchmark 2012
CCME ISQG = Canadian Council of Ministers of the Environment Sediment Quality Guidelines - Interim Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life
CCME PEL = Canadian Council of Ministers of the Environment Sediment Quality Guidelines - Probable Effect Levels for the Protection of Freshwater Aquatic Life
F1 (C6-C10) = Fraction 1, Carbon range 6 to 10; BTEX = benzene, toluene, ethylbenzene and xylene
F2 (C10-C16) = Fraction 2, Carbon range 10to 16
F3 (C16-C34) = Fraction 3, Carbon range 16 to 34
F4 (C34-C50) = Fraction 4, Carbon range 34 to 50
F4 Gravimetric = Fraction 4 obtained by gravimetric analysis
Total Petroleum Hydrocarbons (TPH) is equal to the sum of the F1 to F4 Fractions. Where F4 Gravimetric was greater than F4 (C34-C50), the F4 Gravimetric concentration was used in calculating

Appendix A:
Summary of Results of the Sediment Assessment in Proporsed Work Areas 1 to 11 in the Rideau Canal

Parameter	Lowest Method Detection Level	MOECC Table 9 Sediment Standards	MOECC Table 7 Shallow Soils - Commercial Property	Atlantic RBCA 2012	CCME ISQG (Freshwater)	CCME PEL (Freshwater)	Work Area 1				Work Area 2				Work Area 3			
							No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration
Volatile Organic Compounds																		
1,1,1,2-Tetrachloroethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,1,1-Trichloroethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,1,2,2-Tetrachloroethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,1,2-Trichloroethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,2-Dichlorobenzene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,3-Dichlorobenzene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,4-Dichlorobenzene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,1-Dichloroethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,2-Dichloroethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,1-Dichloroethylene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
cis-1,2-Dichloroethene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
trans-1,2-Dichloroethene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
1,2-Dichloropropane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
cis-1,3-Dichloropropene	0.03						3	<	<	<	7	<	<	<	5	<	<	<
trans-1,3-Dichloropropene	0.04						3	<	<	<	7	<	<	<	5	<	<	<
1,2-Dibromoethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
4-Methyl-2-pentanone	0.5						3	<	<	<	5	<	<	<	5	<	<	<
Acetone	0.5						3	<	<	<	7	<	1.04	4.3	5	<	0.51	0.56
Bromodichloromethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Bromoform	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Bromomethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Carbon Tetrachloride	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Chlorobenzene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Chloroform	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Dibromochloromethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Dichlorodifluoromethane	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Methyl Ethyl Ketone	0.5						3	<	<	<	7	<	0.54	0.77	5	<	<	<
Methylene Chloride	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Methyl tert-Butyl Ether	0.05						3	<	<	<	7	<	<	<	5	<	<	<
n-Hexane	0.05						3	<	<	<	7	<	0.052	0.063	5	<	<	<
Tetrachloroethylene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Trichloroethene	0.01						3	<	<	<	7	<	<	<	5	<	<	<
Trichlorofluoromethane	0.05						3	<	0.17	0.41	7	<	<	<	5	<	<	<
Styrene	0.05						3	<	<	<	7	<	<	<	5	<	<	<
Vinyl Chloride	0.02						3	<	<	<	7	<	<	<	5	<	<	<

Parameter	Work Area 4				Work Area 5				Work Area 6				Work Area 7			
	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration
Volatile Organic Compounds																
1,1,1,2-Tetrachloroethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,1,1-Trichloroethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,1,2,2-Tetrachloroethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,1,2-Trichloroethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,2-Dichlorobenzene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,3-Dichlorobenzene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,4-Dichlorobenzene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,1-Dichloroethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,2-Dichloroethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,1-Dichloroethylene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
cis-1,2-Dichloroethene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
trans-1,2-Dichloroethene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,2-Dichloropropane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
cis-1,3-Dichloropropene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
trans-1,3-Dichloropropene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
1,2-Dibromoethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
4-Methyl-2-pentanone	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Acetone	13	<	<	<	7	<	<	<	6	<	0.917	2.5	2	<	<	<
Bromodichloromethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Bromoform	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Bromomethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Carbon Tetrachloride	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Chlorobenzene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Chloroform	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Dibromochloromethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Dichlorodifluoromethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Methyl Ethyl Ketone	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Methylene Chloride	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Methyl tert-Butyl Ether	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
n-Hexane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Tetrachloroethylene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Trichloroethene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Trichlorofluoromethane	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Styrene	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<
Vinyl Chloride	13	<	<	<	7	<	<	<	6	<	<	<	2	<	<	<

Parameter	Work Area 8				Work Area 9				Work Area 10				Work Area 11	
	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Minimum Concentration	Mean Concentration	Maximum Concentration	No. Samples	Result
Volatile Organic Compounds														
1,1,1,2-Tetrachloroethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,1,1-Trichloroethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,1,2,2-Tetrachloroethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,1,2-Trichloroethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,2-Dichlorobenzene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,3-Dichlorobenzene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,4-Dichlorobenzene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,1-Dichloroethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,2-Dichloroethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,1-Dichloroethylene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
cis-1,2-Dichloroethene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
trans-1,2-Dichloroethene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,2-Dichloropropane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
cis-1,3-Dichloropropene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
trans-1,3-Dichloropropene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
1,2-Dibromoethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
4-Methyl-2-pentanone	4	<	<	<	3	<	<	<	0	-	-	-	0	-
Acetone	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Bromodichloromethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Bromoform	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Bromomethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Carbon Tetrachloride	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Chlorobenzene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Chloroform	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Dibromochloromethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Dichlorodifluoromethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Methyl Ethyl Ketone	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Methylene Chloride	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Methyl tert-Butyl Ether	4	<	<	<	4	<	<	<	3	<	<	<	0	-
n-Hexane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Tetrachloroethylene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Trichloroethene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Trichlorofluoromethane	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Styrene	4	<	<	<	4	<	<	<	3	<	<	<	0	-
Vinyl Chloride	4	<	<	<	4	<	<	<	3	<	<	<	0	-

Notes
All units in micrograms per gram (µg/g) except otherwise noted.
% = percent; mg/L = milligrams per litre
m bml = metres below mudline
MOECC = Ontario Ministry of Enviroment and Climate Change
Table 9 Sediment Standards = For all types of property use for sediment in generic site condition for use within 30 m of a water body in a non-potable groundwater condition (O. Reg 153 [2011])
Table 7 Shallow Soil Standards = For commercial property use for shallow soils in a non-potable
PSQG LEL = Provincial Sediment Quality Guidelines Lowest Effect Level (OMOE 2008)
PSQG SEL = Provincial Sediment Quality Guidelines Severe Effect Level (OMOE 2008)
Atlantic RBCA = Atlantic Risk-Based Corrective Action, Non-Narcosis Sediment Benchmark 2012
CCME ISQG = Canadian Council of Ministers of the Environment Sediment Quality Guidelines - Interim Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life
CCME PEL = Canadian Council of Ministers of the Environment Sediment Quality Guidelines - Probable Effect Levels for the Protection of Freshwater Aquatic Life
F1 (C6-C10) = Fraction 1, Carbon range 6 to 10; BTEX = benzene, toluene, ethylbenzene and xylene
F2 (C10-C16) = Fraction 2, Carbon range 10to 16
F3 (C16-C34) = Fraction 3, Carbon range 16 to 34
F4 (C34-C50) = Fraction 4, Carbon range 34 to 50
F4 Gravimetric = Fraction 4 obtained by gravimetric analysis
Total Petroleum Hydrocarbons (TPH) is equal to the sum of the F1 to F4 Fractions. Where F4 Gravimetric was greater than F4 (C34-C50), the F4 Gravimetric concentration was used in calculating

APPENDIX B

Water Quality Predictions

Table B1: Water Quality Predictions for Work Area 1

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=3)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	-	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	57	90	0.00029	0.0006	0.0014	0.0029	0.0043	0.0057	0.0089	Assumed to be in Cr(III) form
Copper	140	197	0.00070	0.0014	0.0035	**0.0070**	**0.0105**	**0.0140**	0.004	At H = 200
Lead	**160**	91.3	0.00080	0.0016	0.0040	**0.0080**	**0.0120**	**0.0160**	0.007	At H = 200
Mercury	0.205	0.486	0.0000010	0.0000021	0.0000051	0.000010	0.000015	0.000021	0.000026	
Zinc	**580**	315	0.003	0.006	0.015	0.029	**0.044**	**0.058**	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	**0.55**	0.0889	0.0000028	0.0000055	0.0000138	0.000028	0.000041	0.000055	0.0058	
Acenaphthylene	**0.305**	0.128	0.000002	0.000003	0.000008	0.000015	0.000023	0.000031	--	
Anthracene	**1.75**	0.245	0.000009	**0.000018**	**0.00004**	**0.00009**	**0.00013**	**0.00018**	0.000012	
Benzo [b,j] fluoranthene	3.65	--	0.000018	0.000037	0.00009	0.00018	0.00027	0.00037	--	
Benzo[a]anthracene	**3.2**	0.385	0.000016	**0.000032**	**0.00008**	**0.00016**	**0.00024**	**0.00032**	0.000018	
Benzo[a]pyrene	**2.95**	0.782	0.000015	**0.000030**	**0.00007**	**0.00015**	**0.00022**	**0.00030**	0.000015	
Benzo[g,h,i]perylene	1.9	--	0.0000095	0.000019	0.000048	0.00010	0.00014	0.00019	--	
Benzo[k]fluoranthene	1.265	--	0.0000063	0.0000127	0.000032	0.000063	0.000095	0.000127	--	
Chrysene	**2.75**	0.862	0.000014	0.000028	0.000069	0.00014	0.00021	0.00028	--	
Dibenzo[a,h]anthracene	**0.525**	0.135	0.0000026	0.0000053	0.0000131	0.000026	0.000039	0.000053	--	
Fluoranthene	**6.8**	2.355	0.000034	**0.000068**	**0.00017**	**0.00034**	**0.00051**	**0.00068**	0.00004	
Fluorene	**0.945**	0.144	0.0000047	0.0000095	0.000024	0.000047	0.000071	0.000095	0.003	
Indeno[1,2,3-cd]pyrene	2	--	0.000010	0.000020	0.00005	0.00010	0.00015	0.00020	--	
Naphthalene	**0.45**	0.391	0.0000023	0.0000045	0.0000113	0.000023	0.000034	0.000045	0.0011	
Phenanthrene	**5.95**	0.515	0.000030	0.000060	0.00015	0.00030	**0.00045**	**0.00060**	0.0004	
Pyrene	**5.55**	0.875	**0.000028**	**0.000056**	**0.00014**	**0.00028**	**0.00042**	**0.00056**	0.000025	
1-Methylnaphthalene	0.325	--	0.0000016	0.0000033	0.0000081	0.000016	0.000024	0.000033	--	
2-Methylnaphthalene	**0.335**	0.201	0.0000017	0.0000034	0.0000084	0.000017	0.000025	0.000034	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B2: Water Quality Predictions for Work Area 2

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=15)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS		-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	74	90	0.0004	0.0007	0.0019	0.0037	0.0056	0.0074	0.0089	Assumed to be in Cr(III) form
Copper	96	197	0.0005	0.0010	0.0024	**0.0048**	**0.0072**	**0.0096**	0.004	At H = 200
Lead	**145**	91.3	0.001	0.001	0.004	**0.007**	**0.011**	**0.015**	0.007	At H = 200
Mercury	**0.55**	0.486	0.000003	0.000006	0.000014	**0.000028**	**0.000041**	**0.000055**	0.000026	
Zinc	315	315	0.0016	0.0032	0.0079	0.016	0.024	**0.032**	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	**0.395**	0.0889	0.000002	0.000004	0.000010	0.000020	0.000030	0.000040	0.0058	
Acenaphthylene	**0.18**	0.128	0.0000009	0.0000018	0.0000044	0.0000088	0.0000131	0.0000175	--	
Anthracene	**0.6**	0.245	0.000003	0.000006	**0.000016**	**0.000032**	**0.000047**	**0.000063**	0.000012	
Benzo [b,j] fluoranthene	1.7	--	0.00001	0.00002	0.00004	0.00009	0.00013	0.00017	--	
Benzo[a]anthracene	**1.3**	0.385	0.000007	0.000013	**0.000033**	**0.000065**	**0.000098**	**0.000130**	0.000018	
Benzo[a]pyrene	**1.2**	0.782	0.000006	0.000012	**0.000029**	**0.000058**	**0.000087**	**0.000116**	0.000015	
Benzo[g,h,i]perylene	0.8	--	0.000004	0.000008	0.000020	0.000040	0.000060	0.000080	--	
Benzo[k]fluoranthene	0.6	--	0.000003	0.000006	0.000015	0.000030	0.000044	0.000059	--	
Chrysene	**1.3**	0.862	0.000006	0.000013	0.000031	0.000063	0.000094	0.000125	--	
Dibenzo[a,h]anthracene	**0.19**	0.135	0.0000010	0.0000019	0.0000048	0.0000095	0.000014	0.000019	--	
Fluoranthene	**3.4**	2.355	0.00002	0.00003	**0.00009**	**0.00017**	**0.00026**	**0.00034**	0.00004	
Fluorene	**0.4**	0.144	0.000002	0.000004	0.000011	0.000022	0.000033	0.000045	0.003	
Indeno[1,2,3-cd]pyrene	0.8	--	0.000004	0.000008	0.000021	0.000042	0.000062	0.000083	--	
Naphthalene	0.3	0.391	0.000001	0.000003	0.000006	0.000013	0.000019	0.000026	0.0011	
Phenanthrene	**2.2**	0.515	0.00001	0.00002	0.00006	0.00011	0.00017	0.00022	0.0004	
Pyrene	**2.7**	0.875	0.00001	**0.00003**	**0.00007**	**0.00013**	**0.00020**	**0.00027**	0.000025	
1-Methylnaphthalene	0.175	--	0.000001	0.000002	0.000004	0.000009	0.000013	0.000018	--	
2-Methylnaphthalene	**23.5**	0.201	0.0001	0.0002	0.0006	0.0012	0.0018	0.0023	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B3: Water Quality Predictions for Work Area 3

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=12)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	62	90	0.00031	0.00062	0.00154	0.00309	0.00463	0.00618	0.0089	Assumed to be in Cr(III) form
Copper	41	197	0.0002	0.0004	0.001	0.002	0.003	**0.004**	0.004	At H = 200
Lead	77.3	91.3	0.0004	0.0008	0.0019	0.0039	0.0058	**0.0077**	0.007	At H = 200
Mercury	0.086	0.486	0.00000	0.00000	0.00000	0.00000	0.00001	0.00001	0.000026	
Zinc	155	315	0.0008	0.0016	0.0039	0.0078	0.012	0.016	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.0665	0.0889	0.0000003	0.0000007	0.0000017	0.0000033	0.0000050	0.0000067	0.0058	
Acenaphthylene	0.08175	0.128	0.0000004	0.0000008	0.0000020	0.0000041	0.0000061	0.0000082	--	
Anthracene	0.1225	0.245	0.000001	0.000001	0.000003	0.000006	0.000009	**0.000012**	0.000012	
Benzo [b,j] fluoranthene	0.625	--	0.000003	0.000006	0.000016	0.000031	0.000047	0.000063	--	
Benzo[a]anthracene	**0.44**	0.385	0.000002	0.000004	0.000011	**0.000022**	**0.000033**	**0.000044**	0.000018	
Benzo[a]pyrene	0.4625	0.782	0.000002	0.000005	0.000012	**0.000023**	**0.000035**	**0.000046**	0.000015	
Benzo[g,h,i]perylene	0.3	--	0.000002	0.000003	0.000008	0.000015	0.000023	0.000030	--	
Benzo[k]fluoranthene	0.22	--	0.000001	0.000002	0.000006	0.000011	0.000017	0.000022	--	
Chrysene	0.4275	0.862	0.000002	0.000004	0.000011	0.000021	0.000032	0.000043	--	
Dibenzo[a,h]anthracene	0.0775	0.135	0.0000004	0.0000008	0.0000019	0.0000039	0.0000058	0.0000078	--	
Fluoranthene	0.925	2.355	0.000005	0.000009	0.000023	**0.000046**	**0.000069**	**0.000093**	0.00004	
Fluorene	0.0535	0.144	0.000000	0.000001	0.000001	0.000003	0.000004	0.000005	0.003	
Indeno[1,2,3-cd]pyrene	0.3225	--	0.000002	0.000003	0.000008	0.000016	0.000024	0.000032	--	
Naphthalene	0.05	0.391	0.0000003	0.0000005	0.0000013	0.0000025	0.0000038	0.0000050	0.0011	
Phenanthrene	**0.475**	0.515	0.000002	0.000005	0.000012	0.000024	0.000036	0.000048	0.0004	
Pyrene	**0.785**	0.875	0.000004	0.000008	0.000020	**0.000039**	**0.000059**	**0.000079**	0.000025	
1-Methylnaphthalene	0.04625	--	0.0000002	0.0000005	0.0000012	0.0000023	0.0000035	0.0000046	--	
2-Methylnaphthalene	0.05225	0.201	0.0000003	0.0000005	0.0000013	0.0000026	0.0000039	0.0000052	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B4: Water Quality Predictions for Work Area 4

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=19)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	140	90	0.00070	0.00140	0.00350	0.00700	**0.0105**	**0.014**	0.0089	Assumed to be in Cr(III) form
Copper	71	197	0.0004	0.0007	0.002	0.004	**0.005**	**0.007**	0.004	At H = 200
Lead	125.0	91.3	0.0006	0.0013	0.0031	0.0063	**0.0094**	**0.0125**	0.007	At H = 200
Mercury	0.265	0.486	0.00000	0.00000	0.00001	0.00001	0.00002	**0.00003**	0.000026	
Zinc	170	315	0.0009	0.0017	0.0043	0.0085	0.013	0.017	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.015	0.0889	0.0000001	0.0000001	0.0000004	0.0000007	0.0000011	0.0000015	0.0058	
Acenaphthylene	0.049	0.128	0.0000002	0.0000005	0.0000012	0.0000024	0.0000036	0.0000049	--	
Anthracene	0.048	0.245	0.000000	0.000000	0.000001	0.000002	0.000004	0.000005	0.000012	
Benzo [b,j] fluoranthene	0.26	--	0.000001	0.000003	0.000007	0.000013	0.000020	0.000026	--	
Benzo[a]anthracene	0.17	0.385	0.000001	0.000002	0.000004	0.000009	0.000013	0.000017	0.000018	
Benzo[a]pyrene	0.175	0.782	0.000001	0.000002	0.000004	0.000009	0.000013	**0.000018**	0.000015	
Benzo[g,h,i]perylene	0.140	--	0.000001	0.000001	0.000004	0.000007	0.000011	0.000014	--	
Benzo[k]fluoranthene	0.085	--	0.000000	0.000001	0.000002	0.000004	0.000006	0.000008	--	
Chrysene	0.155	0.862	0.000001	0.000002	0.000004	0.000008	0.000012	0.000016	--	
Dibenzo[a,h]anthracene	0.0305	0.135	0.0000002	0.0000003	0.0000008	0.0000015	0.0000023	0.0000031	--	
Fluoranthene	0.365	2.355	0.000002	0.000004	0.000009	0.000018	0.000027	0.000037	0.00004	
Fluorene	0.021	0.144	0.000000	0.000000	0.000001	0.000001	0.000002	0.000002	0.003	
Indeno[1,2,3-cd]pyrene	0.150	--	0.000001	0.000002	0.000004	0.000008	0.000011	0.000015	--	
Naphthalene	0.031	0.391	0.0000002	0.0000003	0.0000008	0.0000016	0.0000023	0.0000031	0.0011	
Phenanthrene	0.130	0.515	0.000001	0.000001	0.000003	0.000007	0.000010	0.000013	0.0004	
Pyrene	0.360	0.875	0.000002	0.000004	0.000009	0.000018	**0.000027**	**0.000036**	0.000025	
1-Methylnaphthalene	0.029	--	0.0000001	0.0000003	0.0000007	0.0000015	0.0000022	0.0000029	--	
2-Methylnaphthalene	0.037	0.201	0.0000002	0.0000004	0.0000009	0.0000018	0.0000027	0.0000037	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B5: Water Quality Predictions for Work Area 5

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=14)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	120	90	0.00060	0.00120	0.00300	0.00600	**0.00900**	**0.01200**	0.0089	Assumed to be in Cr(III) form
Copper	56	197	0.0003	0.0006	0.001	0.003	**0.004**	**0.006**	0.004	At H = 200
Lead	37.5	91.3	0.0002	0.0004	0.0009	0.0019	0.0028	0.0038	0.007	At H = 200
Mercury	0.061	0.486	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.000026	
Zinc	130	315	0.0007	0.0013	0.0033	0.0065	0.010	0.013	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.011	0.0889	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000011	0.0058	
Acenaphthylene	0.015	0.128	0.0000001	0.0000002	0.0000004	0.0000008	0.0000011	0.0000015	--	
Anthracene	0.022	0.245	0.0000001	0.0000002	0.000001	0.000001	0.000002	0.000002	0.000012	
Benzo [b,j] fluoranthene	0.1175	--	0.000001	0.000001	0.000003	0.000006	0.000009	0.000012	--	
Benzo[a]anthracene	0.0905	0.385	0.0000005	0.000001	0.000002	0.000005	0.000007	0.000009	0.000018	
Benzo[a]pyrene	0.0805	0.782	0.0000004	0.000001	0.000002	0.000004	0.000006	0.000008	0.000015	
Benzo[g,h,i]perylene	0.058	--	0.0000003	0.000001	0.000001	0.000003	0.000004	0.000006	--	
Benzo[k]fluoranthene	0.037	--	0.0000002	0.0000004	0.000001	0.000002	0.000003	0.000004	--	
Chrysene	0.070	0.862	0.0000004	0.000001	0.000002	0.000004	0.000005	0.000007	--	
Dibenzo[a,h]anthracene	0.01275	0.135	0.0000001	0.0000001	0.0000003	0.0000006	0.0000010	0.0000013	--	
Fluoranthene	0.14	2.355	0.000001	0.000001	0.000004	0.000007	0.000011	0.000014	0.00004	
Fluorene	0.011	0.144	0.0000001	0.0000001	0.0000003	0.000001	0.000001	0.000001	0.003	
Indeno[1,2,3-cd]pyrene	0.060	--	0.0000003	0.000001	0.000002	0.000003	0.000005	0.000006	--	
Naphthalene	0.01375	0.391	0.0000001	0.0000001	0.0000003	0.0000007	0.0000010	0.0000014	0.0011	
Phenanthrene	0.063	0.515	0.0000003	0.000001	0.000002	0.000003	0.000005	0.000006	0.0004	
Pyrene	0.198	0.875	0.000001	0.000002	0.000005	0.000010	0.000015	0.000020	0.000025	
1-Methylnaphthalene	0.01825	--	0.0000001	0.0000002	0.0000005	0.0000009	0.0000014	0.0000018	--	
2-Methylnaphthalene	0.032	0.201	0.0000002	0.0000003	0.0000008	0.0000016	0.0000024	0.0000032	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B6: Water Quality Predictions for Work Area 6

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=12)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	92	90	0.00046	0.00092	0.00230	0.00460	0.00690	**0.00920**	0.0089	Assumed to be in Cr(III) form
Copper	46	197	0.0002	0.0005	0.001	0.002	0.003	**0.005**	0.004	At H = 200
Lead	43.0	91.3	0.0002	0.0004	0.0011	0.0022	0.0032	0.0043	0.007	At H = 200
Mercury	0.21	0.486	0.00000	0.00000	0.00001	0.00001	0.00002	0.00002	0.000026	
Zinc	130	315	0.0007	0.0013	0.0033	0.0065	0.010	0.013	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.01	0.0889	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	0.0058	
Acenaphthylene	0.01	0.128	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	--	
Anthracene	0.017	0.245	0.000000	0.000000	0.000000	0.000001	0.000001	0.000002	0.000012	
Benzo [b,j] fluoranthene	0.074	--	0.000000	0.000001	0.000002	0.000004	0.000006	0.000007	--	
Benzo[a]anthracene	0.04	0.385	0.000000	0.000000	0.000001	0.000002	0.000003	0.000004	0.000018	
Benzo[a]pyrene	0.047	0.782	0.000000	0.000000	0.000001	0.000002	0.000004	0.000005	0.000015	
Benzo[g,h,i]perylene	0.036	--	0.000000	0.000000	0.000001	0.000002	0.000003	0.000004	--	
Benzo[k]fluoranthene	0.022	--	0.000000	0.000000	0.000001	0.000001	0.000002	0.000002	--	
Chrysene	0.045	0.862	0.000000	0.000000	0.000001	0.000002	0.000003	0.000005	--	
Dibenzo[a,h]anthracene	0.01	0.135	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	--	
Fluoranthene	0.13	2.355	0.000001	0.000001	0.000003	0.000007	0.000010	0.000013	0.00004	
Fluorene	0.01	0.144	0.000000	0.000000	0.000000	0.000001	0.000001	0.000001	0.003	
Indeno[1,2,3-cd]pyrene	0.037	--	0.000000	0.000000	0.000001	0.000002	0.000003	0.000004	--	
Naphthalene	0.01	0.391	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	0.0011	
Phenanthrene	0.033	0.515	0.000000	0.000000	0.000001	0.000002	0.000002	0.000003	0.0004	
Pyrene	0.1	0.875	0.000001	0.000001	0.000003	0.000005	0.000008	0.000010	0.000025	
1-Methylnaphthalene	0.01	--	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	--	
2-Methylnaphthalene	0.01	0.201	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B7: Water Quality Predictions for Work Area 7

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=5)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	37	90	0.00019	0.00037	0.00093	0.00185	0.00278	0.00370	0.0089	Assumed to be in Cr(III) form
Copper	20	197	0.0001	0.0002	0.001	0.001	0.002	0.002	0.004	At H = 200
Lead	150.0	91.3	0.0008	0.0015	0.0038	**0.0075**	**0.0113**	**0.0150**	0.007	At H = 200
Mercury	1.500	0.486	0.00001	0.00002	**0.00004**	**0.00008**	**0.00011**	**0.00015**	0.000026	
Zinc	71	315	0.0004	0.0007	0.0018	0.0036	0.005	0.007	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.012	0.0889	0.0000001	0.0000001	0.0000003	0.0000006	0.0000009	0.0000012	0.0058	
Acenaphthylene	0.073	0.128	0.0000004	0.0000007	0.0000018	0.0000037	0.0000055	0.0000073	--	
Anthracene	0.073	0.245	0.000000	0.000001	0.000002	0.000004	0.000005	0.000007	0.000012	
Benzo [b,j] fluoranthene	0.51	--	0.000003	0.000005	0.000013	0.000026	0.000038	0.000051	--	
Benzo[a]anthracene	0.29	0.385	0.000001	0.000003	0.000007	0.000015	**0.000022**	**0.000029**	0.000018	
Benzo[a]pyrene	0.4	0.782	0.000002	0.000004	0.000010	**0.000020**	**0.000030**	**0.000040**	0.000015	
Benzo[g,h,i]perylene	0.240	--	0.000001	0.000002	0.000006	0.000012	0.000018	0.000024	--	
Benzo[k]fluoranthene	0.170	--	0.000001	0.000002	0.000004	0.000009	0.000013	0.000017	--	
Chrysene	0.270	0.862	0.000001	0.000003	0.000007	0.000014	0.000020	0.000027	--	
Dibenzo[a,h]anthracene	0.058	0.135	0.0000003	0.0000006	0.0000015	0.0000029	0.0000044	0.0000058	--	
Fluoranthene	0.65	2.355	0.000003	0.000007	0.000016	0.000033	**0.000049**	**0.000065**	0.00004	
Fluorene	0.023	0.144	0.000000	0.000000	0.000001	0.000001	0.000002	0.000002	0.003	
Indeno[1,2,3-cd]pyrene	0.290	--	0.000001	0.000003	0.000007	0.000015	0.000022	0.000029	--	
Naphthalene	0.01	0.391	0.0000001	0.0000001	0.0000003	0.0000005	0.0000008	0.0000010	0.0011	
Phenanthrene	0.180	0.515	0.000001	0.000002	0.000005	0.000009	0.000014	0.000018	0.0004	
Pyrene	0.550	0.875	0.000003	0.000006	0.000014	**0.000028**	**0.000041**	**0.000055**	0.000025	
1-Methylnaphthalene	0.0079	--	0.0000000	0.0000001	0.0000002	0.0000004	0.0000006	0.0000008	--	
2-Methylnaphthalene	0.009	0.201	0.0000000	0.0000001	0.0000002	0.0000004	0.0000007	0.0000009	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B8: Water Quality Predictions for Work Area 8

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=4)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	45	90	0.00022	0.00045	0.00111	0.00223	0.00334	0.00445	0.0089	Assumed to be in Cr(III) form
Copper	41	197	0.0002	0.0004	0.001	0.002	0.003	**0.004**	0.004	At H = 200
Lead	162.5	91.3	0.0008	0.0016	0.0041	**0.0081**	**0.0122**	**0.0163**	0.007	At H = 200
Mercury	0.255	0.486	0.00000	0.00000	0.00001	0.00001	0.00002	0.00003	0.000026	
Zinc	178	315	0.0009	0.0018	0.0044	0.0089	0.013	0.018	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	**0.113**	0.0889	0.0000006	0.0000011	0.0000028	0.0000057	0.0000085	0.0000113	0.0058	
Acenaphthylene	0.090	0.128	0.0000004	0.0000009	0.0000022	0.0000045	0.0000067	0.0000090	--	
Anthracene	0.178	0.245	0.000001	0.000002	0.000004	0.000009	**0.000013**	**0.000018**	0.000012	
Benzo [b,j] fluoranthene	0.8425	--	0.000004	0.000008	0.000021	0.000042	0.000063	0.000084	--	
Benzo[a]anthracene	**0.615**	0.385	0.000003	0.000006	0.000015	**0.000031**	**0.000046**	**0.000062**	0.000018	
Benzo[a]pyrene	0.635	0.782	0.000003	0.000006	**0.000016**	**0.000032**	**0.000048**	**0.000064**	0.000015	
Benzo[g,h,i]perylene	0.388	--	0.000002	0.000004	0.000010	0.000019	0.000029	0.000039	--	
Benzo[k]fluoranthene	0.270	--	0.000001	0.000003	0.000007	0.000014	0.000020	0.000027	--	
Chrysene	0.550	0.862	0.000003	0.000006	0.000014	0.000028	0.000041	0.000055	--	
Dibenzo[a,h]anthracene	0.105	0.135	0.0000005	0.0000011	0.0000026	0.0000053	0.0000079	0.0000105	--	
Fluoranthene	1.275	2.355	0.000006	0.000013	0.000032	**0.000064**	**0.000096**	**0.000128**	0.00004	
Fluorene	0.108	0.144	0.000001	0.000001	0.000003	0.000005	0.000008	0.000011	0.003	
Indeno[1,2,3-cd]pyrene	0.448	--	0.000002	0.000004	0.000011	0.000022	0.000034	0.000045	--	
Naphthalene	0.0395	0.391	0.0000002	0.0000004	0.0000010	0.0000020	0.0000030	0.0000040	0.0011	
Phenanthrene	**0.545**	0.515	0.000003	0.000005	0.000014	0.000027	0.000041	0.000055	0.0004	
Pyrene	**1.050**	0.875	0.000005	0.000011	**0.000026**	**0.000053**	**0.000079**	**0.000105**	0.000025	
1-Methylnaphthalene	0.0305	--	0.0000002	0.0000003	0.0000008	0.0000015	0.0000023	0.0000031	--	
2-Methylnaphthalene	0.048	0.201	0.0000002	0.0000005	0.0000012	0.0000024	0.0000036	0.0000048	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B9: Water Quality Predictions for Work Area 9

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=9)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	27	90	0.00014	0.00027	0.00068	0.00135	0.00203	0.00270	0.0089	Assumed to be in Cr(III) form
Copper	18	197	0.0001	0.0002	0.000	0.001	0.001	0.002	0.004	At H = 200
Lead	14.0	91.3	0.0001	0.0001	0.0004	0.0007	0.0011	0.0014	0.007	At H = 200
Mercury	0.050	0.486	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.000026	
Zinc	49	315	0.0002	0.0005	0.0012	0.0025	0.004	0.005	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.015	0.0889	0.0000001	0.0000002	0.0000004	0.0000008	0.0000011	0.0000015	0.0058	
Acenaphthylene	0.028	0.128	0.0000001	0.0000003	0.0000007	0.0000014	0.0000021	0.0000028	--	
Anthracene	0.063	0.245	0.000000	0.000001	0.000002	0.000003	0.000005	0.000006	0.000012	
Benzo [b,j] fluoranthene	0.23	--	0.000001	0.000002	0.000006	0.000012	0.000017	0.000023	--	
Benzo[a]anthracene	0.13	0.385	0.000001	0.000001	0.000003	0.000007	0.000010	0.000013	0.000018	
Benzo[a]pyrene	0.18	0.782	0.000001	0.000002	0.000005	0.000009	0.000014	**0.000018**	0.000015	
Benzo[g,h,i]perylene	0.110	--	0.000001	0.000001	0.000003	0.000006	0.000008	0.000011	--	
Benzo[k]fluoranthene	0.069	--	0.000000	0.000001	0.000002	0.000003	0.000005	0.000007	--	
Chrysene	0.150	0.862	0.000001	0.000002	0.000004	0.000008	0.000011	0.000015	--	
Dibenzo[a,h]anthracene	0.023	0.135	0.0000001	0.0000002	0.0000006	0.0000012	0.0000017	0.0000023	--	
Fluoranthene	0.34	2.355	0.000002	0.000003	0.000009	0.000017	0.000026	0.000034	0.00004	
Fluorene	0.022	0.144	0.000000	0.000000	0.000001	0.000001	0.000002	0.000002	0.003	
Indeno[1,2,3-cd]pyrene	0.110	--	0.000001	0.000001	0.000003	0.000006	0.000008	0.000011	--	
Naphthalene	0.0068	0.391	0.0000000	0.0000001	0.0000002	0.0000003	0.0000005	0.0000007	0.0011	
Phenanthrene	0.150	0.515	0.000001	0.000002	0.000004	0.000008	0.000011	0.000015	0.0004	
Pyrene	0.270	0.875	0.000001	0.000003	0.000007	0.000014	0.000020	**0.000027**	0.000025	
1-Methylnaphthalene	0.0064	--	0.0000000	0.0000001	0.0000002	0.0000003	0.0000005	0.0000006	--	
2-Methylnaphthalene	0.006	0.201	0.0000000	0.0000001	0.0000001	0.0000003	0.0000004	0.0000006	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B10: Water Quality Predictions for Work Area 10

Parameter	75th Percentile Sediment Concentration (mg/kg) (n=4)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	--	-	5	10	25	50	75	100	-	-
Metals										
Chromium (Total)	30	90	0.00015	0.00030	0.00076	0.00151	0.00227	0.00303	0.0089	Assumed to be in Cr(III) form
Copper	17	197	0.0001	0.0002	0.000	0.001	0.001	0.002	0.004	At H = 200
Lead	27.3	91.3	0.0001	0.0003	0.0007	0.0014	0.0020	0.0027	0.007	At H = 200
Mercury	0.050	0.486	0.0000003	0.0000005	0.0000013	0.0000025	0.0000038	0.0000050	0.000026	
Zinc	43	315	0.0002	0.0004	0.0011	0.0021	0.003	0.004	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.006	0.0889	0.0000000	0.0000001	0.0000002	0.0000003	0.0000005	0.0000006	0.0058	
Acenaphthylene	0.013	0.128	0.0000001	0.0000001	0.0000003	0.0000006	0.0000009	0.0000013	--	
Anthracene	0.019	0.245	0.000000	0.000000	0.000000	0.000001	0.000001	0.000002	0.000012	
Benzo [b,j] fluoranthene	0.1005	--	0.000001	0.000001	0.000003	0.000005	0.000008	0.000010	--	
Benzo[a]anthracene	0.069	0.385	0.000000	0.000001	0.000002	0.000003	0.000005	0.000007	0.000018	
Benzo[a]pyrene	0.076	0.782	0.000000	0.000001	0.000002	0.000004	0.000006	0.000008	0.000015	
Benzo[g,h,i]perylene	0.065	--	0.000000	0.000001	0.000002	0.000003	0.000005	0.000007	--	
Benzo[k]fluoranthene	0.035	--	0.000000	0.000000	0.000001	0.000002	0.000003	0.000003	--	
Chrysene	0.059	0.862	0.000000	0.000001	0.000001	0.000003	0.000004	0.000006	--	
Dibenzo[a,h]anthracene	0.015775	0.135	0.0000001	0.0000002	0.0000004	0.0000008	0.0000012	0.0000016	--	
Fluoranthene	0.13275	2.355	0.000001	0.000001	0.000003	0.000007	0.000010	0.000013	0.00004	
Fluorene	0.008	0.144	0.000000	0.000000	0.000000	0.000000	0.000001	0.000001	0.003	
Indeno[1,2,3-cd]pyrene	0.064	--	0.000000	0.000001	0.000002	0.000003	0.000005	0.000006	--	
Naphthalene	0.00595	0.391	0.0000000	0.0000001	0.0000001	0.0000003	0.0000004	0.0000006	0.0011	
Phenanthrene	0.057	0.515	0.000000	0.000001	0.000001	0.000003	0.000004	0.000006	0.0004	
Pyrene	0.113	0.875	0.000001	0.000001	0.000003	0.000006	0.000008	0.000011	0.000025	
1-Methylnaphthalene	0.005825	--	0.0000000	0.0000001	0.0000001	0.0000003	0.0000004	0.0000006	--	
2-Methylnaphthalene	0.011	0.201	0.0000001	0.00000011	0.00000028	0.00000056	0.00000085	0.00000113	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B11: Water Quality Predictions for Work Area 11

Parameter	Sediment Concentration (mg/kg) (n=1)	CCME PEL (mg/kg)	Predicted Water Concentration (mg/L)						CCME WQG (mg/L)	Qualifiers
TSS	-	-	5	10	25	50	75	100	-	-
Metals										
Arsenic	2	17	0.00001	0.00002	0.00005	0.0001	0.00015	0.0002	0.005	
Chromium (Total)	20	90	0.0001	0.0002	0.0005	0.001	0.0015	0.002	0.0089	Assumed to be in Cr(III) form
Copper	18	197	0.00009	0.00018	0.00045	0.0009	0.00135	0.0018	0.004	At H = 200
Lead	24	91.3	0.00012	0.00024	0.0006	0.0012	0.0018	0.0024	0.007	At H = 200
Mercury	0.05	0.486	0.00000025	0.0000005	0.0000013	0.0000025	0.0000038	0.000005	0.000026	
Nickel	13	16 (b)	0.0001	0.0001	0.0003	0.0007	0.0010	0.0013	0.15	At H = 200
Zinc	65	315	0.0003	0.0007	0.0016	0.0033	0.0049	0.0065	0.03	
Polycyclic aromatic hydrocarbons										
Acenaphthene	0.014	0.0889	0.00000007	0.00000014	0.00000035	0.0000007	0.0000011	0.0000014	0.0058	
Acenaphthylene	0.023	0.128	0.0000001	0.00000023	0.0000006	0.0000012	0.0000017	0.0000023	--	
Anthracene	0.055	0.245	0.0000003	0.00000055	0.0000014	0.0000028	0.0000041	0.0000055	0.000012	
Benzo [b,j] fluoranthene	0.17	--	0.00000085	0.0000017	0.0000043	0.0000085	0.0000128	0.0000170	--	
Benzo[a]anthracene	0.13	0.385	0.00000065	0.0000013	0.0000033	0.0000065	0.0000098	0.0000130	0.000018	
Benzo[a]pyrene	0.13	0.782	0.00000065	0.0000013	0.0000033	0.0000065	0.0000098	0.0000130	0.000015	
Benzo[g,h,i]perylene	0.076	--	0.00000038	0.00000076	0.0000019	0.0000038	0.0000057	0.0000076	--	
Benzo[k]fluoranthene	0.055	--	0.0000003	0.00000055	0.00000138	0.0000028	0.0000041	0.0000055	--	
Chrysene	0.12	0.862	0.0000006	0.0000012	0.000003	0.000006	0.000009	0.000012	--	
Dibenzo[a,h]anthracene	0.021	0.135	0.0000001	0.00000021	0.0000005	0.00000105	0.0000016	0.0000021	--	
Fluoranthene	0.26	2.355	0.0000013	0.0000026	0.0000065	0.000013	0.0000195	0.000026	0.00004	
Fluorene	0.027	0.144	0.0000001	0.00000027	0.0000007	0.0000014	0.0000020	0.0000027	0.003	
Indeno[1,2,3-cd]pyrene	0.083	--	0.0000004	0.00000083	0.0000021	0.0000042	0.0000062	0.0000083	--	
Naphthalene	0.011	0.391	0.00000006	0.00000011	0.00000028	0.00000055	0.00000083	0.00000110	0.0011	
Phenanthrene	0.16	0.515	0.0000008	0.0000016	0.000004	0.000008	0.000012	0.000016	0.0004	
Pyrene	0.23	0.875	0.00000115	0.0000023	0.00000575	0.0000115	0.00001725	0.000023	0.000025	
1-Methylnaphthalene	0.0092	--	0.000000046	0.000000092	0.00000023	0.00000046	0.00000069	0.00000092	--	
2-Methylnaphthalene	0.014	0.201	0.00000007	0.00000014	0.00000035	0.0000007	0.00000105	0.0000014	--	

Notes:
Bold, underlined values exceed the CCME PEL or other SQG
Bold, yellow-highlighted values exceed the CCME WQG for protection of freshwater aquatic life
CCME – Canadian Council of Ministers of the Environment; H – hardness; PEL – probable effects level; WQG – water quality guideline

Table B12: Summary of Calculated Benzo(a)pyrene Toxic Potency Equivalents

Work Area	Calculated Benzo(a)pyrene Total Potency Equivalent at TSS of:					
	5	10	25	50	75	100
1	0.00002	0.000045	0.00011	0.00023	0.00034	**0.00045**
2	0.00001	0.00002	0.00005	0.00009	0.00014	0.00018
3	0.000004	0.000007	0.000018	0.000035	0.000053	0.000071
4	0.0000014	0.0000028	0.0000069	0.000014	0.000021	0.000028
5	0.0000006	0.000001	0.000003	0.000006	0.000009	0.000013
6	0.0000004	0.000001	0.000002	0.000004	0.000006	0.000008
7	0.000003	0.000006	0.00001	0.00003	0.00004	0.00006
8	0.000005	0.000010	0.000024	0.000048	0.000073	0.000097
9	0.0000013	0.0000026	0.000006	0.000013	0.000019	0.000026
10	0.000001	0.000001	0.000003	0.000006	0.000009	0.000012
11	0.000001	0.000002	0.000005	0.000010	0.000015	0.000020

Notes:
Bold, yellow-highlighted values exceed the screening value for recreational contact

o:\final\2017\3 proj\1776320_pwgsc_ottawa walls_rideau canal\1776320-004-r-rev0\attachments\appendix b.docx

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
Suite 200 - 2920 Virtual Way
Vancouver, BC, V5M 0C4
Canada
T: +1 (604) 296 4200

Golder Associates